Study Protocol

Official Title: Integrating Behavioral Economics and Self-Determination Theory to Advance Patient Engagement in Diabetes Prevention

Brief Title: Behavioral Economics and Self-Determination Theory to Change Diabetes Risk (BEST Change)

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Objective

We seek to generate new scientific knowledge that will significantly advance understanding of how to engage at-risk patients in evidence-based strategies to prevent Type 2 Diabetes Mellitus (T2DM). Specifically, our project will yield new insights into how principles from behavioral economics and Self-Determination Theory (SDT) can be translated alone and in combination to advance patient engagement in T2DM prevention. Through our analyses, we will identify important mechanisms of the effects of each intervention approach as well as variation in effects across subgroups. These analyses will inform efforts to sustain and refine the intervention as well as speed its implementation in other practice settings.

Specific Aims

Aim 1: Compare the effectiveness of financial incentives plus tailored messages based on SDT principles, financial incentives, and tailored messages based on SDT principles in decreasing hemoglobin A1c, weight, and in increasing participation in a Diabetes Prevention Program (DPP) or use of metformin. We will assess changes in the primary

outcome of hemoglobin A1c and in secondary outcome of weight at six and 12 months. We will use health insurance claims data to measure the secondary outcome of participation in a DPP or use of metformin.

Aim 2: Identify mediators and moderators of the effectiveness of financial incentives plus tailored messages based on SDT principles, financial incentives, and tailored messages based on SDT principles. To measure these, we will survey participants at baseline, 6, and 12 months.

Aim 3: Evaluate facilitators of and barriers to scalability, acceptability, and sustainability of financial incentives plus tailored messages based on SDT principles, financial incentives, and tailored messages based on SDT principles. To identify facilitators of and barriers to intervention implementation and sustainability, we will interview participants, workplace health promotion staff, and health system staff. With these interview data and program cost data, we will evaluate program implementation and sustainability using an integration of the Reach, Effectiveness, Adoption, Implementation, and Maintenance and Consolidated Framework for Implementation Research frameworks.

Aim 4: **Compare 12-month changes in HbA1c and weight in the Enhanced Usual Care (EUC) arm to similar patients who received no intervention**. This exploratory aim was added after analyses of primary and secondary outcomes found that participants in the least research-intensive arm, the Enhanced Usual Care (EUC) arm, saw the best improvements in weight and HbA1c. We will conduct an analysis to compare the HbA1c and weight outcomes in the EUC arm to similar patients who received no intervention (external controls). The results will be used to provide context to staff who we interview as part of Aim 3.

Background Information

Significance

Prediabetes Is a Major Public Health Problem in the United States. Prediabetes is an asymptomatic condition in which patients' blood glucose levels are higher than normal but not high enough to meet diagnostic criteria for type 2 diabetes mellitus (T2DM). The American Diabetes Association (ADA) defines prediabetes as either a fasting plasma glucose (FPG) of 100 to 125 mg/dL, a 2-hour plasma glucose of 149 to 199 mg/dL after a 75-gram oral glucose tolerance test, or a hemoglobin A1c (HbA1c) of 5.7% to 6.4%. An estimated 84 million US adults have prediabetes, which is associated with an approximately 3-fold greater annual incidence of T2DM and an approximately 50% greater risk of consequent cardiovascular disease.

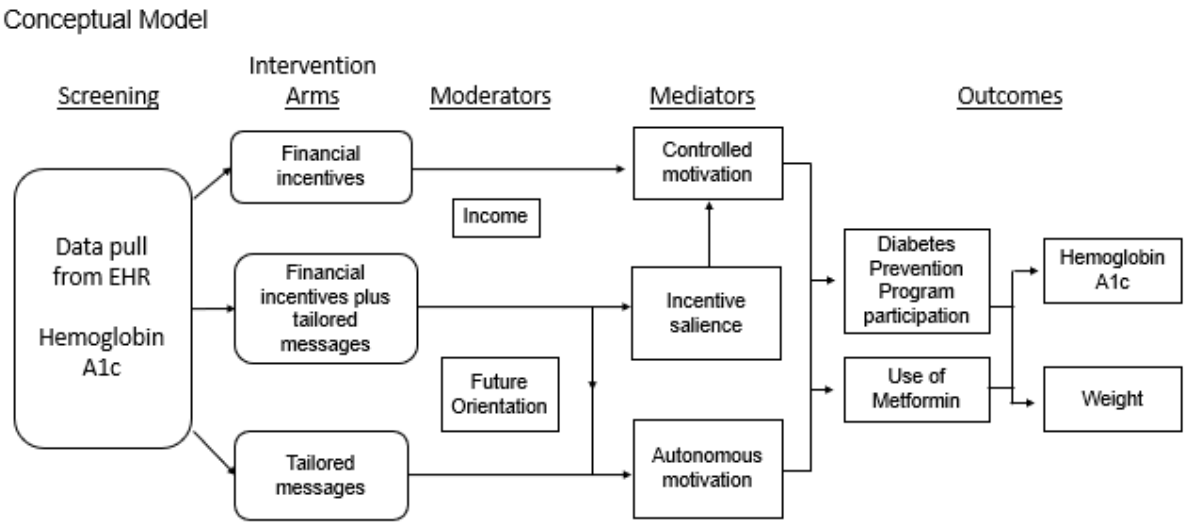
Patients with Prediabetes Can Significantly Reduce Their Risk for T2DM. The landmark Diabetes Prevention Program (DPP) trial demonstrated that a lifestyle modification program with the goals of at least 7% weight loss and at least 150 minutes of physical activity per week led to a 58% reduction in the 3-year incidence of T2DM. This was significantly greater than the 31% reduction in the incidence of T2DM that was observed among patients who received metformin 850 mg by mouth twice daily. Progression to T2DM with metformin, however, was still significantly less than the rate of progression in the control group. Due to the long-term effectiveness and cost-effectiveness of these interventions, the National DPP (NDPP), led by the Centers for Disease Control and Prevention (CDC), has disseminated the DPP across the United States. The DPP is now also covered by Medicare and a growing number of private

insurers. Metformin is safe, widely available and, for insured patients, carries low cost-sharing relative to other prescription drugs.

Strategies to Prevent T2DM Are Widely Available but Few Patients with Prediabetes Engage in Them. Despite their widespread availability and affordability, very few patients with prediabetes participate in a DPP or use metformin. In the first four years of the NDPP, just 35,844 of the estimated 84 million US adults with prediabetes participated in one of the 435 CDC-recognized DPPs. Among individuals who participated in these DPPs, only 43% completed the 16 core sessions (compared to 95% in the original DPP trial), resulting in 4.2% mean weight loss among participants after one year (compared to 7.2% in the original DPP trial). Fewer than 1% of US adults with prediabetes are using metformin, despite its availability, safety, and low cost. At our own institution, the University of Michigan (U-M), Premier Care, the health insurance plan chosen by nearly three in four U-M employees who take up U-M insurance, covers DPPs at no cost to plan members with prediabetes and offers metformin as a Tier one (i.e., lowest co-pay) medication. Despite little to no cost-sharing for these evidence-based strategies to prevent T2DM, in the last year just 8% of U-M employees with prediabetes and Premier Care participated in a DPP, and only 8% took metformin. These major gaps illustrate the critical need for effective, scalable, and sustainable approaches to increase engagement of patients with prediabetes in evidence-based strategies to prevent or delay their progression to T2DM.

