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Technology-Mediated Diabetes Prevention Program (DPP) Benchmark Project

Devon Senical
dmsenical@gmail.com

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Devon Senical

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Contents

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Executive Summary

This benchmark project intends to broaden access to the Diabetes Prevention Program (DPP) by offering technology-mediated content at the primary care level because the Primary Care Physician (PCP) predominantly diagnoses prediabetes due to the recommendation by The U.S. Preventive Services Task Force (USPSTF) that nonpregnant overweight or obese adults aged 35 to 70 be screened for prediabetes and type 2 diabetes (Davidson et al., 2021). Thus, the primary care setting is the first opportunity to impact the conversion from prediabetes to type 2 diabetes. Of the 84 million people in the United States (U.S.) with prediabetes, they are estimated to convert to type 2 diabetes at a rate of 5-10% per year (Almeida et al., 2020). The PICOT question guiding this benchmark project is as follows: In prediabetics (P), how does participating in a technology-mediated Diabetes Prevention Program (DPP) and implementing lifestyle interventions in the future (I) compared to not attending DPP and implementing lifestyle interventions (C) affect the development of type 2 diabetes (O) over one-year (T)? This benchmark project intends to delay or prevent prediabetics from progressing to type 2 diabetes in the future due to the burden and cost type 2 diabetes places on the healthcare system. This will be accomplished by a PCP practice partnering with a technology-mediated DPP to engage and enroll their prediabetic patients in DPP. Traditional in-person DPP is one-year in length with the first 6 months consisting of weekly 1-hour group classes and the latter 6 months consisting of monthly 1-hour group classes. Though the CDC-recognized National DPP has demonstrated over 50% risk reduction in progression to type 2 diabetes, its attendance has been underwhelming due to the rigorous schedule of traditional in-person classes. The technology-mediated DPP is much easier for participants to access and engage in during their own time without having to go somewhere for weekly/monthly in-person classes. Its potential for large scalability and

dissemination should appeal to PCPs aiming to decrease incident type 2 diabetes among a prediabetic population.

Technology-Mediated Diabetes Prevention Program (DPP) Benchmark Project

Rationale for the Project

The burden of diabetes is expected to increase from 415 million people in 2015 to 642 million people by 2040 (Khetan & Rajagopalan, 2018). Diabetes and the associated complications place a significant strain on the U.S. healthcare system, with 7.8 million hospitalizations annually among diabetic patients and $237 billion in direct medical costs (Dougherty & Heile, 2020). Ongoing consequences, if the evidence-based change is not implemented would result in the continuing increase of the diabetic population resulting in a persistent burden on the healthcare system. Because of the resource burden, financial, and utilization, type 2 diabetes places on the healthcare system, it is essential to try to mitigate, or delay, the progression of prediabetic patients to type 2 diabetes. Most patients pass through a phase of prediabetes before developing type 2 diabetes (Khetan & Rajagopalan, 2018). This trajectory can be altered by providing DPP to prediabetics. The landmark U.S. DPP study demonstrated that intensive lifestyle intervention was effective at reducing the incidence of type 2 diabetes by 58% over three years (Williams et al., 2022). Economic studies suggest that the earlier lifestyle intervention is initiated, the greater the reduction in the development of type 2 diabetes (Glechner et al., 2018). The increasing prevalence of prediabetes and the success of DPP has led to increasing efforts to provide readily accessible, cost-effective, DPP. Technology-mediated DPP can be widely distributed and sustained compared to traditional in-person DPP (Grock et al., 2017).

Literature Synthesis

This literature review consists of twelve journal articles that were synthesized of which five are Level I, five are Level II, one is Level III, and one is Level IV evidence. Gletchner et al.,

2018; Uusitupa et al., 2019; and Almeida et al., 2020 findings demonstrate that prediabetics who received lifestyle intervention had a lower rate of progression to type 2 diabetes and it decreased risk significantly. Costs per quality-adjusted life-year were also lower when the benefits of lifestyle intervention were analyzed (Gletner et al., 2018; Almeida et al., 2020; Zhou et al., 2020). The articles also showed meaningful reductions in weight, BMI, and glycemic biomarkers, such as HbgA1C and fasting glucose, in the intervention arms, and this was especially the case for those studies based on the DPP curriculum (Birse et al., 2020; Block et al., 2015; Katula et al., 2022; Moin et al., 2018; Toro-Ramos et al., 2020).

Importantly, when comparing the results of in-person DPP and technology-mediated DPP, the positive results of DPP were consistent. Moin et al., 2018 explicitly compared the two approaches and found that participants enrolled in online DPP had higher participation, with similar weight loss, the main outcome measured, compared to those enrolled in in-person DPP. Griauzde et al., 2019 also demonstrated higher retention and adherence rates with technology-mediated DPP in the app-plus intervention arm. Technology-mediated DPPs were shown to be effective at decreasing diabetes risk while demonstrating high potential for widespread dissemination and scalability among prediabetics without the added barriers of in-person interventions (Villegas et al., 2022; Bian et al., 2017; Block et al., 2015; Katula et al., 2022; Moin et al., 2018; Toro-Ramos et al., 2020). These results are especially compelling because diabetes disproportionately impacts low-and middle-income populations. Transitioning these populations from intensive in-person lifestyle programs to remotely administered, technology-based programs increases the likelihood that the higher-risk population enrolls and remains engaged in DPP (Villegas et al., 2022).

