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A Scoping Review of Behavioral Economic Interventions for Prevention and Treatment of Type 2 Diabetes Mellitus

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Abstract

Purpose of review—To review studies of behavioral economic interventions (financial incentives, choice architecture modifications, or commitment devices) to prevent type 2 diabetes mellitus (T2DM) among at-risk patients or improve self-management among patients with T2DM.

Recent findings—We found 15 studies that used varied study designs and outcomes to test behavioral economic interventions in clinical, workplace, or health plan settings. Of four studies that focused on prevention of T2DM, two found that financial incentives increased weight loss and completion of a fasting blood glucose test, and two choice architecture modifications had mixed effects in encouraging completion of tests to screen for T2DM. Of 11 studies that focused on improving self-management of T2DM, four of six tests of financial incentives demonstrated increased engagement in recommended care processes or improved biometric measures, and three of five tests of choice architecture modifications found improvements in self-management behaviors.

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Compliance with Ethics Guidelines

Conflict of Interest

Jeffrey T. Kullgren has received consulting fees from SeeChange Health and HealthMine, and speaking honoraria from AbilTo, Inc. Dina Hafez, Michele Heisler, and Allison Fedewa declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

Summary—Though few studies have tested behavioral economic interventions for prevention or treatment of T2DM, those that have suggest such approaches have potential to improve patient behaviors and should be tested more broadly.

Keywords

behavioral economics; diabetes; self-management; prevention; interventions; scoping review

INTRODUCTION

The prevention and treatment of type 2 diabetes mellitus (T2DM) both have clearly defined clinical strategies that can help patients reduce their risk for future T2DM-related health problems. Patients with prediabetes -- who have not yet developed T2DM but have elevated blood glucose levels that put them at high risk for developing T2DM[1–3] -- can significantly reduce their risk for T2DM through two main strategies. First, they could participate in a Diabetes Prevention Program (DPP) with the goals to lose 7% of their body weight and get at least 150 minutes of moderate physical activity per week. Second, they could take metformin.[4–6] For patients who already have T2DM, weight loss[7] and regular physical activity,[8] an array of pharmacotherapies,[9] and numerous disease management programs[10] can help them optimize their disease control and reduce their risk for future complications. All of these strategies are either already widely available in clinical settings or are rapidly being disseminated through community partnerships.[11,12]

This widespread availability of efficacious strategies to prevent and treat T2DM has great potential to reduce the public health burden of T2DM.[13] However, the real world impact of these strategies is limited by low levels of patient engagement. In the case of prevention of T2DM, even when at-risk patients are aware of their elevated risk, few are consistently engaged in strategies to help them prevent or delay the onset of T2DM.[14–17] For individuals diagnosed with T2DM, while overall levels of glycemic control have increased in the United States in recent years, good glycemic control remains elusive for many,[18] and levels of recommended weight loss and physical activity are low in this population.[19]

One key contributor to this gulf between the widespread availability of efficacious strategies to prevent and treat T2DM and patients' engagement in these strategies may be cognitive biases representing errors in mental processing that can keep individuals from taking steps that will help them achieve their long-term goals. In recent years such cognitive biases have been elucidated by the field of behavioral economics, which combines elements of neoclassical economics and psychology to improve the understanding and shaping of human behavior.[20] One important cognitive bias that may hinder engagement in strategies to prevent and treat T2DM is individuals' tendency to overvalue near-term costs and benefits in their decision making.[21] These "present-biased preferences" can impede behaviors to prevent and treat T2DM because such behaviors often require individuals to exhibit high levels of self-control[22] by enduring certain and immediate inconveniences (e.g., decreasing pleasurable intake of high-caloric foods or injecting insulin) in return for uncertain and distant benefits (e.g., reducing long-term risk for complications from T2DM). Other examples of cognitive biases that can influence individuals' decisions to engage in

strategies to prevent and treat T2DM include their excessive optimism about experiencing a positive outcome in the future (e.g., expecting to win a state lottery after buying one ticket) [23] and their perception of losses of a given magnitude as being more painful than the enjoyment gained from otherwise equivalent gains (e.g., regretting losing $10 more than enjoying winning $10).[24]

A range of interventions have been developed and tested that seek to overcome cognitive biases that can impede engagement in behaviors to achieve long-term goals (Figure 1). One such approach is the use of financial incentives to provide an immediate benefit for engaging in behaviors with certain and immediate inconveniences but uncertain and distant benefits. These types of incentives have been shown to promote weight loss,[25–37] physical activity, [38–45] and medication adherence.[46–48] Other approaches grounded in insights from behavioral economics with potential applications to the prevention and treatment of T2DM include choice architecture modifications (i.e., restructuring choice environments to systematically influence decisions)[49–52] and commitment devices (i.e., opportunities for individuals to commit their future selves to a course of action in order to achieve a long-term goal).[32,53–56]

Such behavioral economic approaches offer new opportunities to reduce the public health burden of T2DM by surmounting the cognitive biases that can limit patients' engagement in evidence-based strategies to prevent and treat T2DM. The objective of our review was to identify behavioral economic strategies that have been tested to promote prevention and treatment of T2DM and suggest promising directions for future research in this area.