Tailoring Incentives to Roles, Values, and Strengths Could Engage Many More Patients in Strategies to Prevent T2DM. One way to achieve greater integrated regulation and thus autonomous motivation to prevent T2DM would be to first elicit from individuals their roles, values, and strengths and then use interactive messaging to connect (1) a financial incentive for engaging in strategies to prevent T2DM and (2) preventing T2DM to their roles, values, and strengths. Tailoring financial incentives in this way could make incentives more salient by helping individuals to see them as serving value-concordant purposes while also turning them into a vehicle to promote autonomous motivation. For example, in an automated message an individual who is a spouse, values spirituality, and feels competent at helping others could first be asked how an incentive to prevent T2DM could support these roles, values, and strengths. The individual might reply that, *"I could buy a gift for my spouse, purchase a new worship book, or donate the money to a local shelter."* This first type of framing adds "meaning to money" to intensify the motivational potential of financial incentives while they are being offered. The automated message could then ask how preventing T2DM could support their roles, values, and strengths. In response to this question, the individual might answer, *"Preventing diabetes could help me live longer with my spouse, would support the self-control that is a key part of my faith, and would help me be better able to volunteer in my community."* This second type of framing aims to support autonomous motivation to prevent T2DM that will persist after incentives are removed. As illustrated in our Conceptual Model, we hypothesize that using automated messaging to (1) increase the salience of financial incentives and (2) build autonomous motivation to prevent T2DM will increase participation in DPPs and use of metformin. These in turn will drive improvements in HbA1c and weight.

Conceptual Model



Approach

Overview. To test our novel strategy of linking financial incentives and preventing T2DM to people's roles, values, and strengths, our team of experts in T2DM prevention, behavioral economics, and SDT will conduct a 4-arm pragmatic RCT among patients of Michigan Medicine (the U-M health system) who have prediabetes and U-M Premier Care health insurance. Our study will utilize the Way to Health (W2H) web platform of the University of Pennsylvania (Penn). This platform was developed with support from NIH and permits automated delivery and efficient evaluation of behavioral interventions that leverage insights from behavioral economics. We will compare the effects of 12 months of (a) financial incentives plus tailored messages based on SDT principles, (b) financial incentives alone, (c) tailored messages based on SDT principles alone, and (d) an enhanced control group on the primary outcome of change in HbA1c. These four arms will enable evaluations of the effects of adding tailored messages to financial incentives (i.e., financial incentives plus tailored messages vs. financial incentives alone), adding financial incentives to tailored messages (i.e., financial incentives plus tailored messages vs. tailored messages alone), and adding both tailored messages and financial incentives to automated feedback (i.e., financial incentives plus tailored messages vs. enhanced control). To measure the primary outcome of change in HbA1c, and secondary outcome of change in weight, we will conduct assessments at baseline, 6, and 12 months. To measure the secondary outcome of participation in a DPP or use of metformin we will use health insurance claims data. We will measure mediators and moderators of intervention effectiveness by surveying participants at baseline, 6, and 12 months. To identify facilitators of and barriers to intervention implementation and sustainability, after the 12-month intervention we will interview participants, workplace health promotion staff, and PCPs. We will then conduct a comprehensive evaluation of program implementation and sustainability using the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) and Consolidated Framework for Implementation Research (CFIR) frameworks.

Lessons from Our Prior RCTs of Financial Incentives for Healthy Behaviors. Our approach builds directly on our team's deep and complementary expertise in each of the disciplines and methodologies integral to testing a novel, scalable, and sustainable intervention that uses

financial incentives and tailored messages to increase patient engagement in strategies to prevent T2DM. Dr. Kullgren trained as a Robert Wood Johnson Foundation Clinical Scholar at Penn and the Penn Leonard Davis Institute for Health Economics Center for Health Incentives and Behavioral Economics (LDI CHIBE). While there, he developed behavioral economic interventions that he tested in four separate RCTs. In two trials, Drs. Kullgren and Volpp tested different designs of financial incentives to promote weight loss among obese employees. In a third trial, Drs. Kullgren, Volpp, and Heisler tested whether financial incentives and peer connections could encourage older adults to walk more. The fourth study was a pragmatic health system trial in which Dr. Kullgren found that financial incentives integrated into usual care can increase patient completion of colorectal cancer screening. As Director of the LDI CHIBE, Dr. Volpp is an international authority on the use of financial incentives to encourage healthy behaviors. He has conducted numerous RCTs of financial incentives to encourage healthy behaviors such as weight loss, physical activity, and medication adherence.

While our research has demonstrated the potential for financial incentives to promote short-term behavior change, it has also highlighted important challenges that limit the impact of incentives on population health. First, the initial behavior change promoted by financial incentives is often modest. For example, in our two previous RCTs of financial incentives for weight loss, four of the five incentive designs we tested yielded less than 2.5% weight loss after six months. Low levels of initial weight loss have also been found in other incentive studies. Second, the initial behavior change achieved by incentives is often poorly sustained. For example, the most effective incentive design in our RCTs of financial incentives for weight loss led to 4.9% mean weight loss after six months. Just three months after incentives ended, mean weight loss in this arm fell to 3.5%. These findings illustrate the critical need to make the financial incentives that are popular among employers more effective at promoting both initial and sustained engagement in healthy behaviors.

Insights from Our Prior RCTs of Interventions Leveraging Insights from SDT. Dr. Resnicow is an internationally recognized expert in the design and evaluation of health promotion interventions and motivational interviewing who specializes in developing and testing tailored interventions based on SDT. He has developed and evaluated tailored interventions for nutrition, physical activity, and weight loss in multiple populations. Dr. Heisler also has extensive experience with designing, evaluating, and implementing interventions testing novel SDT-based strategies to improve patients' healthy behaviors and health-related decisions. Her studies have used quantitative and qualitative methods to show the positive effects of greater patient engagement in health decisions; and of patient self-efficacy and autonomous motivation. She brings significant expertise in evaluation of the effectiveness and implementation of innovative programs.

Knowledge from T2DM Prevention Studies. Dr. Kullgren has a VA Health Services Research & Development (HSR&D) Career Development Award (CDA 13-267) to identify novel ways to increase engagement of at-risk patients in strategies to prevent T2DM. In a recent mixed-methods study, he and Dr. Heisler found that U-M employees diagnosed with prediabetes in a workplace screening were more likely to subsequently engage in strategies to prevent T2DM if they had higher levels of autonomous and controlled motivation to prevent T2DM, and if they had also received external supports. He has used quantitative and qualitative methods to identify patient and provider factors that influence decision-making about T2DM prevention, and literature reviews to identify opportunities for behavioral economic and workplace interventions to prevent T2DM. Dr. Heisler has collaborated with Dr. Kullgren on many studies and is a Principal Investigator of an R18-funded study (5R18DK113403-02) testing a peer support intervention to prevent T2DM. Dr. Herman directs the Michigan Center for Diabetes Translational Research (5P30DK092926-08) and is an investigator for the Diabetes Prevention Program Outcomes Study (DPPOS). He has examined strategies to screen for T2DM and costs

of T2DM prevention and care. He is PI for an R01-funded evaluation (5R01DK109995-03) of U-M Premier Care coverage of DPPs that is using Blue Care Network (BCN) claims data to measure participation in a DPP and use of metformin.

Preliminary Studies. Dr. Kullgren recently led two conceptual studies outlining how applying concepts from SDT could make financial incentives more effective in promoting sustained behavior change. Our team translated the most promising of these applications into an intervention we pilot tested among obese U-M employees in partnership with MHealthy, U-M's workplace health promotion program. We first developed a novel system for linking financial incentives and weight loss to employees' three main aspirations in life as measured by the Aspiration Index (AI). After developing and refining our approach, we conducted a 12-week pilot RCT to test the acceptability to participants, feasibility to deliver, and preliminary effects of a low-dose version of our novel Financial Incentives Plus Tailored Messages intervention among 62 obese U-M employees. With only a 0.5 full-time equivalent Research Coordinator we used electronic newsletter and social media to recruit ten participants per week, while turning away over 100 interested employees once recruitment closed. All 62 participants were given a goal to lose 12 pounds over 12 weeks and measured their weight each week on a Withings Body Composition Wi-Fi Scale. The 31 participants in the Financial Incentives Plus Tailored Messages Arm were informed they would have a one in two chance of receiving $10 and a one in five chance of receiving $100 each week they were below their weekly target weight. They were then informed of the three main aspirations in life we identified from their responses to the AI items in their baseline survey and invited to complete two online writing prompts. In the first prompt, participants typed into a text box how they could use the incentive to help them achieve these aspirations or something else important to them. This component aimed to make the incentive more salient by helping individuals consider using incentives for value-concordant purposes. In the second prompt, participants typed into a text box how losing weight could help them achieve these aspirations or something else important to them. This component aimed to help individuals perceive weight loss as being concordant with their aspirations to promote autonomous motivation for weight loss. All 31 participants completed both writing prompts, and their response to the prompts was communicated back to them by email for 12 weeks.