Project Stakeholders

The key stakeholders for this benchmark project will be the physicians, practice manager, practice director, medical group or physician organization that the PCP practice belongs to, and the practice staff. There would be an opportunity for interprofessional involvement from multiple disciplines from the practice and from the medical group/physician organization to serve on the change project team that will be involved in the implementation plan. These key stakeholders on the change project team will be the practice manager, practice director, population health director, data analyst, registered nurse (RN), care manager, lead medical assistant (MA), and physician champion. Other stakeholders involved in this benchmark project include the patients and their families that will participate in the technology-mediated DPP. These are the stakeholders that this project aims to help by implementing lifestyle interventions and ultimately reducing their risk of type 2 diabetes. This benchmark project is starting with one PCP practice within the medical group/physician organization, however, if successful could be widespread among all PCP practices within the medical group/physician organization. If this were the case, the stakeholders involved could be the executive leadership, finance, medical director, and potential system-level leadership if the practice is part of a healthcare system or the Chief Nursing Officer (CNO) and Chief Medical Officer (CMO).

Implementation Plan

The PCP practice will need to invest internal resources, and staff to assist with the data collection, and participate in the implementation of the change project team. The primary task of the change project team will be selecting a technology-mediated DPP vendor, that is recognized by the CDC's Diabetes Prevention Recognition Program (DPRP) and negotiating a contract. The change project team should consider if the vendor's program is covered by the majority of their

patients' insurance providers, ease of functionality (quality of tech support offered), and existing customer outcomes. To the extent that the selected vendor does not accept all, or any, of the practice's patients' insurance, the practice will pay the program costs for non-covered patients.

The initial step will be to organize the key stakeholders that will be participating in the change project team and establish a regular weekly meeting schedule to discuss progress, issues, and next steps. The second step will be to analyze the evidence by assessing the feasibility, benefits, and risks of implementing technology-mediated DPP by conducting a cost analysis of ROI based on the average cost of potential partnering technology-mediated DPP vendors. This is a crucial step to determine what the upfront costs will be and what the cost/benefit relationship is. The third step will be to design the evaluation of the change project and determine what the desired outcomes are and metrics/data that will be tracked along the way to identify success. The fourth step will be for the change project team to interview and meet with several technology-mediated DPP vendor consultants to determine which vendor to partner with. Once the technology-mediated DPP vendor is chosen, the next step will be to include the vendor consultant in the change project team's weekly meetings, so they can be a part of the implementation process. The next step will be discussing getting patients enrolled in the program, technology needs, and retention plans. This step is important because the DPP is a year-long program, so it is important to have a set date that all first-time participants will begin the program and have a retention plan in place to keep them engaged during its course.

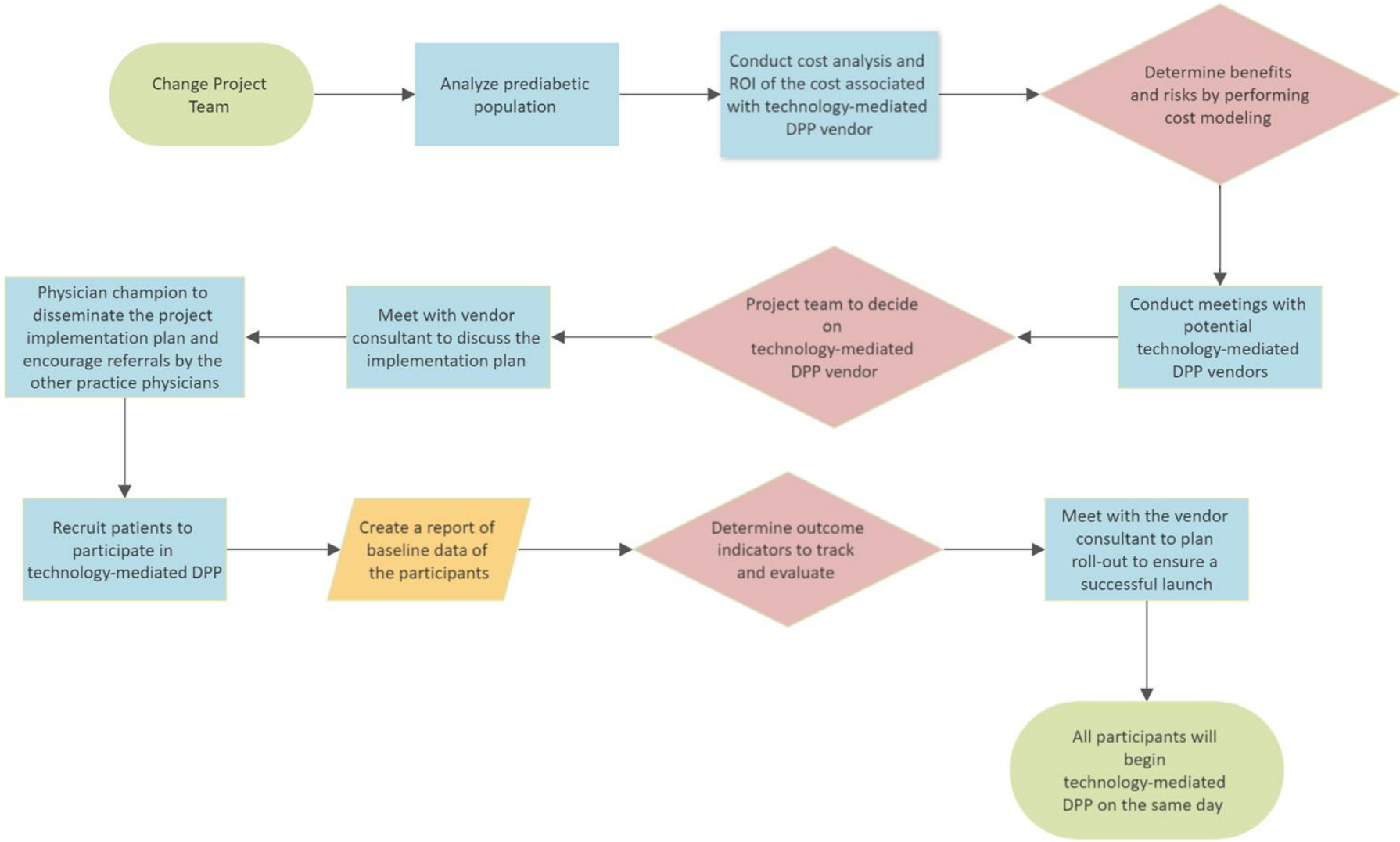
The next step is the practice manager and physician champion rolling out the implementation plan to the rest of the staff at an upcoming practice staff meeting. It will be critical during the staff meeting for them to explain the 'why' behind the initiative and for updates to be discussed at each staff meeting thereafter to keep it in the forefront. The next step