METHODS

Data Sources and Search Strategy

In January 2017 we conducted a comprehensive search of MEDLINE and PsycINFO, a key database of behavioral and social science research, for patient-oriented studies published after January 1, 2000 that used a behavioral economic strategy to prevent T2DM or to improve T2DM self-management.

Numerous behavioral economic strategies have been used to encourage lifestyle change. To ensure that we captured these diverse interventions in our review, a research librarian first conducted exploratory searches in MEDLINE and Google Scholar to find key articles and citations that related to behavioral economics and health promotion. Using this information, the research librarian then worked with two authors (AF and JK) to generate a broad search using controlled vocabulary (e.g., MeSH terms) and keywords to identify behavioral economic approaches (e.g., choice architecture, commitment devices, loss aversion, nudges, incentives, or reinforcements) used in interventions that were tested among individuals with elevated risk for developing T2DM (e.g., prediabetes or glucose intolerance) or existing T2DM. Because of great heterogeneity in intervention approaches, populations, and outcomes, and because to our knowledge there have been no previous efforts to summarize the use of patient-oriented behavioral economic strategies to improve T2DM prevention and treatment, our aim was to map this literature through a scoping review.[57]

Study Eligibility and Selection Criteria

We used the PICOTS (Population, Intervention, Comparator, Outcome, Time, Setting) framework to identify relevant studies (Table 1). Studies were eligible for inclusion if they evaluated a patient-facing behavioral economic intervention to either prevent T2DM (including both uptake of screening and modification of behavioral risk factors) or improve T2DM self-management among individuals with T2DM. We did not limit our review to any particular study design (e.g., randomized controlled trials) because several studies used an observational approach (e.g., a cohort study) to evaluate a behavioral economic intervention. We included studies with diverse outcomes given significant heterogeneity among study objectives and outcome measures. Outcomes for prevention of T2DM included weight loss and having a screening test for T2DM. Outcomes for T2DM self-management included medication adherence, home self-monitoring, use of recommended clinical monitoring, physical activity, enrollment in a health promotion program, and glycemic control. We excluded studies of provider-focused interventions such as financial incentives directed at providers (i.e., pay-for-performance) because these have been previously summarized.[58] We also excluded studies that used behavioral economic approaches to promote weight loss and physical activity without the stated aim of encouraging prevention of T2DM or improved T2DM self-management, as this literature is less directly related to the target populations for this review and has already been summarized elsewhere.[25,43,59] Finally, we excluded articles that were not published in English. The reference lists of articles meeting eligibility criteria were manually screened and electronic citation tracking was performed using Scopus. Additional search details are available from the authors upon request.

Using this search strategy, one author (AF) reviewed titles and abstracts for eligibility. Full text articles were reviewed in detail when the title and abstract contained insufficient information to determine study eligibility. All discrepancies were resolved through consensus discussion with a second author (JK). The full texts of 30 articles were reviewed in detail. Of these 30 articles, 15 publications met our eligibility criteria and were included in the final sample for our review (Figure 2).

Data Abstraction

One author (AF) abstracted the data related to the following: (1) study design and purpose; (2) behavioral economic approach; (3) participant characteristics, and (4) outcome measures. A second author (DH) reviewed each article to validate the abstracted data.

RESULTS

Fifteen publications met our eligibility criteria. These included four studies that tested behavioral economic strategies to improve the prevention of T2DM (Table 2) and 11 studies that tested behavioral economic strategies to improve the treatment of T2DM (Table 3).