Our pilot study's primary outcome was change in autonomous motivation for weight loss as measured from six to 42 by the Treatment Self-Regulation Questionnaire (TSRQ). While high baseline levels of autonomous motivation (mean 37.6 with 18 participants scoring 42) limited our ability to detect intervention effects on autonomous motivation, the eight intervention participants with a baseline autonomous motivation score less than 35 had a mean 4.4 point increase (95% CI, -1.4 to 10.1) in autonomous motivation after 12 weeks. The 31 intervention participants lost an average of 3.6 pounds (95% CI, -5.6 to -1.4), and using 0 to ten scales reported high median ratings for intervention acceptability (8), satisfaction (8), and willingness to repeat (10). Participants completed 95% of the week 12 weight measurements and 98% of the week 12 and 24 surveys. In 20 post-intervention interviews, 80% of participants said they would participate in a similar study for up to 24 months. These findings demonstrate the approach's high acceptability, the feasibility of our recruitment and tracking mechanisms, and preliminary efficacy of the Financial Incentives Plus Tailored Messages intervention.

Methodology

Inclusion and Exclusion Criteria

Inclusion Criteria	Source
Primary Care Provider part of Michigan Medicine	

BMI of 25 or higher (23 or higher if of Asian descent) Age 18 or older	Custom Pull from MM medical records, Data Office for Clinical and Translational Research (DOCT-R), UM School of Medicine and confirmed in screener questionnaire
Primary health insurance is U-M Premier Care, Community Blue PPO by BCBSM, or Comprehensive Major Medical by BCBSM	Custom Pull from MM medical records, DOCT-R and asked if primary screener questionnaire
Recent Hgb A1c 5.7 – 6.4% (inclusive)	Custom Pull from MM medical records, DOCT-R and confirmed during screening process via blood test at MLab
Exclusion Criteria	**Source**
Expects to change health insurance plan in the next three months to something other than the three listed above	Online screener questionnaire in Way to Health (W2H) or screened over the phone by study staff; entered into Qualtrics
Is enrolled in Medicare or plans to enroll in Medicare in the next 12 months	Online screener questionnaire in Way to Health (W2H) or screened over the phone by study staff; entered into Qualtrics
Participated in pretesting of intervention materials	List of 10-30 pretesters kept by study staff
Ever diagnosed with T2DM as indicated by the following ICD codes: • E08 Diabetes mellitus due to underlying condition • E09 Drug or chemical induced diabetes mellitus • E10 Type 1 diabetes mellitus • E11 Type 2 diabetes mellitus • E13 Other specified diabetes mellitus • 250 Diabetes mellitus (ICD-9)	Custom Pull from MM medical records, DOCT-R and confirmed in screener questionnaire
Serious mental health conditions as indicated by the following ICD-10 codes: F20 Schizophrenia F21 Schizotypal disorder F22 Delusional disorders F24 Shared psychotic disorder F25 Schizoaffective disorders F28 Other psychotic disorder not due to a substance or known physiological condition F29 Unspecified psychosis not due to a substance or known physiological condition F31 Bipolar disorder F33.2 Major depressive disorder, recurrent severe without psychotic features	Custom Pull from MM medical records, DOCT-R

F33.3 Major depressive disorder, recurrent, severe with psychotic symptoms	
End-stage renal disease is indicated by the following ICD codes: N18.6 End stage renal disease Z99.2 Dependence on renal dialysis ICD-9-CM 585.6 End stage renal disease ICD-9-CM V45.11 Renal dialysis status	Custom Pull from MM medical records, DOCT-R
Alcohol dependence (ICD-10: F10.2) and opioid dependence (ICD-10: F11.2)	Custom Pull from MM medical records, DOCT-R
Unable to send and receive several text messages weekly	Online screener questionnaire in Way to Health (W2H) or screened over the phone by study staff; entered into Qualtrics
Does not have a smart phone	
Currently taking metformin	
Unable to take metformin due to contraindications or side effects	
Participated in a Diabetes Prevention Program covered by UM Premier Care insurance	
Currently enrolled in an interventional research study that is examining how a diet, program, or drug might: promote physical exercise, healthy eating habits, or weight loss; lower blood pressure; or lower blood sugar	
Not planning to live in local area over the next year	
Pregnant or planning a pregnancy in the next year	
Received treatment for an eating disorder (e.g. anorexia or bulimia), not including binge-eating disorder, in last 12 months	
Intensive cancer treatment such as bone marrow transplant, chemotherapy, radiation, or cancer related surgery (not including hormonal chemotherapy like Tamoxifen) in last six months or near future	
Organ transplant in last six months	
Bariatric/ gastric bypass surgery, gastric sleeve surgery, or gastric balloon procedure in last six months	

Stroke, heart attack, heart surgery, or hospitalization for congestive heart failure in the past three months	
Other serious health issues or personal concerns that could prevent participant from completing study	

Patients of Michigan Medicine with U-M Premier Care health insurance (either because they are U-M employees or dependents of U-M employees) will be eligible to participate. The U-M has nearly 50,000 diverse employees (25% minority and 60% female) across three campuses. Nearly 75% of U-M employees with U-M health insurance choose Premier Care for their coverage.

Premier Care currently covers the online DPP offered by the company Omada at no cost to plan members with prediabetes. Premier Care also covers metformin as a Tier one (i.e., lowest co-pay) medication.

Recruitment

We will recruit 380 adults meeting the criteria in Table 1. Because the criterion of a certain A1c value range is verified after a participant is consented, we may need to enroll up to 500, with up to 120 being screen failures due to their baseline A1c value being outside of the prediabetes range. We will closely monitor recruitment and adjust our approaches if needed (with IRB amendment approval) to ensure we successfully reach our recruitment targets.

We conservatively estimate that at least 10,000 of the ~33,000 Michigan Medicine patients with U-M Premier Care insurance will meet these criteria. Patients will need to have one of the three insurance plans listed in Table 1 above to ensure coverage of the DPP and low cost-sharing for metformin. Exclusion criteria will include conditions that would make participation in a program to prevent T2DM unfeasible (e.g., inability to consent or illiteracy), inapplicable (e.g., prior diagnosis of T2DM, does not meet an eligibility requirement of the online DPP) or potentially unsafe (e.g., alcohol or opioid dependence, serious psychiatric diagnoses, intensive cancer treatment).

Data pull and outreach. We will use queries of the Michigan Medicine electronic health record (EHR) to identify patients who meet the inclusion a subset of the criteria in Table 1. The A1c must have been completed at least 30 days ago and less than 12 months ago and have a value from 5.7% to 6.4%, inclusive, or not have had an A1c test in the last year. The list of patients will be reviewed to remove any patients who are not eligible because they participated in the pretesting of study intervention materials (10-30 patients). The remaining patients will be mailed (and/or emailed, when email is listed in health record) a two-sided 5x8 card, in a brightly colored envelope, that describes the study. To protect privacy, the envelope will have the University of Michigan Medical School name, return address, and the block “M,” and in the bottom left corner, the text, “Chance to participate in a research study that could benefit you and your health!” On the recruitment card and email, recipients are given the chance to “opt-out” of any further communications about the study by emailing or calling the provided contact information. The email message will contain similar text and photographs as the mailed card, but exact layout will be modified to fit the communication mode.

Website on Qualtrics. The postcard and email direct them to a website hosted in Qualtrics that first asks if they received a mailed card or email about the study that was addressed to them. We ask this question because we anticipate some interested potential participants going to the website after hearing about the study from family and friends who we contact directly.

If they respond that they *did* receive a postcard or email addressed to them, they are taken to pages with more information about the study, contact information for study staff so potential participants can ask questions, and a question about their interest that, if answered affirmatively, takes them to the W2H) platform so that they can begin the screening process.