will be getting patients engaged and enrolled in the technology-mediated DPP. This will be done by marketing efforts which will consist of signage throughout the practice, physicians discussing it with their prediabetic patients and making referrals, and RN and lead MA conducting outreach to prediabetic patients to recruit into the program. The next step will be to gather baseline data on all participants including weight, BMI, BP, fasting blood glucose, HbgA1C, and lipid profile to be able to track and evaluate the change project. The final step should be to meet with the technology-mediated DPP vendor to ensure a successful launch by determining that all participants have the necessary technology, software, and equipment and that the vendor has available IT support for any issues. All first-time participants will begin the technology-mediated DPP on the same day and will have access to customer service/IT support numbers in case of any issues.

Timetable/Flowchart

Week 1	Assemble the change project team consisting of the practice manager, practice director, population health director, data analyst, RN, care manager, lead MA, and physician champion and determine a weekly cadence to meet that works for all members.
Week 2	Data analyst from the change project team to analyze data of the prediabetic population in the practice, conduct cost analysis and ROI of the upfront costs associated with technology-mediated DPP vendors (average for cost forecasting purposes), and determine cost/benefit relationship.
Week 3	Change project team to discuss data analyst's findings and determine benefits and risks by reviewing cost modeling based on data from EBP of potential ROI and cost/benefit analysis.
Week 4	Change project team to discuss desired outcomes of the project and what they anticipate being considered successful, and as a result determine what metrics/data will be tracked to evaluate the project.
Week 5	Determine project feasibility based on interviews/meetings with several potential technology-mediated DPP vendor consultants that fit the needs of the practice and patient population. Consider whether they accept healthcare insurance, upfront costs, and ease of technology.

Week 6	Change project team to decide on a technology-mediated DPP vendor and include the vendor consultant in future change project team meetings to be involved in the implementation process.
Week 7	Change project team along with vendor consultant to discuss the implementation plan i.e., getting patients enrolled, technology needs, and retention plan.
Week 8	Have the practice manager and physician champion from the change project team roll out the implementation plan to the other PCPs and staff at a practice staff meeting.
Week 9	Enrollment – marketing the technology-mediated DPP by hanging signs and having brochures throughout the practice. RN and lead MA to conduct outreach to recruit prediabetic patients and encourage physicians to discuss with their prediabetic patients and refer them to the program.
Week 10	Gather baseline data of participants including weight, BMI, BP, fasting blood glucose, HbgA1C, and lipid profile to be able to track and evaluate the change project. Create a report in EMR so data is easily pulled throughout the course of the program.
Week 11	Meet with the vendor consultant to plan roll-out to ensure a successful launch of the project (i.e., make sure technology-mediated DPP participants have the necessary software/equipment). Ensure vendor tech support is available should participants have issues.
Week 12	Implement the project – all participants will begin technology-mediated DPP on the same day.


Change Project Team
Analyze prediabetic population
Conduct cost analysis and ROI of the cost associated with technology-mediated DPP vendor
Determine benefits and risks by performing cost modeling
Conduct meetings with potential technology-mediated DPP vendors
Project team to decide on technology-mediated DPP vendor
Meet with vendor consultant to discuss the implementation plan
Physician champion to disseminate the project implementation plan and encourage referrals by the other practice physicians
Recruit patients to participate in technology-mediated DPP
Create a report of baseline data of the participants
Determine outcome indicators to track and evaluate
Meet with the vendor consultant to plan roll-out to ensure a successful launch
All participants will begin technology-mediated DPP on the same day

Data Collection Methods/Planned Evaluation

This benchmark project will track and collect quantitative data including (a) weight, (b) BMI, (c) BP, (d) fasting blood glucose, (e) HbgA1C, and (f) lipid profile. As discussed previously, this will be assessed for each participant before starting the technology-mediated DPP to establish a baseline. Then a report will be created in the practice's EMR to track the above data points when participants come in at three-month intervals for appointments throughout the year-long program. Many technology-mediated DPPs have a companion app for tracking food, exercise, and weight/BMI to enhance the participant experience. The weight and BMI data submitted by participants will also be collected by the vendor and reports will be sent to the practice monthly. This will help determine the success of the change project and adherence to lifestyle interventions by participants.

Research has demonstrated the CDC-recognized DPP participants who lost 5-7% of their body weight, increased physical activity, and made dietary changes achieved a 58% reduction in the incidence of diabetes (Block et al., 2015; CDC, 2022). The anticipated outcomes will be an overall risk reduction of progression to type 2 diabetes by the reduction in the above biomarkers. Since the CDC-recognized DPP demonstrated that even a modest weight loss of 7% of body weight drastically reduced risk, this should be the goal for participants, in conjunction with 150 minutes of exercise per week, and carb counting through food tracking. The benchmark project also reduces cost, as type 2 diabetes is an expensive disease not only for the patient but often for the PCP due to quality measure incentives. The change project team should continue to meet monthly to discuss the trajectory of the program and desired outcomes.

To evaluate whether the program is effective the change project team should review the monthly reports from the vendor of participants' weight and BMI and layer the quarterly data

with it once received updated lab work from each 3-month appointment. Forecast modeling should be completed by the data analyst by predicting projections if patients continue the same trajectory of lifestyle interventions. Upon receiving updated lab work from participants, the data analyst will then create graphs for each data point to illustrate the change in each biomarker for the change project team to review. This will denote if the participants are on their way to losing 7% of their body weight and if there has been a demonstrated reduction in biomarkers and therefore risk.