Behavioral Economic Strategies to Improve Prevention of T2DM

Of the four studies focused on prevention of T2DM, two tested the use of different forms of financial incentives. In the first incentive study, 99 overweight or obese employees from four

US long-term care facilities who had elevated risk for T2DM were enrolled in a group-level randomized trial in which they participated in a 16-week weight loss program.[60] In the program, all participants received a personalized weight loss and physical activity consultation that established weekly weight loss goals. Employees of two of the four facilities were randomized to receive financial incentives for losing weight that they could receive as either (1) a fixed payment per pound of weight lost or (2) an opportunity to commit their own money for each pound of weight they hoped to lose that was matched dollar-for-dollar by the investigators but forfeited when goals were not achieved. The other two facilities served as controls. Immediately after the 16-week program, employees in the incentivized facilities lost an average of 5.0 pounds more and had healthier eating scores compared to employees in the non-incentivized facilities. After a 12-week follow-up only the healthier eating difference was sustained. The authors did not find evidence of differences in outcomes between the two incentive approaches, but noted their study was not powered to evaluate their comparative effectiveness. The second incentive study was a cohort study of 4,186,047 members of a private health insurance plan in South Africa in which enrollees could choose to pay roughly 20 US dollars per month to join a voluntary incentive program.[61] In this program, enrollees could receive points for healthy behaviors such as receiving clinical preventive services (e.g., fasting glucose testing), visiting a gym, or buying healthier foods. These points accumulated and could then be exchanged for discounts on a variety of consumer goods and services. Nearly two-thirds (65.5%) of plan members joined the incentive program, which led to an estimated 4.7% increase in fasting glucose testing relative to plan members who did not join the incentive program.

The other two studies focused on prevention of T2DM tested different ways of framing information about opportunities to participate in health screenings that aimed to prevent T2DM and related chronic conditions. In the first framing study, 116 non-diabetic patients of two general practices in the UK who were found to be at elevated risk for T2DM were randomized to receive by mail one of two invitations to be screened for T2DM: (1) a gain frame (“if your diabetes is detected early, you can receive earlier and more effective treatment”) or (2) a loss frame (“if you have diabetes but are not detected early, your diabetes may lead to more complications”).[62] There were no differences in screening uptake between the two arms. In the second framing study, 3,511 patients of four general practices of the National Health Service in the UK were randomized to receive by mail one of two invitations to participate in a cardiovascular risk assessment (an NHS Health Check) that in part aimed to prevent or delay the onset of T2DM.[63] The control invitation used a standard informational NHS Health Check invitation template. The intervention invitation featured four manipulations that leveraged specific behavioral science insights: simplification, behavioral specificity, enhanced personal salience, and implementation intentions. These manipulations of the standard invitation template led to a statistically significant 4.2% increase in the percentage of patients who attended an NHS Health Check.

Behavioral Economic Strategies to Improve Treatment of T2DM

Of the 11 studies focused on treatment of T2DM, six tested different forms of financial incentives. Two studies tested gift cards for completing recommended processes of care. One quasi-experimental study of 1,157 patients with T2DM who were due for hemoglobin A1c

(HbA1c) and low-density lipoprotein cholesterol (LDL-C) testing found that a reminder letter combined with a $6 gas card increased the mean number of HbA1c tests over two years from 2.7 to 3.3.[64] A three-arm pilot randomized trial of 60 insulin-dependent diabetic patients found that neither a gift card worth $10 for every 10 glucometer measurements nor pain-free lancets increased self-monitoring of blood glucose over 30 days compared to usual care.[65]

Two studies tested other forms of financial incentives to encourage adherence to recommended care processes. The first study was a single-arm nonconcurrent multiple baseline trial which found that graduated daily financial incentives for medication adherence worth up to $84.10 combined with text messages improved medication adherence by nearly 40% over three weeks among three patients who were prescribed oral medications for their T2DM.[66] The second study was a six month, three-arm randomized trial that tested whether 12 weeks of lottery incentives with daily values of $2.80 and $1.40, respectively, could increase daily home wireless device monitoring of blood glucose, blood pressure, and weight among patients with T2DM.[67] Both incentives significantly increased daily home self-monitoring over 12 weeks by approximately the same amount, but only the smaller incentive led to higher levels of daily self-monitoring 12 weeks after the incentives ended.