1. If they respond that they *did not* receive a postcard or email that was addressed to them, they will be informed that the study is currently screening and enrolling only those identified that met key study criteria. It will also provide resources for those that are concerned they may have prediabetes and urge them to discuss their concerns with their provider. Study contact information will be provided to allow these individuals to ask any questions they may have.

At least 7 days after the cards and at least 3 days after emails have been sent, a follow-up call will be made to encourage potential participants with a recent A1c in the prediabetes range to consider enrolling in the study. The study team member will follow a script (attached in the IRB section on recruitment) that describes the study. During the call, the study team member will answer any questions the person may have and then offer to ask the screening questions to determine initial eligibility. If the person agrees, the study team member will use a Qualtrics survey to ask and record the screening questions and responses, respectively. Only the studyID will be entered into the Qualtrics survey. If eligible, the study team member will create an account in W2H for the participant and send the participant an email with instructions so that the participant can reset their login password, log into W2H, and continue with the next enrollment step, which is reading the informed consent. No more than three unresponsive call attempts will be made per person, and potential participants will not be mailed or emailed, unsolicited, more than three times (any combination of cards/emails).

W2H web platform. For those who self-enroll by first going to the informational website, potential participants who finish reading the informational website are then taken to the W2H platform and asked to create a unique password-protected online account in W2H and verify their account by entering a code automatically sent to them via text. The W2H platform is a secure, scalable vehicle for conducting RCTs of behavioral interventions that automates enrollment, email and text messaging, delivery of financial incentives, and online survey administration. Drs. Kullgren and Volpp have successfully used the platform in many previous trials. The platform has extensive security measures that are described in detail at the end of this document.

Screening among those who self-enroll. Once an account is created, potential participants are asked screening questions to determine the criteria detailed in Table 1. Screener questions were uploaded to Section 8-1.8 of the IRB application. Responses to certain questions may trigger a staff alert so that the staff can contact the person to assess eligibility, and potential participants who trigger staff alerts are made aware of this. If no staff alert is triggered, the potential participant in informed of their eligibility at the end of the screener, and contact information for study staff is shared in case the person has any questions. Before the screener questions are presented, text in W2H will inform potential participants that if they are deemed ineligible to join the study, their answers to the screening questions will be deleted, that the study will keep a record of reasons people are ineligible but the reason will not be connected to any individual, and that the study will keep a record indicating that who was found to be ineligible so that those individuals are not contacted again. If, after answering the screener questions, the person is deemed ineligible, they will be informed, and the same message about

their data will be included. The final eligibility criterion, recent A1c in the prediabetes range, is assessed after consent is obtained.

Enrollment

Consent. If determined to be preliminarily eligible from the screening questions, the potential participant is then asked to read and sign the consent form electronically, in the W2H platform. Participants will be encouraged at the start of the consent to call or email study staff if they have any questions or concerns. W2H will take them through an automated online informed consent. The consent document will be divided into sections and potential participants will have to click a button to advance through each section. This is to help ensure that participants read the consent form thoroughly by breaking down the form into manageable blocks of text. At five points in the consent document, the potential participant will be asked a question to assess the participant's understanding and to drive home key points in the consent. If answered correctly, the participant will be affirmed of their correct response; if answered incorrectly, participant needs to try again until the correct answer is selected. On the final consent screen, potential participants will choose to click one of two options: one stating that they agree to participate in the study, and the other that they do not wish to participate. The participant who agrees to participate is then to sign in a box using their mouse. In the back end of W2H, a time and date stamp indicates when the signature was submitted. The participant will have the opportunity to download the consent for their records after signing the consent and at any time they are enrolled in the study. Participants will be provided with details regarding how to contact the research team via email or phone at any time if they subsequently wish to withdraw from the study. This contact information will remain easily accessible via the participants' individual W2H dashboard throughout the study.

Final screening: A1c test. Once the consent form is signed, staff will receive a prompt to place an order in the patient's Michigan Medicine MiChart record for an A1c test. Once staff place the order, they indicate this in W2H, and an email and text are automatically sent to the participant asking them to visit any MLab to give a blood sample for the A1c test, to confirm eligibility. A link to a directory of all MLabs is included in the message. To be fully eligible for the study, patients must have an HbA1c of 5.7% to 6.4%, inclusive.

When the test result is available in MiChart, the result will appear in a custom list that staff can see in MiChart. Staff will enter the result value into W2H, and this will trigger an email and text to the potential participant that indicates if the value is in the eligible range for the study, too high, or too low.

- For those whose A1c is in the normal range, the message indicates this, provides resources to help them maintain a normal A1c, and lets the patient know that they are not eligible for the study.
- If the value is above the prediabetes range, the patient is informed via message that the value is such, is provided resources, is encouraged to check with their provider to confirm, is informed that the result will be noted in their record for their provider to see, and is informed that they are not eligible to enroll in the study.
- Those with an A1c in the prediabetes range are told they are fully eligible and are prompted to return to W2H to complete next enrollment steps.

Collection of SSN and prescription drug member ID. Next, participants are asked to:

- confirm their name and address
- enter their social security number in W2H for tax reporting purposes related to incentives

- provide their prescription drug coverage member ID number. A link will connect to a Qualtrics page that provides helpful information for those who cannot find their prescription drug coverage member ID number.

Baseline Assessments

Baseline survey. Once eligibility is fully confirmed via A1c test, participants will be asked to complete a baseline survey within the W2H platform. The survey will take, on average, less than 20 minutes for participants to complete.

Body weight scales. Next, participants are informed that a digital body weight scale will shipped to their home.
Body weight scales will be shipped from the vendor on a rolling basis.

The A1c test that was used as a final screening for eligibility will also be used as the baseline A1c measure.

For more information on the Baseline assessments, see the *Measures* section of this protocol.

Incentive. Once study staff receive the baseline body weight of the participant, staff will trigger W2H to send the participant a text letting them know their ClinCard, loaded with $50, will be mailed to them, and soon they will be notified that they have been randomized into one of four programs.

Randomization

We will then, in an equal ratio, randomly allocate participants to an: (1) Enhanced Control Arm, (2) Financial Incentives Arm, (3) Tailored Messages Arm, or (4) Combo Arm.

Prior to start of recruitment, the W2H platform will be programmed to randomize with variable block lengths (block lengths: n=1, n=2) and stratification by participants' household income and autonomous motivation to prevent diabetes. Data on household income and autonomous motivation to prevent diabetes will be collected from the baseline survey. For household income, three levels of stratification will be used to ensure a balance of lower-income households among the arms: below $45,000, $45,000 and above, and non-response. Stratification on the sum score for autonomous motivation to prevent diabetes -- derived from the Treatment Self-Regulation Questionnaire administered in the baseline survey -- will use two levels: less than 35 to indicate lower autonomous motivation and 35 or higher to indicate higher autonomous motivation.

The allocation sequence will be generated dynamically by the randomization program so that research staff will not be able to predict future assignments.

Arm assignments will be communicated to participants by an email and text message. Neither participants nor the Research Coordinator will be blinded to arm assignment due to the nature of the interventions. All investigators, data analysts, and the project manager will be blinded to arm assignment until primary outcome data are collected.

Interventions

Enhanced Control Arm [ECA]. Starting on the first day of the intervention, participants will all receive a series of initial educational messages delivered via text message. These messages will welcome participants to the study, set expectations for the following 12 months, and establish a consistent minimum level of knowledge among all participants on the topics of prediabetes, the DPP, and metformin. Participants will receive one of these messages each day for the first two weeks of the intervention.

Following the series of initial educational messages, *Enhanced Control Arm* participants will receive three automated messages by text every week for 11.5 months. These messages will provide evidence-based educational content about prediabetes and tips on prevention based on information from sources including: doihaveprediabetes.org, the CDC, the NIDDK, and academic institutions. Each month, in addition to these three automated messages, participants will receive one automated message reminding them about U-M Premier Care's coverage of the DPP at no cost and coverage of metformin as a Tier one medication, as well as one message providing feedback on their participation in the DPP and use of metformin in the previous calendar month.