This benchmark project will also collect qualitative data through qualitative surveys sent via the technology-mediated DPP companion app to assess the effectiveness, usability, and experience of the program (see Appendix B). This will be sent to participants at 3-month intervals and the completion of the program. It will include questions that participants rate their experience on a Likert scale of 1-5 in which 1 is ‘strongly disagree’ and 5 is ‘strongly agree’ rating. The survey will also consist of a comment box where participants can enter comments or suggestions. The results will be sent quarterly and at program completion by the vendor in reports to the practice. The results should be analyzed and illustrated using graphs for each question displaying participants’ mean responses on the 1-5 Likert scale. The data analyst should then display the difference between each survey from quarter 1 to program completion. This data will be used to assess participants’ responses and experience with the technology-mediated DPP and where adjustments need to be made. Participant comments should also be analyzed, and themes identified for review. The anticipated outcome is that the majority of participants report a positive experience and find the technology-mediated DPP easier to engage and participate in compared to traditional in-person DPP classes. It will be essential to analyze both quantitative

data points and qualitative survey results and have the change project team review the evaluation to understand the success of the program overall.

Cost/Benefit Discussion

Due to technology-mediated DPP being new, it is not covered by all healthcare insurance providers yet. The change project team should consider when deciding on a vendor if it is covered by the majority of their patients' insurance providers. As stated previously, the practice will pay the program costs for non-covered patients. A community-based DPP on average costs $500 per participant. The technology-mediated program is estimated to be lower. This amount is less than the average annual medical care expenditure of $2,671 per patient for the first one-to-three-year period following diabetes diagnosis (Smith, 2017). Examples of available programs include Alive-PD, Lark, Omada Health, and Noom, just to name a few, but there are many more. Lark is a program with whom several BlueCross BlueShield affiliated insurances partner. Omada partners with employers and insurance plans and charges self-pay patients $140 per month for the first four months and then $20 per month thereafter, while Noom charges the patient $129 for the 12-month program. Ultimately, the upfront cost of this benchmark project would depend on which technology-mediated vendor the change project team decides to partner with, whether they accept some of the practice's patients' insurance, and how many patients the practice gets to enroll in the program. A conservative estimate would be $250 per patient for a total of 100 patients enrolled, which would be a start-up cost of $25,000. The goal of this project is to avoid requiring patients to pay for the program cost, as the out-of-pocket expense could be a deterrent for patients to participate.

Overall, DPP has shown to have a positive ROI over three years with an estimated 42% compared to no lifestyle interventions (Smith, 2017). Costs per quality-adjusted life-year were

lower when the benefits of lifestyle intervention were analyzed (Glechner, 2018; Uusitupa, 2019). Those that followed a DPP curriculum had a median incremental cost-effectiveness ratio (ICER) of $6,212 per quality-adjusted life-year (QALY), while those that did not follow a DPP curriculum had a median ICER of $13,228/QALY (Zhou et al., 2020). The DPP lasts for 12 months, and the practice would incur costs on an annual basis for participants of the practice. Although there are upfront and annual costs, delaying and/or mitigating these prediabetic patients from converting to type 2 diabetes is a cost-saving to the practice, especially when factoring in the value-based quality measures PCPs are strictly held to for incentive payments. It may seem like a large investment upfront but will eventually have a positive ROI and cost-benefit. It will also have an immense benefit to the patients it serves and their families as delaying or mitigating the progression to type 2 diabetes will add years to their lifespan. And the hope would be that they pass along the healthy lifestyle interventions they learn from participating in this program to their family members and children.

Discussion of Results

This benchmark project anticipates demonstrating that technology-mediated DPP and lifestyle interventions are a successful way of reducing the incidence of type 2 diabetes in a prediabetic population at high risk. Furthermore, the use of technology-mediated DPP is just as effective as traditional in-person DPP but provides large scalability to engage more patients that otherwise may not attend. This benchmark project expects that participants will achieve 7% weight loss and significantly reduce biomarkers and therefore reduce their risk of progressing to type 2 diabetes. Additionally, there is an expectation that participants provide positive and valuable feedback through the qualitative surveys that the practice can use to increase interest in the program in the future. DPP has proven to be an effective ROI for health systems, employers,

and insurance companies and the impact can be long-lasting with participants who complete DPP being one-third less likely to develop type 2 diabetes after ten years (Smith, 2017). Overall, the success of DPP is undeniable, however, today's society functions much more through the use of technology than ever before.

Conclusions/Recommendations

Broadening the reach of DPP through the use of technology not only has the potential for large-scale dissemination but also provides access for communities that diabetes disproportionately impacts. Transitioning DPP to technology-mediated platforms increases the likelihood that the higher-risk populations participate and remain engaged. Technology-mediated DPP is also a significant way to engage patients in rural communities that are at higher risk of developing diabetes due to increased rates of obesity. As the population continues to get younger when diagnosed with prediabetes, it is important to acknowledge the best way to engage them, as traditional in-person DPP may not be a possibility for many of them due to barriers such as work, school, home life responsibilities, and caring for children.

Recommendations are to examine the results from this first group of participants in technology-mediated DPP and determine the feasibility of disseminating it broadly to other PCP practices within the medical group/physician organization. Also, for the practice to continue marketing the technology-mediated DPP and recommending it to patients to sustain the implementation of the program. If the benchmark project cannot be implemented, recommendations would be to educate PCP practices on the efficacy of various vendors of technology-mediated DPP that they could be recommending to prediabetic patients to help drive usage while still decreasing risk. There would be merit in helping providers understand that technology-mediated DPP is a valuable resource for prediabetic patients that have barriers to

attending in-person DPP classes. It has the potential to reduce the practices' diabetic population by preventing the conversion of prediabetics to type 2 diabetics. Overall, technology-mediated DPP can be a game changer for reducing risk in a prediabetic population through the use of technology and will hopefully demonstrate a reduction in conversion and incident rates of type 2 diabetes altogether.