Two studies tested financial incentives that were partially or completely based on achieving diabetes care targets. The first study was a retrospective cohort analysis of 2,103 employees with T2DM who received either a $100 incentive to participate in an employer-sponsored disease management program, a $300 incentive to participate in the disease management program, or a 30% health insurance premium discount that was tied to both disease management program participation and achievement of HbA1c, LDL-C, and blood pressure targets.[68] Overall these financial incentives led to modest declines in HbA1c levels, systolic blood pressure, LDL-C, and weight over five years compared to 2,672 commercially insured non-employee patients of the same primary care physicians. The other study was a three-arm randomized trial of 118 predominantly African American Veterans with T2DM and persistently poor glycemic control. Participants received $100 for decreasing HbA1c by one point and $200 for decreasing HbA1c by two points or to 6.5%. Financial incentives did not improve HbA1c levels over six months while the study arm receiving a peer mentoring program without financial incentives decreased HbA1c levels by an average of 1.1 points.[69]

The other five studies examined different ways to frame information to encourage better self-management of T2DM. Four of these studies focused on improving behaviors that are key components of T2DM self-management. The first study was a randomized trial among 3,906 diabetic members of a South African health insurance plan who chose to participate in a voluntary wellness program and found that a T2DM-specific message, a recommendation from a peer with T2DM, a physician's recommendation, and a T2DM-specific message with a choice architecture modification called enhanced active choice[52] all increased enrollment in an incentivized healthy food program at 1 month, with little difference in gains achieved among the different approaches.[70] The second study randomized 180 patients with longstanding T2DM to view a gain-framed or loss-framed educational video about proper foot care and found that the gain-framed video increased reported recommended foot

care behaviors six months later more than the loss-framed video.[71] The third study randomized 27 sedentary patients with T2DM, a pedometer, and personal physical activity plan to receive repeated text messages that either did (treatment) or did not (control) adapt based on an individual's walking behaviors and found that the adaptive messages were significantly more effective in increasing the amount and pace of their walking.[72] The fourth study was a randomized trial that used a two-by-two design to test gain vs. loss and immediate vs. distal frames to increase physical activity among 239 patients with T2DM and found no differences in immediate intentions to increase physical activity among the four arms.[73] Just one study examined the effects of message framing on glycemic control. In this study, 177 patients with poorly controlled T2DM were randomized to one of three "report cards" that communicated current glycemic control as either a letter grade ranging from A to F, faces with an emotion, or an HbA1c value, and found no differences in glycemic control or perceptions of control at six months.[74]

DISCUSSION

Our scoping review identified 15 studies that have tested different behavioral economic approaches to enhance the prevention and treatment of T2DM. The vast majority of these studies focused on treatment rather than prevention, and most tested financial incentives, which to date have likely been the most widely tested behavioral economic strategy to encourage healthy behaviors, rather than choice architecture modifications or commitment devices.

The eight studies of financial incentives we identified illustrate that financial incentives have potential in the short-term to encourage behaviors that are integral to the successful prevention and self-management of T2DM. Yet the varied incentive designs, populations, and outcomes in these studies preclude the ability to draw firm conclusions about where, when, and how incentives might work best to promote healthy behaviors in different contexts and among different populations. One important conclusion that can be drawn from these studies, however, is that in future research there are a number of ways in which financial incentives could better support the prevention and treatment of T2DM. First, many of the financial incentives that were tested in this context offered rewards that were infrequent and provided long after the behavior they were seeking to encourage. Such rewards could more effectively promote engagement in recommended behaviors by being more frequent and immediately after the targeted behavior. Second, although financial incentives for healthy behaviors have become nearly ubiquitous in large US workplaces, [75,76] such incentives are typically offered either for a one-time behavior (e.g., completion of a health risk appraisal) or for a limited period of time. Therefore, incentives might be most cost-effective if they are used to encourage participation in time-limited programs known to have long-term benefits (e.g., DPPs[5,77]) or to enhance engagement in programs that help individuals form new habits (e.g., daily self-monitoring of glucose or weight) that may carry forward into the future even when those behaviors are not being directly incentivized. Third, though financial incentives have been shown to encourage a range of healthy behaviors that are integral to the prevention and self-management of T2DM, these changes are often modest and not well sustained after removal of the incentives. Financial incentives could potentially be more effective by integrating insights from behavioral

economics with principles of other evidence-based psychological approaches such as self-determination theory.[78,79] For example, incentives could be reinforced with tailored messages that link incentives to people's aspirations in life as well as link recommended behaviors to these aspirations. In this way, financial incentives could be more salient and cultivate greater autonomous motivation to prevent and treat T2DM, resulting in sustained engagement in recommended behaviors after incentives end.[80,81]

We identified seven studies that tested different message framing strategies to encourage prevention and self-management of T2DM. Those that were effective either integrated multiple behavioral science insights into messages that encouraged a specific one-time behavior (e.g., enrollment in a healthy eating program) or used an alternative modality (e.g., video or repeated text messages) that afforded a higher messaging "dose" to encourage longitudinal behaviors that required a greater degree of effort. Messages that were ineffective either used simple gain vs. loss framing or targeted only proximal mediators (e.g., perceptions or intentions) of engagement in the target behavior. These findings highlight the promise of messaging strategies which leverage novel behavioral insights. They also underscore the importance of ensuring messages to encourage T2DM prevention and treatment are of a dose that is proportionate to the effort required to engage in the targeted behavior.