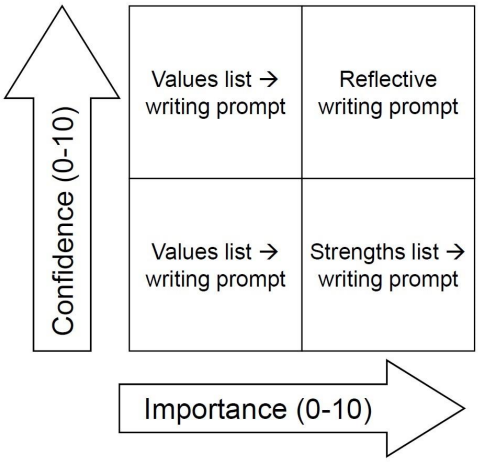
Financial Incentives Arm [financial]. In addition to the series of initial education messages followed by three automated educational messages per week, monthly personal feedback on participation in the DPP and use of metformin, and the monthly reminder of U-M Premier Care's coverage for the DPP and metformin described above, participants in the *Financial Incentives Arm* will have an opportunity to earn a financial incentive for 11 of the 12 intervention months in which they (a) participate in the DPP or (b) use metformin with a high rate of adherence. The incentive will range from $50 to $250 based on a design we have previously used to maximize the efficacy of monthly financial incentives. In this design, at the start of the intervention period, five sequential participants randomized to this *Financial Incentives Arm* will be joined together into a virtual group in the W2H platform. Participants will not receive any information about the other four participants in their virtual group. Each month, these participants will be informed by text that $50 has been set aside for them into a study account. At the end of the month, all participants in the virtual group who (a) participated in the DPP or (b) used metformin with a high rate of adherence will share in the $250 that had been set aside for the group ($50 per participant x five participants). If all five individuals in a virtual group participated in a DPP or used metformin, each individual will receive $50. If only one individual participated in a DPP or used metformin, that individual will receive $250. We define participation in the DPP as completing all of the following actions within a given calendar month: 1) completing four weekly lessons, 2) submitting at least four body weight measurements, 3) tracking meals on at least four days, and 4) logging physical activity on at least four days. This standard threshold will apply to the entire year-long DPP curriculum. We will define adherence to metformin based on a participant's proportion of days covered (PDC) for metformin for that month (i.e., the proportion of days in that month that metformin was supplied to the total number of days in that month), and consider high adherence to be a metformin PDC of at least 0.8. Two weeks into each month, immediately following the monthly message providing feedback on their participation in the DPP and use of metformin in the previous month, participants in this *Financial Incentives Arm* will receive an additional text message informing them whether they earned a financial

incentive, and stating the amount of any financial incentive that was earned. The amount earned is added to the participant's ClinCard a few business days later.

We chose this particular incentive design because of its high potential for effectiveness, sustainability, and spread. First, our group-based design leverages behavioral science insights such as overoptimism, knowledge that others will acquire incentives one fails to earn, competition, loss aversion, and regret that we have previously used to maximize the potency of a monthly incentive. Second, a monthly incentive would be more feasible for employers to implement and sustain than a weekly or daily incentive. Third, in planning this study our MHealthy partners indicated that $600 ($50 per month x 12 months) per participant is at the upper range of what U-M would be able to sustain as an incentive for employees with prediabetes. Fourth, $600 per year is comparable to the size of incentives used in other recent studies and workplaces, below what employers can legally offer as rewards for healthy behaviors, and, based on our studies of incentives of a similar magnitude and other research, unlikely to be coercive.

In addition to these monthly financial incentives that participants can earn in 11 of the 12 intervention months, participants will also have an opportunity to earn a one-time bonus incentive of $50 during the first month of the intervention if they provide confirmation that they have either a) enrolled in the DPP or b) made an appointment with their health care provider to discuss acquiring a prescription for metformin. To earn this bonus incentive, participants must provide confirmation of these actions within two weeks of indicating that they have taken them. The purpose of this bonus incentive is to provide a near-term motivator for participants to begin engaging with evidence-based strategies to help prevent T2DM. As such, this bonus incentive is only available during the first two months of the intervention, and eligibility is determined solely by participants' individual actions rather than being tied to the previously described incentive groups.

Tailored Messages Arm [tailored]. Participants in the *Tailored Messages Arm* will also receive the same series of initial educational messages described in the *Enhanced Control Arm* starting on the first day of the intervention and delivered once per day for the first two weeks. Immediately following the series of initial educational messages, participants in this *Tailored Messages Arm* will receive an additional series of messages via text that are designed to provide supplemental education on the DPP and metformin as well as resources to facilitate enrolling in the DPP or acquiring a metformin prescription, and others to help participants navigate significant barriers preventing them from enrolling in the DPP or acquiring a metformin prescription through their primary care provider. Participants will receive this series of messages until the end of the first month of the intervention or until they have indicated they are either enrolling in the DPP or taking steps to acquire a metformin prescription through their primary care provider.



In addition to the series of initial educational messages and the educational and facilitative messages for enrolling in the DPP or acquiring a metformin prescription outlined above, participants in the *Tailored Messages Arm* will also receive the same monthly personal feedback on participation in a DPP and use of metformin, and the monthly reminder of U-M Premier Care's coverage for the DPP and metformin described for the Enhanced Control Arm. Each week, the *Tailored Messages Arm* participants will also receive three automated educational messages covering the same topics as

the automated messages sent to participants in the *Enhanced Control Arm*, but optimized with language that supports autonomy. Separately, participants in the *Tailored Messages Arm* will also receive two text messages each week that are tailored to roles and values (e.g., "good parent," "supportive of others," "respected at work") or strengths (e.g., "discipline," "learning new things," "staying positive") that they had identified in the baseline and 6-month surveys as being important to them. These tailored messages were adapted from message libraries that Dr. Resnicow has used in previous studies. For example, some messages will provide content that links their roles to prevention of T2DM and others will ask participants to reflect on ways in which preventing T2DM could influence their roles. These messages will aim to build integrated regulation, and thus autonomous motivation, for preventing T2DM. Another type of interactive message will ask participants to answer two questions that will measure on a zero to ten scale how important preventing T2DM currently is to them and how confident they currently are that they can prevent T2DM. Participants' responses to these items will be used to guide the selection of future messages and ensure that they are appropriately matched to participants' current levels of motivation and perceived competence. Those with importance scores of less than seven will be sent messages describing, or prompting them to reflect on, ways in which preventing T2DM could affect one of their values. These reflective messages will also aim to build autonomous motivation for taking steps to prevent T2DM. Participants with importance scores of seven or greater but confidence scores of less than seven will be sent messages describing, or prompting them to reflect on, ways in which one of their strengths could help them prevent T2DM. These messages will encourage self-affirmation to increase perceived competence for preventing T2DM. Participants with importance scores of seven or greater and confidence scores of seven or greater will be asked to reflect on how they could translate this high importance and confidence into preventing T2DM, presented within the context of one their identified values or strengths. These interactive tailored messages based on SDT principles will aim to increase autonomous motivation and support its preconditions of autonomy, competence, and relatedness.

Participants whose monthly feedback on engagement indicates low or no participation in the DPP and a metformin PDC below 0.8 will receive two to three additional text messages each month. These messages will:

- ask participants to identify significant barriers that prevented them from engaging with evidence-based interventions at a higher level (with an optional secondary assessment available to address barriers specific to participating in the DPP or taking metformin),
- provide a supportive message to help them navigate the barriers they identify. Some of these messages will include broadly worded prompts for participants to reflect on their roles and values or leverage their strengths, while others will provide specific resources or supplemental education relevant to their identified barrier. These messages will aim to increase autonomous motivation and perceived competence in order to facilitate higher levels of engagement with evidence-based strategies to prevent T2DM.