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Appendix A

Evaluation Table

Citation: Author, Date of Publ. & Title	Purpose of Study	Conceptual Framework	Design/ Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Worth to Practice: LOE Strengths/Weaknesses Feasibility Conclusion RECOMMENDATION
(Study #1) Villegas et al., (2022). Prevention of type 2 diabetes through remotely-administered lifestyle programs: A systematic review	To conduct a systematic review to evaluate the efficacy of remotely-administered lifestyle interventions on preventing T2D.	None	A systematic review of randomized trial or cluster trial published in English through June 15, 2021.	8 articles including 7 RCTs and 1 non-randomized trial was included because the trial compared an online DPP to the standardized in-person DPP and non-randomization was not an exclusion criteria.	Weight loss, progression to T2D and, changes in fasting glucose and HbA1C.	Measurement of weight, BMI, lab tests for HbA1C and fasting plasma glucose, and participation was measured by the completion of eight or more sessions.	Summarized evidence from 7 RCTs and 1 non-randomized trial.	These findings suggest that remotely-administered lifestyle interventions for T2D prevention could be a promising participant-friendly alternative to in-person programs, with efficacy for reducing weight and glycemic biomarkers.	1. Level I 2. Cannot conclude with a high degree of certainty whether remote DPPs are equally effective as in-person programs, as there simply is not enough evidence. 3. Though this is a small SR with only 8 articles, it is still useful for evidence in practice by demonstrating a higher participation with remote DPP. Compared to usual care those that attended DPP had significant reductions in weight, HbA1C, and fasting glucose.
(Study #2) Uusitupa et al., (2019). Prevention of	To update the evidence for the European Association for	None.	A systematic review and meta-	7 RCTs comprising 4090 study participants and	Increasing physical activity, reducing weight,	A standardized form was used to	All analyses were conducted using Stata	In seven trials involving 4090 participants lifestyle	1. Level: I 2. Rigorous search and selection strategy that

type 2 diabetes by lifestyle changes: A systematic review and meta-analysis	the Study of Diabetes (EASD) clinical practice guidelines for nutrition therapy.		analysis of randomized controlled trials (RCTs) was conducted through June 21, 2019.	2466 incident type 2 diabetes cases.	and changing dietary habits.	extract data on sample size, participant characteristics, study setting and design, level of monitoring of eating habits, intervention and control arm, macronutrient composition of diets, energy balance, follow-up duration, funding source and outcome data.	16. Data were expressed as risk ratios (RRs) with 95% confidence intervals (CIs) and pooled using the restricted maximum likelihood (REML) random-effects models. the assessment of the overall certainty of the evidence using the GRADE approach.	intervention significantly decreased T2D risk compared to control groups (RR = 0.53 (95% CI: 0.41, 0.67), p < 0.001), with evidence of substantial inter-study heterogeneity (I2 = 63%, p = 0.01).	identified all available randomized controlled trials examining the effect of lifestyle modification on T2D in individuals. 3. I would use it within a body of evidence to support my PICOT question. Because educating patients with prediabetes on the benefits of lifestyle modifications can reduce their risk of later being diagnosed with T2D.
(Study #3) Glechner et al., (2018). Effects of lifestyle changes on adults with prediabetes: A systematic review and meta-analysis	To assess the efficacy, safety, and cost-effectiveness of lifestyle intervention, compared with treatment as usual in people with prediabetes as defined by the American Diabetes Association. For older	None.	Included systematic reviews and meta-analyses, health technology assessments, randomized controlled trials (RCTs), prospective cohort	A total of 58 of these articles, one systematic review (1 article), 22 RCTs (38 articles), three prospective studies (5 articles),and 13 cost-effectiveness studies (14 articles) were relevant for our systematic review.	Efficacy and safety of lifestyle intevention: diabetes incidence, body weight, quality of life, adverse events. Long-term complications associated with type 2 diabetes: cardiovascular events, cardiovascular mortality and	We calculated either the relative risk (RR) of reducing diabetes incidence or the weighted mean difference of changes on body weight.	For each meta-analysis, we conducted a test of heterogeneity and applied the DerSimonian and Laird method. All statistical analyses were conducted using	Pooled results of 16 randomized controlled trials showed that people with prediabetes who received lifestyle intervention had a lower rate of progression to type 2 diabetes after one and	1. Level I 2. The only weakness is that lifestyle intervention varied in mode, frequency, and intensity. There is no “one size fits all” when it comes to implementing lifestyle interventions. 3. I would use this as a keeper study

	studies, we used the 1985 World Health Organization definition.		studies, and cost-effectiveness studies through April 26, 2017.		overall mortality, microvascular events. Cost-effectiveness: cost per life-year gained, costs per quality adjusted life-year, costs per type 2 diabetes case prevented.		Comprehensive Meta-Analysis (CMA),version 2.2.050. Two persons evaluated the quality of the body of evidence for each outcome of interest using an approach proposedby the GRADE working group.	three years of follow-up. The majority of the studies also showed a greater weight loss in lifestyle intervention participants. Costs per quality-adjusted life-year were lower when the benefits of lifestyle intervention were analyzed.	to answer my PICOT question.
(Study #4) Bian et al., (2017). The effect of technology-mediated diabetes prevention interventions on weight: A meta-analysis	Conducted a meta-analysis to evaluate the effect of such technology-mediated interventions on weight loss.	None	Examined studies evaluating interventions that used technology to disseminate diet and exercise lifestyle programs, with the aim to achieve weight loss and improve glycemic control in adult patients with	15 studies met the inclusion criteria and evaluated 18 technology-mediated intervention arms delivered to a total of 2774 participants. Study duration ranged from 12 weeks to 2 years.	The primary outcome was absolute weight change following the intervention. Glycemic changes were also reported, if available.	Weight was either directly reported in the study results, calculated by determining the within-person difference between reported weights before and after the intervention, or obtained from the authors. Glycemic changes as	Weight change outcomes in the core phase of each intervention were assessed using a meta-analysis. Statistical analyses were carried out in STATA 13 and R 3.3.0.	The meta-analysis showed that technology-mediated diabetes prevention interventions resulted in weight loss and lead to significant improvements in glycemia. These results suggest that technology-mediated interventions could be an alternative to in-person diabetes	1. Level I 2. While a few of the studies in this analysis compared different forms of technology, further analysis is required to understand the advantages that each technology contributes to intervention outcome. 3. Although there are limitations of comparison of different forms of technology, this is still a valuable MA in that it demonstrates