One promising behavioral economic strategy that was applied in a limited way in just one of the studies we identified was the use of a commitment device.[60] This strategy of committing one's self to a future course of action and then applying supports to encourage adherence to that course of action[55,82–84] has been shown to improve a range of behaviors that can be influenced by cognitive biases such as savings,[85] academic performance,[83] tobacco use,[54,86] and weight loss.[29,32]. This strategy could have important applications in both T2DM prevention and treatment, for example by inviting individuals to commit to taking evidence-based steps to prevent T2DM or to improve their self-management of T2DM.

This review has several limitations. First, we only included interventions described in the peer-reviewed literature and therefore may not have captured interventions sponsored by employers or health plans that have not been reported in journals. Second, because the field of behavioral economics draws on psychology and other behavioral sciences to overcome the limitations of neoclassical economic theory it is perhaps less of a discrete field than other social science disciplines. As a result, there are no commonly accepted definitions of what constitutes a behavioral economic intervention. Thus our team had to rely on our own knowledge of this literature to classify interventions as using a behavioral economic approach. Third, we conducted a scoping review which aimed to map out the use of behavioral economic strategies in the context of preventing and treating T2DM. Consistent with the focus of this type of review we did not systematically rate the quality of evidence generated from each study. However, we have strived to describe the studies we reviewed in sufficient detail for readers to understand their respective methodologic strengths and limitations.

CONCLUSIONS

Behavioral economic approaches have great potential to overcome the present-biased preferences that can hinder patients' engagement in healthy behaviors, including proven strategies to prevent and treat T2DM. Our scoping review identified a number of studies that illustrate this potential and highlight key future directions for research into behavioral economic strategies to improve the prevention and treatment of T2DM.

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•• Of major importance

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Type of Intervention	Example
Financial incentives	Offering a financial reward to people who achieve a physical activity goal [38–45]
Choice architecture modification	Using color-coded labeling and increased visibility to encourage healthier food choices [49]
Commitment device	Asking people who want to lose weight to put money into a "deposit contract" in which they will lose their deposit if they do not achieve a weight loss goal [29,31,32]