Financial Incentives Plus Tailored Messages Arm [Combo Arm]. This arm combines the elements described above for the *Financial Incentives Arm* and the *Tailored Messages Arm*. Participants in this *Combo Arm* will receive all of the following messaging components previously described for the *Tailored Messages Arm*:

- the series of initial educational messages
- the educational and facilitative messages for enrolling in the DPP or acquiring a metformin prescription

- the three weekly automated messages communicating educational content using autonomy-supportive language
- the monthly reminder of U-M Premier Care's coverage for the DPP and metformin
- the monthly message with personalized feedback on participation in the DPP and use of metformin for the previous month
- two weekly text messages tailored to participants' indicated roles, values, or strengths.

Additionally, participants in this *Combo Arm* will have the opportunity to earn the one-time $50 bonus incentive for providing confirmation of either enrolling in the DPP or taking steps to acquire a metformin prescription from their primary care provider, as well as the monthly incentives for either participating in the DPP or using metformin, as described above for the *Financial Incentives Arm*.

Additionally, participants in this *Combo Arm* will receive two types of messages that will facilitate linkages between the financial incentives and individuals' roles and values. First, some messages will provide content that links the financial incentive directly to their roles and values (e.g., how the incentive could be used for value-concordant purposes). Other interactive messages will ask participants to reflect on ways the incentive could influence one of their roles or values. These two types of messages will aim to add "meaning to money" to intensify the motivational potential of financial incentives. Together, these interactive tailored messages based on both behavioral economics and SDT principles will aim to make incentives more salient by helping individuals consider using them for purposes that are concordant with their roles and values while simultaneously building autonomous motivation for preventing T2DM. Participants will receive one of these messages every other week in place of one of the messages tailored to roles, values, or strengths described above for the *Tailored Messages Arm*.

A table describing the different message types, their frequency, arms that receive them, and sample messages are uploaded in the IRB study, section 44.1.

All Arms: Connections with Participants' Primary Care Providers. Prior to the start of recruitment, the Principal Investigator will connect with all of Michigan Medicine's 13 primary care sites for adults in SE Michigan. He will ask to be on the agenda of each clinic's regular meeting of providers via Zoom in order to provide an overview of the study, explain how the study can help providers with important work that is hard to accomplish in the time constraints of the clinical setting, provide detail about the evidence-based options for lowering diabetes risk, provide suggested talking points that providers can use with patients when discussing prediabetes and strategies to reduce risk, and explain how providers will see quarterly updates in the EHR for patients enrolled in the study. These reports will provide regular communication about patient progress and outcomes, including reports on monthly participation in the DPP and prescription fills of metformin. See Section 44 of the IRB application for templates of the reports.

A document containing the templates for the five quarterly updates that will be entered into each subject's chart are uploaded in the IRB study, section 44.1.

Measures and Data Collection

We will collect data from nine sources. The first three comprise participant assessments that will be completed at baseline, 6, and 12 months.

1. HbA1c. To objectively measure our clinically meaningful primary outcome of change in HbA1c, participants will have their HbA1c measured at a Michigan Medicine lab. The A1c completed as part of the enrollment process to confirm eligibility will also be used as the baseline A1 value. If enrollment is delayed and three or more months lapse between the A1c measure and final enrollment steps, the participant will need to get another A1c test completed to be used for the baseline measure.
2. Weight. Participants will be shipped a digital body weight scale after the participant is fully enrolled. Participants will be given instructions on how to use their scales to weigh themselves (use of scale, time of day, type of clothing) and how to submit a photo of the scale's display of their weight to the study in the secure Way to Health platform. See final section of protocol beginning on page 19 for details on privacy, confidentiality, and security measures. Participants will keep the scale after their study participation ends.
3. Survey. Participants will complete online surveys in the W2H platform at three time points. None of these measures are outcome measures; rather, they describe the participant population, are potential moderators or mediators, or provide insight into the participants' experiences in the study. Survey domains and measures are shown in the table below:

Domain	Survey Month			Measures
	0	6	12	
Demographics	X			Age, gender, race/ethnicity, job, education, household income, whether diagnosed with prediabetes and time since diagnosis, diagnosis of comorbidities, provider clinic and name, people in household, work status
Roles, values, strengths	X	X		Measures from our prior studies[67]
Physical Activity	X	X	X	International Physical Activity Questionnaire
Eating habits	X	X	X	Rapid Eating Assessment for Participants
Future orientation	X			Consideration of Future Consequences Scale[33]
Health causality orientation	X	X	X	Health Causality Orientations Scale
Autonomous/controlled motivation	X	X	X	Treatment Self-Regulation Questionnaire[157]
Incentive salience		X	X	0 to 10 rating of incentive importance from our prior studies[39,41]
Perceived coercion		X	X	Financial Incentive Coercion Assessment Questionnaire[172]
Perceived experience in study			X	Ease of completing study tasks, satisfaction with program elements, whether would recommend to others, most and least helpful aspects, kind of person who would benefit from the program, how to improve

4. Monthly level of engagement in the online DPP offered by Omada. To measure engagement in an evidence-based strategy to prevent T2DM, we will obtain data from Omada on participants' completion of weekly lessons, number of weigh-ins, days physical activity is tracked, and days food consumption is tracked. These data will be transmitted securely to the study team. See final section of protocol for details on privacy, confidentiality, and security measures.
5. Proportion of days covered (PDC) of metformin. We define adherence to metformin based on a participant's proportion of days covered (PDC) for metformin for that month (i.e., the proportion of days in that month that metformin was supplied to the total number of days in that month). Data will be securely transmitted to us from the U-M's

Prescription Drug Plan team. See final section of protocol for details on privacy, confidentiality, and security measures.

6. Costs of delivering each intervention. We will collect data on costs from the perspective of a payer. Cost data will include the costs of incentives, use of the W2H platform, and staff time to identify and recruit participants (which will be tracked in detailed research staff logs).
7. Facilitators of and barriers to intervention implementation and sustainability. After the end of the 12-month intervention period, we will conduct semi-structured telephone interviews with up to ten MHealthy workplace health promotion staff, up to 20 Michigan Medicine PCPs. **Details of the work to identify facilitators and barriers will be developed later in the study and submitted to IRB as an amendment.**
8. Participant experiences of the intervention. We will conduct semi-structured interviews via Zoom with up to 30 participants after they have completed their intervention and 12-month assessments. These interviews will ask about the participant's experience of being in the program, and this qualitative data will complement the set of process questions asked of every participant in the 12-month survey.
    a. Sampling plan: Participants will be sampled from each of the four arms, and within each arm, we will sample from low engagers (0-1 calendar months) and high engagers (10-11 calendar months). We will use the same criteria to determine engagement as we do for tailoring messaging and determining monthly rewards. The first calendar month will not be included in the count because participants rarely start early enough in the month to meet the engagement criteria. Only participants who indicate they are open to participating in an interview will be contacted.
    b. Additional question in 12-month survey: At the end of the 12-month survey, participants will be asked to indicate if they would be open to being contacted to participate in an interview. They will be told that checking the box does not mean they will necessarily be contacted because only a small number of participants will be interviewed, and they can always later decide that they do not want to participate. If they leave the box unchecked, the study will not contact them about interviewing.
    c. Interview details: Each interview will last about 30 minutes, and participants will have $25 added to their ClinCard balance for completing an interview. The interviewer will be a study team member trained in conducting semi-structured interviews who did not interact with the participant. Zoom (audio and screen share) will be used so that the interviewer may share examples of the different types of text messages the participant will be asked about. Interviews will be recorded using the Zoom recording feature. Files of the recordings will be stored in a secure study folder on a secure departmental shared drive and destroyed once notes are completed.
    d. Consent: Prior to recording and prior to asking interview questions, the interviewer will read an abbreviated consent form that details the interview and what will be done with the recording and data collected. After answering any questions, the interviewer will ask for the participant's consent.
    e. Post-interview: Interviews will be completed until we reach thematic saturation for each arm. Notes will be "near transcripts," meaning nearly word-for-word, but without most of the "ums" and other similar things said that in no way affect the

meaning. Good illustrative statements will be captured verbatim and indicated as such. Notes will be stored in a secure study folder on a departmental shared drive. Interview notes will be coded and analyzed using NVivo software. A code book will be developed beginning with the key domains from the interview guide and using an iterative process among three study staff and PI, with additional codes and subcodes added to account for details that emerged during interviews. The same four individuals will independently code four set of notes and will discuss concordance (Hemmler et al., 2022) to resolve discrepancies in coding via a consensus process. If the study team determines that a high level of consistency in coding had been established, then the sets of notes will be coded independently, with coders applying a "flag for review" code to any sections of text where the coder would like confirmation of a code via team review. If consistency in coding is not established after the group codes four sets of notes, more notes will be coded until consistency in coding is established. The codebook will be revised as needed to reflect new codes that emerge, with notes being recoded as needed. Once coding is complete, the four study team members will independently review key code reports and discuss interpretation of findings. Findings may be used to assist in interpreting study outcomes, improve the program itself, and to identify potential facilitators of and barriers to adoption, implementation, and sustainability. In reports and manuscripts, all data will be deidentified.