			prediabetes. A systematic review was performed on the literature published between January 1, 2002 and August 4, 2016.			measured by changes in oral glucose tolerance test results, fasting blood glucose levels, HbA1C levels, prediabetes prevalence, or incidence of diabetes over the intervention period.		prevention programs.	significant improvements in weight loss and glycemia. The option of using technology-mediated delivery can potentially overcome barriers of access and allow expanded dissemination of such interventions.
(Study #5) Block et al., (2015). Diabetes prevention and weight loss with a fully automated behavioral intervention by email, web, and mobile phone: A randomized controlled trial among persons with prediabetes	The aim was to evaluate the effectiveness of a fully automated algorithm-driven behavioral intervention for diabetes prevention, Alive-PD, delivered via the Web, Internet, mobile phone, and automated phone calls.	None	The trial randomly assigned 339 persons to the Alive-PD intervention (n=163) or a 6-month wait-list usual-care control group (n=176).	The goal for enrollment was 314 persons to achieve a sample size of 268 after 15% estimated attrition at the Palo Alto Medical Foundation (PAMF), a community-based multispecialty group practice in Northern California.	IV1= Intervention group provided Alive-PD with tailored behavioral support for improvements in physical activity, eating habits, and factors such as weight loss, stress, and sleep. IV2=Usual care 6-month wait-list control group. DV=reduction in fasting glucose and HbA1C, weight, BMI, waist circumference, and TG/HDL ratio.	Primary outcome: changes in HbA1c and fasting glucose at 6-month follow-up from baseline. Secondary outcomes: changes in body weight, BMI, waist circumferenc, TG to HDL ratio and metabolic syndrome - defined as 3 or more of 5 components	Intention-to-treat (ITT) analyses of change in HbA1c, fasting glucose, and weight were prespecified. Baseline characteristics were compared by chi-square tests for categorical variables and *t* tests for continuous variables.	In intention-to-treat analyses, Alive-PD participants achieved significantly greater reductions than controls in fasting glucose, HbA1C, and body weight. Reductions in BMI, waist circumference, and TG/HDL were also significantly greater in Alive-PD participants than in the control group. At 6 months,	1. Level II 2. The fully automated nature of the Alive-PD program is both a strength and a limitation. Some people need and respond better to human interaction and support, and effect sizes might be greater if combined with human support. Alive-PD was effective in improving markers of glycemic control and body weight in patients with prediabetes, and is a cost-effective

						(ie, abdominal obesity, elevated BP, elevated TG, low HDL, and dysglycemia) specified by the AHA and the National Heart, Lung, and Blood Institute.	Mean between-group treatment differences in outcomes were evaluated by ITT analysis using linear regression approaches.	the Alive-PD group reduced their Framingham 8-year diabetes risk from 16% to 11%, significantly more than the control group (P<.001).	fully automated technology with the potential of serving large number populations. 3. I would use this to support my PICOT question as Alive-PD did demonstrate positive outcomes on glycemic control and weight, while being cost effective.
(Study #6) Almeida et al., (2020). Preventing diabetes with Digital Health and coaching for translation and scalability (predicts): A type 1 hybrid effectiveness-implementation trial protocol	To describe the methods and design of a type 1 hybrid effectiveness-implementation trial of a digital diabetes prevention program (DPP) using the iPARIHS and RE-AIM frameworks.	iPARIHS and RE-AIM.	PREDICTS employs a single-blind randomized controlled trial (RCT) design. Patients at risk for developing diabetes will be randomly assigned to either an intervention group (digital DPP) or a control group (small group, SG).	Adults at risk for diabetes (BMI ≥25 and 5.7%≤HbA1c≤6.4) will be randomly assigned to either the intervention group (n=241) or the small group (n=241).	IV1 = a digital DPP consisting of small group support, personalized health coaching, digital tracking tools, and weekly behavior change curriculum. IV2 = DPP small group, in-person class. DV= Reduction in A1C, weight loss, costs, and cardiovascular risk factors. To examine the potential for future adoption, implementation, and sustainability of digitally-based programs within typical clinical settings.	Assessment of primary (HbA1c) and secondary (weight loss, costs, cardiovascular risk factors) outcomes will occur at baseline, 4, and 12 months.	To examine the potential for future adoption, implementation, and sustainability of digitally-based programs within typical clinical set tings, a hybrid deductive and inductive qualitative analysis approach will be used for analyses.	This trial of a digital DPP will allow the research team to determine the relationships between reach, effectiveness, implementation, and costs.	1. Level II 2. Results have yet to be determined. 3. I would use this article in my body of evidence as it demonstrates what a difference DPP and lifestyle interventions make.