Figure 1.
Categories of Behavioral Economic Interventions

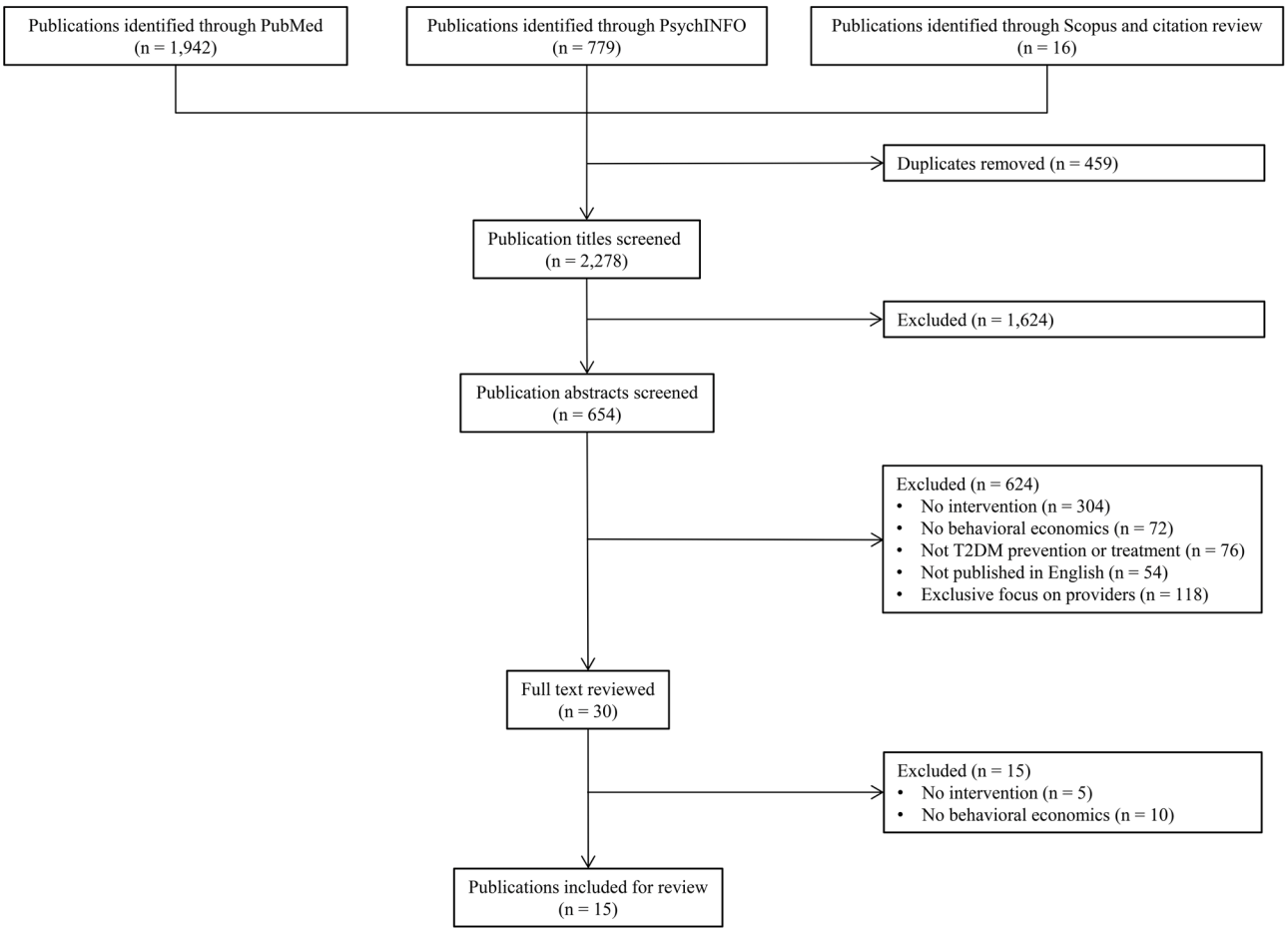

Figure 2.
Article Flow Chart

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Population	
• Individuals at risk for T2DM • Individuals with T2DM	• Providers only
Intervention	
• Behavioral economic intervention that aimed to either prevent T2DM or improve self-management of T2DM – Financial incentives – Choice architecture modification – Commitment device	• Interventions targeting only providers
Comparator	
• Presence of a defined non-treated comparison group	
Outcomes	
• Primary outcome relevant to prevention of T2DM or self-management of T2DM	
Timing	
	• None
Setting	
	• None

Table 2

Behavioral Economics Interventions Targeting T2DM Prevention

	Faghri, USA[60]	Mehrotra, South Africa[61]	Park, England[62]	Sallis, England[63]
REACH				
Enrolled	99	1,317,654	116	3,511
Analyzed	73	1,317,654	116	3,511
Study population	Long-term nursing home facility employees	Members of private health plan in South Africa	Patients of general practice clinics	Patients of general practice clinics
Study design	3-arm cluster randomized controlled trial **1** Incentive group (IG) **a.** Standard incentive **b.** Standard incentive plus deposit **2** Non-incentive group (NIG)	Prospective cohort study	2-arm randomized controlled trial **1** Gain framed screening invitations **2** Loss framed screening invitations	Single-arm quasi-randomized controlled trial
Recruitment	Workplace announcements; newsletters; posters; flyers	NA	NA	Members eligible for a health check
Screening	All employees screened for eligibility	NA	Medical record review	NA
Eligibility	Non-diabetic; BMI ≥25kg/m^2; ADA Diabetes risk score ≥8	Voluntary program available to all health plan members	Non-diabetic; aged 40–69 years; high risk of T2DM based on Cambridge risk score	Age 40 to 74 years
PARTICIPANT CHARACTERISTICS				
Mean age in years (SD)	IG: 45 (11) NIG: 49 (11)	NR	Gain frame: 57.6 (7.7) Loss frame: 59.0 (7.0)	Control: 53.1 (9.8) Intervention: 52.8 (9.8)
Mean BMI at baseline (SD)	IG: 36.7 (7.7) NIG: 33.9 (5.8)	NR	Gain frame: 61% (n=35) ≥30 Loss frame: 68% (n=40) ≥30	NR
Gender (% female)	IG: 91 NIG: 89	Enrollees: 50.4 Non-enrollees: 52.3	Gain frame: 18 (32) Loss frame: 22 (37)	Control: 939 (53.5) Intervention: 894 (50.9)
Race (% Caucasian)	IG: 40 NIG: 55	NR	NR	NR
Ethnicity (% Hispanic)	IG: 2.9 NIG: 6.3	NR	NR	NR
INTERVENTION CHARACTERISTICS				
Strategy	Financial incentives	Financial incentives	Message-framing	Behavioral science influenced invitations