9. External controls data. Prior to conducting interviews with the key stakeholders described above as data source #7, we will obtain data that will allow us to share with those interviewed a comparison, between the EUC arm and similar patients who had no intervention, of changes in weight and HbA1c over approximately twelve months. Data will be of patients matching the same initial eligibility criteria that were used for the data pulls for recruitment. Patients will be excluded if they participated in the study, declined to participate after a recruitment call, were unable to reach for recruitment, or were ineligible as determined by screening. Variables provided will be: coded identifier, height, age, sex, race, ethnicity, and both weight and HbA1c with corresponding measurement dates.

Measures taken to protect privacy and confidentiality are described in the *Privacy and Confidentiality Measures* section of this protocol.

Strategies to Maximize Retention and Data Collection. Participants will receive $50 when they complete each assessment consisting of the online survey, weigh-in, and A1c test. They will also receive email, text messages, and phone calls to remind them to complete these tasks. We used this approach to limit attrition rates to 2% at 12 weeks in our pilot study and to less than 10% at nine months in two previous trials.[39,41]

Statistical Design

Sample Size

Based on data from previous studies, in the Enhanced Control Arm we anticipate a mean 12-month absolute HbA1c change (defined as the 12-month measure minus the baseline measure) of 0.0%, a mean 12-month absolute HbA1c decrease of 0.2% in both the Financial Incentives Arm and the Tailored Messages Arm, and a mean 12-month absolute HbA1c decrease of 0.4%

in the Combo Arm. Assuming a 0.4% standard deviation for 12-month HbA1c change in each arm and using an α of 0.017 to adjust for three main comparisons, 85 subjects per arm will provide 99% power to detect the difference between the Financial Incentives Plus Tailored Messages and Enhanced Control Arms (H1a), and 80% power to detect differences between the Combo Arm and the Tailored Messages Arm and the Financial Incentives Arm (H1b). With this sample size, we will also be able to detect meaningful differences (Cohen's *d* of 0.5 or larger) in secondary outcomes of weight, months of engagement in a Diabetes Prevention Program (DPP), months of taking metformin, and months of engagement in a DPP or taking metformin. To account for possible attrition we have conservatively inflated our sample size by 10% and will enroll 380 participants.

Analysis Plans

Our primary analytic approach will use ordinary least squares (OLS) regression models for continuous outcomes, adjusting for two stratification variables used in randomization (household income and autonomous motivation to prevent diabetes). To assess balance in randomization, we will compare baseline survey measures across arms. Additionally, we expect some missing data on baseline measures and outcomes and will assess the extent and pattern of missingness (e.g., monotone missingness) and predictors of missing outcomes. If we find a baseline measure to be predictive of missing outcome data, we will also adjust for this measure in analyses of outcomes. As an alternative analytic strategy, we will also use mixed-effects models. We will assess for consistency in the results between the two analytic approaches. If more than 10% of the 12-month data are missing, we will also use a multiple imputation strategy in which we will generate ten imputed datasets for missing data using a sequential regression multivariable imputation method, including intervention arms and other baseline variables.[185] The estimates from both the OLS and mixed-effects model analyses using imputed datasets will then be combined using the method of Rubin and Little.[186] All analyses of outcomes will use an intent-to-treat approach and a Bonferroni corrected α of 0.017. Data will be analyzed by a Data Analyst who will be blinded to arm assignment until all primary outcome data have been collected.

Aim 1: Compare the effectiveness of financial incentives plus tailored messages based on SDT principles, financial incentives, and tailored messages based on SDT principles in decreasing hemoglobin A1c, and weight, and in increasing participation in a DPP or use of metformin.

H1a: The mean decrease in HbA1c will be greater in the Combo Arm than in the Enhanced Control Arm.

H1b: The mean decrease in HbA1c will be greater in the Combo Arm than in the Financial Incentives Arm and the Tailored Messages Arm.

Mean 12-month change in HbA1c (defined as the 12-month measure minus the baseline measure) will be reported by arm. To test H1a and H1b, we will use an OLS regression model with 12-month change in HbA1c as the response variable. This model will include an indicator for each of the three arms (with the Financial Incentives Plus Tailored Messages Arm as the reference), stratification factors, baseline HbA1c values, and any baseline measures that are predictive of missing 12-month data. We will use similar, separate OLS regression models to predict our secondary outcomes of 12-month changes in weight (defined as the difference between the 12-month and baseline measures) and mean number of months (calculated out of 12 months to account for those who drop out before 12 months) in which individuals were engaged in a DPP, mean months in which individuals had a metformin PDC of at least 0.8, and mean months in which individuals were engaged in a DPP or had a metformin PDC of at least 0.8.

In alternate analyses, we will fit separate mixed-effects models for the primary and secondary outcomes using baseline, 6, and 12-month data as response variables and with time, study arm indicators, and interactions between time and study arm indicators as predictors and participants as random intercepts. We expect the changes in outcomes in intervention arms to be gradual over time and anticipate these longitudinal data models will confirm findings from our primary analytic approach to testing H1a and H1b, but if the findings differ, we will examine the source of any differences. For models for months of engagement in a DPP or use of metformin, we will first assess the distribution for skewness and, if more appropriate, a count data model (e.g., zero-inflated negative binomial) will be used instead of OLS.

Aim 2: Identify mediators and moderators of the effectiveness of financial incentives plus tailored messages based on SDT principles, financial incentives, and tailored messages based on SDT principles.
H2a: Combo Arm on 12-month change in HbA1c will be mediated by changes in autonomous motivation and changes in controlled motivation.
H2b: Effects of the Financial Incentives Arm on 12-month change in HbA1c will be mediated by changes in controlled motivation.
H2c: Effects of the Tailored Messages Arm on 12-month change in HbA1c will be mediated by changes in autonomous motivation.
H2d: Effects of the Combo Arm, Financial Incentives Arm, and Tailored Messages Arm on 12-month change in HbA1c will be moderated by income and future orientation.

To test H2a, H2b, and H2c we will use structural equation modeling (SEM), which in a single framework will provide indirect and total effects, and provide joint significance testing, for the factors from our Conceptual Model that we hypothesize will mediate 12-month change in HbA1c. Using SEM, we will examine each mediator separately and also estimate joint models with both hypothesized mediators. In supplementary analyses, we will use latent groW2H modeling to separately extend this SEM to longitudinal data on six and 12-month change in HbA1c. We expect these longitudinal data models to confirm the findings from SEM, but if the findings differ we will examine the source of any differences.

To test H2d, we will add to the multivariable OLS regression models described under Aim one (but with the Enhanced Control Arm as the reference) interactions between baseline measures of income and future orientation with indicators for the Combo, Financial Incentives, and Tailored Messages Arms. We hypothesize that the effects of arms with financial incentives on 12-month change in HbA1c will be greater among participants with lower incomes and participants who are less future-oriented. In contrast, we hypothesize that the effects of arms with tailored messages will be greater among participants with higher incomes and participants who are more future-oriented. When a hypothesized moderator is found to statistically significantly modify the effects of an arm on 12-month change in HbA1c, we will conduct separate exploratory mediator analyses among the subgroups defined by this moderator because different intervention effects may imply different mechanisms of effects within subgroups. These mediator and moderator analyses will be repeated for each of the secondary outcomes.