(Study #7) Katula et al., (2022). Effects of a digital diabetes prevention program: An RCT.	The purpose of this study was to determine the effectiveness of a digital Diabetes Prevention Program (d-DPP) for improving weight, HbA1c, and cardiovascular risk factors among people with prediabetes compared to enhanced standard care plus waitlist control.	None	This was a single-blind RCT among participants at risk of developing type 2 diabetes and included 12 months of follow-up.	A total of 599 volunteer patients with prediabetes were recruited primarily through electronic medical records and primary care practices.	IV1= d-DPP (n=299). IV2 = a single-session small group diabetes-prevention education class (n=300). DV=Reduction in HbA1C and body weight.	The primary outcome was a change in HbA1c from baseline to 12 months. Secondary outcomes included change in weight, the proportion of participants that lost ≥5% of initial weight, improvement in diabetes risk categories, and changes in blood lipids and blood pressure (BP).	Demographics and baseline clinical values are summarized by mean (SD) and frequency (%) and assessed for differences using 2 sample t-tests for continuous variables and Fisher's exact tests for categorical variables.	The d-DPPs produced significantly greater reductions in HbA1C and percentage change in body weight at 12 months. A greater proportion of the d-DPPs group achieved a clinically significant weight loss ≥5% and more participants shifted from prediabetes to normal HbA1c range.	1. Level II 2. Limitations include the intervention is not a comparison to in-person DPP, but purpose was to show effectiveness compared to typical care. 3. I would use this to support my PICOT as it showed significant reductions in A1C and weight.
(Study #8) Zhou et al., (2020). Cost-effectiveness of diabetes prevention interventions targeting high-risk individuals and whole populations:	Conduct a systematic review of studies evaluating the cost-effectiveness (CE) of interventions to prevent type 2 diabetes (T2D) among high-risk	None.	Systematically searched seven electronic databases for studies published in English between 2008 and 2017. We grouped	Review included 39 studies: 28 on interventions targeting high-risk individuals and 11 targeting whole populations.	Cost-effectiveness, cost-utility, and cost-benefit.	We used the median incremental cost-effectiveness ratio (ICER), measured in cost per quality-adjusted life year (QALY) or	We abstracted the following information from each study: publication information ,study objective, prevention approach,	Both lifestyle and metformin interventions in high-risk individuals were cost-effective from a health care system or a societal perspective, with median	1. Level I 2. Weaknesses are that most of the evaluations, especially population based approaches, utilized simulation modeling,which canbeheavily influenced by assumptions.

A systematic review	individuals and whole populations.		lifestyle interventions targeting high-risk individuals by delivery method and personnel type.			cost saved to measure the CE of interventions. We used the $50,000/QALY threshold to determine whether an intervention was cost-effective or not.	comparison, target population, delivery method, provider, analytical time horizon, study method, perspective of the evaluation, and results.	ICERs of $12,510/QALY and $17,089/QALY, respectively, compared with no intervention. Among lifestyle interventions, those that followed a Diabetes Prevention Program (DPP) curriculum had a median ICER of $6,212/QALY, while those that did not follow a DPP curriculum had a median ICER of $13,228/QALY.	1. 3. I would use this article in my body of evidence as it demonstrates how cost-effective DPP and lifestyle interventions are for people at high risk of developing type 2 diabetes.
(Study #9) Griauzde et al. (2019). A mobile phone-based program to promote healthy behaviors among adults with prediabetes who declined participation in free diabetes prevention programs:	This study aims to examine the feasibility and acceptability of a mobile health (mHealth) intervention designed to increase autonomous motivation and healthy behaviors among adults with prediabetes	None	In this 3-arm, mixed-methods pilot randomized controlled trial, tested the feasibility of recruiting DPP nonenrollees into an mHealth interventio	69 participants were randomized to 1 of 3 arms, control group, app-only, or app-plus.	IV1=A group that received information about prediabetes and resources for mHealth tools for monitoring (control group); IV2= same information as the control group and the mobile smartphone app (app-only); IV3= same information as the control group,	Primary outcome measures included rates of intervention uptake, retention, and adherence. The secondary outcome measure was change in autonomous	Compared changes in autonomous motivation among app-only and app-plus participants versus control participants using a difference-in-differences analytic approach.	Retention rates were significantly higher among app-plus participants than participants in the other 2 study arms combined. No significant differences were observed in adherence rates between app-only and app-plus	1. Level II 2. Limitations - aimed to enroll 35 individuals in each study arm, but were unable to meet this recruitment target owing to administrative changes within the health plan and competing research interests within our institution. Recruited individuals from a

Mixed-methods pilot randomized controlled trial	who previously declined participation in free DPPs.		n and the acceptability of the mhealth program—used alone and also in conjunction with Fitbit devices.		as well as the mobile smartphone app and Fitbit devices. DV= autonomous motivation among adults.	motivation (measured using the Treatment Self-Regulation Questionnaire).	Semistructured interviews were recorded, transcribed verbatim, and imported into qualitative analysis software, Dedoose	participants. Among all participants, mean autonomous motivation measures were relatively high at baseline, with no statistically significant within- or between-group differences in follow-up scores.	single regional health plan, and results may not be generalizable to other populations; study participants were highly educated with access to personal smartphones and home wireless internet. 3. Despite this being a small study I would use it to support my PICOT as it demonstrated that the addition of devices such as activity tracker and scale had higher retention rates.