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	Faghri, USA[60]	Mehrotra, South Africa[61]	Park, England[62]	Sallis, England[63]
Program details	Standard incentive: received $10 for every 1.0lbs lost per week if BMI ≥25 or 1.5 lbs lost per week if BMI ≥30. Standard incentive plus deposit: same incentive as standard + deposit up to $80 (based on weight loss target) which was met dollar-for-dollar if participants met goal	Voluntary reward program; participants pay monthly rate ($17/ individual, $21/family); earn points for healthy behaviors (e.g. smoking cessation, preventive care); greater points lead to greater discounts on goods and services (e.g. movie tickets, flights). Additional points earned for normal cholesterol and glucose levels.	Invitations with loss frame message (e.g., "If have diabetes, but are not detected early, your diabetes may lead to more complications) or gain frame message (e.g., "If your diabetes is detected early, you can receive early and more effective treatment) used to invited individuals to participate in T2DM screening.	Control group: received standard letters from national primary prevention program Intervention group: received a letter with 4 modifications: (1) simplified sentences; (2) clear action steps (e.g., call to book an appointment); (3) personalization (e.g., "*you* are due for a health check); (4) action reminder (e.g., tear-off slip to place on the refrigerator)
Duration	16-weekly sessions	6 years (2005 to 2011)	NR	1 time screening event
Primary outcome(s)	IG participants lost 2.3 kg more than those in the NIG *	Incentive program participants were more likely to receive preventive care services than non-participants, including blood glucose testing (OR 1.51) *	82% (n=95) of patients attended T2DM screening; there was no significant difference in the overall rate of T2DM screening between loss framed group and gain framed group	33.5% (n=588) of individuals who received the intervention letter attended T2DM screening compared with 29.3% (n=514) of those who received the standard letter (OR 1.26, 95% CI 1.09–1.47)

* $p < 0.05$

NA = not applicable, NR = not reported

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Table 3

Behavioral Economics Interventions Targeting T2DM Management

	Austin, USA[64]	**Gopalan (1), South Africa[70]**	**Gopalan (2), USA[74]**
REACH			
Enrolled	2,565	3,906	177
Analyzed	2,565	3,665	177
Study population	Academic medical center patients	Health plan members	Academic Internal Medicine practices
Study design	Quasi-experimental study	5-arm randomized controlled trial: **1** Control (no message) **2** Diabetes-specific messages (DSM) **3** Recommendation to participate in Healthy Food (HF) by health plan member with T2DM **4** Physician recommendation to participate in HF **5** DSM + enhanced active choice (EAC)	3-arm randomized controlled trial: "T2DM report card" used to reflect an individual's glycemic control using: **1** HbA1c (control) **2** Letter grade (A–F) **3** Face with emotion (e.g. happy vs. sad)
Recruitment	Eligible participants contacted by study team	Eligible participants contacted by study team	Eligible participants contacted by study team
Screening	Physical referral or medical record review	Billing / pharmacy codes for T2DM or oral T2DM medications	Medical record review
Eligibility	T2DM; no HbA1c or LDL-C within 1 year	Age ≥18 years; T2DM	Age ≥18 years; T2DM; HbA1c >8%
PARTICIPANT CHARACTERISTICS			
Mean age in years (SD)	Control: 58.6 Intervention: 63.7	***(1) through (5)*** *refer to study arms, defined above* **(1)** 55.9 (10.9); **(2)** 55.2 (10.7) ; **(3)** 55.0 (10.8); **(4)** 55.4 (10.0); **(5)** 56.0 (10.6)	Control: 56.5 Grade: 57.8 Face: 55.0
Mean baseline HbA1c (%)	NR	NR	Control: 10.2 Grade: 9.7 Face: 9.8
Gender (% female)	Control: 53.2 Intervention: 49.6	***(1) through (5)*** *refer to study arms, defined above* **(1)** 19.7; **(2)** 20.2; **(3)** 19.8; **(4)** 19.1; **(5)** 20.6	Control: 29.3 Grade: 22.4 Face: 27.9
Race (% Caucasian)	NR	NR	Control: 3.5 Grade: 3.4 Face: 6.6
Ethnicity (% Hispanic)	Control: 4.8 Intervention: 2.6	NR	NR
INTERVENTION CHARACTERISTICS			