Aim 3: Evaluate facilitators of and barriers to scalability, acceptability, and sustainability of financial incentives plus tailored messages based on SDT principles, financial incentives, and tailored messages based on SDT principles. Fundamental to the scalability, acceptability, and sustainability of our approaches for health systems and community organizations are the costs of the approaches we are testing relative to their effects. Thus we will examine costs of each study arm from the perspective of a payer and create standard costs

that will be adjusted to current dollars using medical and pharmaceutical components of the Consumer Price Index. Our cost analysis will also estimate the costs of delivering each study arm, including costs associated with financial incentives and use of the W2H platform. Sensitivity analyses will be used to examine the impact of using different cost estimates. We will provide stakeholders from Michigan Medicine, BCN, and U-M MHealthy with estimates of the costs of sustaining each approach.

Later in the study, we will develop a detailed plan to evaluate the domains of RE-AIM. Once the plan is developed, we will submit an amendment to IRB for approval.

Aim 4: Compare 12-month changes in HbA1c and weight in the Enhanced Usual Care (EUC) arm to similar patients who received no intervention. Patients receiving no intervention (external controls) will be matched or adjusted for the following characteristics: age, sex, race, ethnicity, and baseline values of BMI, weight and HbA1c. We will use an OLS regression model with 12-month change in HbA1c as the response variable. This model will include an indicator for the EUC (reference is external control), stratification factors, baseline HbA1c values, number of months between two measurements, and any baseline measures that are predictive of missing 12-month data. We will use similar, separate OLS regression models to compare 12-month changes in weight.

Privacy and Confidentiality Measures

Privacy: A potential risk of participation is a breach of a participant's privacy, in which their participation in the research is disclosed to an individual or entity the participant did not wish to have this knowledge. This risk is less serious and lessened in likelihood by collection of informed consent and survey data through the secure W2H web platform.

To minimize the risk of a breach of privacy, the research team will only disclose information about a participant as needed, in accordance with the processes detailed in the informed consent form. The information on participants' names, addresses, email addresses, phone numbers, and social security numbers that will be collected because it is necessary to conduct the study will be stored in an encrypted database that conforms to applicable data security standards. Access to all such data will be limited to specifically designated research staff that will be responsible for contacting participants. As soon as participants provide their informed consent, they will be assigned a unique study identification number that will be connected to all of their study data. The study ID number will be used in place of the participant's name whenever the name or other identifying information is not absolutely necessary. All communications between participants and the W2H platform will be encrypted with SSL/HTTPS technology. All research findings will be presented in de-identified form only.

Confidentiality: Another potential risk of this study is a breach of subjects' confidentiality, in which their personal information or data collected as part of the study are accessed by an individual or entity that is not authorized to do so. The risk of breach of confidentiality is serious, particularly if social security numbers that will be collected for payment of participation and financial incentives are accessed by unauthorized persons.

However, the security measures that will be taken to protect participants' identities and personal information will ensure that the likelihood of such a breach is low. First, all study team

investigators and staff will have completed privacy and confidentiality training prior to any work on the study.

The W2H web platform uses account-based authentication and permission systems to protect confidentiality. Investigators and most research staff members who log in to the system will be able to access only de-identified data; only research staff responsible for contacting participants will be able to view participant names and contact information. The system will automatically generate logs of all data queries, and these will be reviewed weekly by research staff to ensure that no unauthorized persons have gained access to identifiable information. Study data in W2H will be stored on secure firewalled servers of the University of Pennsylvania in data files that will be protected by multiple password layers. These data servers are maintained in a guarded facility behind several locked doors, with very limited physical access rights. They are also cyber-protected by extensive firewalls and multiple layers of communication encryption. Electronic access rights are carefully controlled by University of Pennsylvania system managers. A detailed document of W2H's Summary Protections and W2H HITRUST certification letters are uploaded in Section 44, Additional Supporting Documents. We will use highly secure methods of data encryption for all transactions involving participants' financial information using a level of security comparable to what is used in commercial financial transactions.

If contacted by phone, a participant may answer screening questions that the study staff member records in a Qualtrics survey. Only the study ID will be entered into the survey—no personally identifiable information will be entered into Qualtrics. Qualtrics The responses will be removed from Qualtrics on a weekly basis so that the study does not retain linked screener data on anyone who did not consent to participating the study. Ineligibility reasons that are not linked to any individual are tracked securely in an Access database on the secure MM departmental server described below.

Qualtrics' servers are protected by high-end firewall systems and scans are performed regularly to ensure that any vulnerabilities are quickly found and patched. Application penetration tests are performed annually by an independent third-party. All services have quick failover points and redundant hardware, with backups performed daily. Access to systems is restricted to specific individuals who have a need-to-know such information and who are bound by confidentiality obligations. Access is monitored and audited for compliance. Qualtrics uses Transport Layer Security (TLS) encryption (also known as HTTPS) for all transmitted data. Surveys may be protected with passwords. Their services are hosted by trusted data centers that are independently audited using the industry standard SSAE-18 method. Qualtrics obtained a SOC 2 Type II report for the trust principles of Security, Availability, and Confidentiality. Qualtrics achieved ISO 27001, 27017, and 27018 certifications. Qualtrics is FedRamp Authorized. FedRAMP is the standard of U.S. government security compliance, with over 300 controls based on the highly-regarded NIST 800-53 that requires constant monitoring and periodic independent assessments. Finally, Qualtrics achieved the HITRUST certification.

Certain data will also be stored in a password-protected folder, accessible to select staff only, that is on a secure Michigan Medicine departmental server (\\corefs.med.umich.edu\shared1\Intmed_Rsrch\Kullgren BEST Change). These include data

received from the Data Office for Clinical and Translational Research for recruitment, body weight measurements, prescription fill data, and Diabetes Prevention Program participation and body weight data from Omada Health.

At the conclusion of the study, all study data in W2H will be downloaded and wiped clean from W2H. Data will be stored in a password protected folder on a secure Michigan Medicine server. Once all analyses and manuscript work are completed, identifying information will be destroyed, and the deidentified data will be archived on the password-protected folder described in the paragraph above.

Process to provide incentives. Deposits to the participant's ClinCard will be made electronically through a University of Pennsylvania-approved partnership with Greenphire. Greenphire's ClinCard program is HIPAA-certified. Social security numbers, names, addresses, and date of birth for all persons to whom incentive payments are sent are kept within the ClinCard system. Each year, Accounts Payable at the University of Pennsylvania securely downloads a report from Greenphire that includes anyone paid in the previous calendar year. That data is kept secure and only the data of people that earned $600 or more is uploaded to a secure third party vendor to process 1099's.

Transfer of body weight data for assessments. Participants will measure their body weight using a digital scale in their home that the study will have shipped to them. Upon receipt of the scale, participants will receive instructions on how to weigh themselves, take a photo of their weight on the display, and submit the photo to the study by texting the photo to the study's number in the Way to Health system.

Transfer of prescription fill data. Each month, study staff will upload to MiShare a file containing the prescription drug plan ID numbers of all current study participants. A member of the University of Michigan's Prescription Drug Plan team will run a query, based on the prescription drug plan ID provided, for the claims extract of the metformin claims for the previous month for study participants only. The results will be uploaded to MiShare to share with select study staff, and study staff person will download and store the data in the study folder.

Transfer of Diabetes Prevention Program participation and body weight data. All study participants will be encouraged to enroll in Omada Health's online DPP. Participants will be directed to a special URL set up only for BEST Change participants, and this special URL will allow Omada to share monthly reports with study staff containing data only on study participants. Data to be shared on each study subject also enrolled in the Omada program: number of lessons completed, days body weight measured, days physical activity is tracked, and days meals or snacks are tracked. body weight at start of the DPP, percent weight lost each week, and dates when participant has lost 5% and 10% of their body weight. The monthly reports will be shared using the secure SFTP site GoAnywhere, and only select study staff will have access to the files. An authorized study staff person will download and store the data in the study folder. A data sharing agreement between UM and Omada Health is in progress.