(Study #10) Toro-Ramos et al. (2020). Mobile delivery of the diabetes prevention program in people with prediabetes: Randomized controlled trial	This study aimed to investigate the long-term weight loss and glycemic efficacy of a mobile-delivered DPP compared with a control group receiving usual medical care.	None	Adults with prediabetes were recruited from a Stony Brook Medicine's clinic in Long Island, New York and were randomized to either a mobile-delivered, coach-guided DPP (Noom) or a control group that received regular medical care.	A total of 202 participants were recruited and randomized into the intervention (n=101) or control group (n=99).	IV1=Access to Noom, an interactive coach-to-participant interface, food logging, and automated feedback. IV2=control group that received regular medical care including a paper-based DPP curriculum and no formal intervention. DV=weight loss and glycemic reduction.	Primary outcomes included changes in weight and HbA1c levels at 6 and 12 months, respectively. Exploratory secondary outcomes included program engagement as a predictor of changes in weight and HbA1c levels.	Descriptive statistics were calculated for baseline characteristics, including mean, SD, and 95% CI, to summarize differences from baseline to 6 months and to study the conclusion at 12 months between program intervention and control groups. Intention-to-treat (ITT) analyses was used.	Weight and BMI were lower in the intervention group. The intervention group showed a 0.23% reduction in HbA1c levels; those who completed the intervention showed a 0.28% reduction.	1. Level II 2. Limitations – 23 participants declined to download the program, 53 participants did not engage or complete the program. A larger sample size would have provided a more robust estimate of the effectiveness of HbA1C. 3. I would use this to support my PICOT because it is the first mobile health DPP to gain full recognition from the CDC.
(Study #11) Moin et al. (2018). Results from a trial of an online diabetes prevention program intervention.	A large non-randomized trial supplemented by a comparative analysis of participating individuals from a concurrent trial of two	None	The study design is a non-randomized Veterans Health Administration (VHA) online DPP trial conducted	Obese/overweight Veterans with prediabetes enrolled in online DPP (n = 268) between 2013 and 2014. In-person participants between 2012 and 2014 (n =	IV1=In-person DPP. IV2=Veterans Administration's standard of care weight loss in-person program (MOVE!) IV3=Online DPP. DV=weight change at 6 and 12 months.	Primary outcomes were weight change (kg) at 6 and 12 months because weight loss is a significant predictor of	A multilevel mixed-effects regression model was used with all available changes in baseline weight during 12	158 participants that completed eight or more modules in the online DPP had a mean weight change was −4.7 kg at 6 months and −4.0 kg at 12 months. Online	1. Level III 2. Limitations – Participants were Veterans receiving care in the VHA, may limit generalizability. Trial participants were not randomized.

	parallel in-person programs: in-person DPP and the Veterans Administration's standard of care weight loss program (MOVE!).		between 2013 and 2016. Eligible Veterans with prediabetes self-selected into a 12-month online DPP developed by OmadaHealth.	273 in-person DPP, n = 114 MOVE!) within a separate trial. Recruitment occurred at four geographically diverse VA sites.		diabetes risk reduction. Weight change was assessed using cellular-enabled scales or EMRs for individuals who did not have scales.	months of follow-up as the dependent variable.	and in-person DPP participants lost significantly more weight than MOVE! participants at 6 and 12 months; there was no significant difference in weight change between online and in-person DPP.	3. Despite limitations I would include this to support my PICOT because it is one of the few studies that compared technology mediated DPP to in-person DPP.
(Study #12) Birse et al., (2020). Impact of a digital diabetes prevention program on risk factors for chronic disease in a workforce cohort	Evaluate the effect of a digital DPP on chronic disease risk factors in a workplace population.	None	This was a retrospective evaluation of digital DPP (dDPP) intervention using a matched control design. Individuals were not compensated for participation in the study, but the cost of intervention was covered by the employer.	The study included employees and spouses who had participated in an annual health assessment program in 2015, 2016, and 2017. In the 2016 assessment, they had a BMI > 24 kg/m2, and glucose > 100 mg/dL or HbA1c > 5.7%. A dDPP was offered to approximately 15% of the eligible workforce population in 2017.	IV1 = dDPP intervention group (n=84) who had completed at least one lesson in a 2017 dDPP pilot study. IV2 = The control group (n=254) was drawn from individuals who participated in dDPP in 2018, but were not offered and did not participate in the dDPP program in 2017. DV= Reduction of risk factors for chronic disease such as body weight, BMI, fasting glucose, triglycerides, total	Measured in an annual health assessment program.	The Amelia II software allows for imputation of missing data within individuals across time. The algorithm assumes a multivariate normal model for the complete set of observed and unobserved data.	In the dDPP group, body weight, BMI, fasting glucose, triglycerides, total cholesterol and LDL-cholesterol decreased in the post-dDPP period compared with the pre-dDPP period ($P<0.05$). In the control group, no difference between the annual change before and after dDPP was observed ($P>0.37$).	1. Level IV 2. Weaknesses are that the number of people in the intervention group was small at 84. 3. I would use this article in my body of evidence as it demonstrates what a difference DPP and lifestyle interventions make.

					cholesterol, and LDL-cholesterol.				

Legend: AHA=American Heart Association; BMI=body mass index; BP=blood pressure; CF=Conceptual Framework; DPP=Diabetes Prevention Program; DV=dependent variables; HbA1C=hemoglobin A1C; HDL=high-density lipoprotein; IV=independent variables; kg=kilograms; MA=meta-analysis; RCT=randomized controlled trial; TG=triglyceride; T2D=type 2 diabetes

Appendix B

Evaluation Tool

Please rate your experience on a 1-5 scale as shown below:

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	**2**	**3**	**4**	**5**

Questions	Participant's Responses				
Usability					
1) The companion app made the program easier to participate in compared to attending in-person classes	1	2	3	4	5
2) The app content in the lessons was easy to follow	1	2	3	4	5
3) The food tracker was intuitive and easy to add food to	1	2	3	4	5
4) It was easy to enter weight and track weight loss in the app	1	2	3	4	5
5) The overall usability of the app was easy to use and navigate	1	2	3	4	5
Effectiveness					
1) The content in the lessons is easy to understand and apply to your lifestyle	1	2	3	4	5
2) You are now engaging in physical activity regularly	1	2	3	4	5
3) You are now carb-counting and making healthy food choices	1	2	3	4	5
4) The lessons taught you new concepts that you did not know prior	1	2	3	4	5
5) The lessons were effective in motivating you to modify your lifestyle	1	2	3	4	5
Experience					
1) Overall, have you or are having a positive experience using the technology-mediated Diabetes Prevention Program	1	2	3	4	5
2) From what you have learned in the lessons, will you continue implementing interventions into your lifestyle	1	2	3	4	5
3) You have or are finding this process helpful in understanding what lifestyle modifications you need to make	1	2	3	4	5
4) You have a better understanding of prediabetes and how to prevent progression to type 2 diabetes	1	2	3	4	5
5) You plan on adhering to the lifestyle interventions long term to prevent the progression to diabetes	1	2	3	4	5
Total Score:					