	Austin, USA[64]	Gopalan (1), South Africa[70]	Gopalan (2), USA[74]
Strategy	Financial incentives and patient reminders	Message-framing	Message-framing
Program details	Participants notified by postal letter that they were past due for lab testing; $6 gas cards offered as reward for completing test	5 e-mail messaging strategies (detailed in “study design”) used to encourage participants to join HF program; 1 initial e-mail and 2 reminder e-mails	Glycemic control shown using 1 of 3 strategies in letters sent via postal mail: (1) HbA1c; (2) letter grade; (3) face/emotion
Duration	3 months	1 month	6 months
Primary outcomes	Increased HbA1c screening frequency among intervention vs. control group in 2-years after intervention (3.34 vs. 2.69 screening tests) *	All message groups had higher HF enrollment rates than the control group *; enrollment rates were highest in the EAC arm	HbA1c at 6 months did not differ significantly between groups.

	Grady, USA[71]	Hochberg, Israel[72]	Huntsman, USA[65]
REACH			
Enrolled	180	27	60
Analyzed	155	27	50
Study population	Diabetes outpatient facility	NR	Community health clinic; predominantly Hispanic/Latino population
Study design	Randomized controlled trial	Randomized controlled trial	3-arm randomized controlled trial: **1** Glucometer + standard lancet **2** Glucometer + financial incentive **3** Glucometer + pain-free lancet
Recruitment	Advertisements in local newspapers	NR	Patients recruited during routine medical visits
Screening	Certified diabetes educator assessed cognitive and physical ability to perform foot care.	NR	Screening of medical records performed so eligible patients notified at regular visit.
Eligibility	Age ≥18 years; T2DM for > 5 years; no known foot problems	T2DM; sedentary lifestyle	Age ≥18 years; insulin-dependent type 1 or type 2 diabetes; limited financial access to glucose monitoring system
PARTICIPANT CHARACTERISTICS			
Mean age in years (SD)	61.2 (11.4)	Control: 55.1 (3.6) Intervention: 58.7 (2.1)	NR
Mean baseline HbA1c (%)	NR	Control: 8.7 Intervention: 7.7	NR
Gender (% female)	58.7	Control: 14 Intervention: 40	NR
Race (% Caucasian)	NR	NR	NR
Ethnicity (% Hispanic)	NR	NR	NR
INTERVENTION CHARACTERISTICS			

	Grady, USA[71]	Hochberg, Israel[72]	Huntsman, USA[65]
Strategy	Message-framing	Message-framing	Financial incentives
Program details	Foot care educational video adapted to gain-framed (i.e. positive outcome of good foot care) and loss-framed (i.e. negative outcome of poor foot care) versions; participant behavior was assessed at 0-, 3-, and 6-months.	Control group: weekly SMS reminders to exercise Intervention: personalized SMS messages (1 to 7 per week) to encourage physical activity through positive and negative feedback with and without social component	Participants in all 3 study arms (detailed above) instructed to measure blood glucose 2/day; glucometer data reviewed by study team at 30 days; incentive group rewarded with gift cards based on the number of measurements (maximum $50).
Duration	1-time intervention, 10-minutes in duration	3 months	30 days
Primary outcomes	Foot care behavioral scores increased in both groups; gain-framed messages led to sustained positive behavior change *	Intervention participants increased minutes of walking/day compared to the control participants *	No significant differences between groups in adherence to self-monitoring of blood glucose

	Long, USA[69]	Misra-Hebert, USA[68]	Myers, USA[73]
REACH			
Enrolled	118	1,092	NR
Analyzed	118	1,092	239
Study population	African American veterans	Academic medical center Employee Health Program (EHP) members	Adults with T2DM
Study design	3-arm randomized controlled trial	Retrospective cohort study; 2-year cohorts used to analyze effect of specific incentives (2008–09, 2009–10, 2010–11, 2011–12)	Randomized controlled trial
Recruitment	Eligible participants contacted by study team	NA	Eligible participants contacted by study team
Screening	Medical record review	EHP claims data linked with medical record data	Medical record review
Eligibility	T2DM; HbA1c ≥8% on 2 occasions; age 50–70 years; black/African American	T2DM	T2DM, Age ≥18 years
PARTICIPANT CHARACTERISTICS			
Mean age in years (SD)	Control: 60(4) Peer mentor group: 60 (5) Financial incentive group: 59 (5)	NR	58.63 (11.96)
Mean baseline HbA1c (%)	Control: 9.9 (1.6) Peer mentor group: 9.8 (1.8) Financial incentive group: 9.5 (1.2)	2008–09: 7.52 (1.82) 2009–10: 7.35 (1.57) 2010–11: 7.33 (1.6) 2011–12: 7.31 (1.69)	NR
Gender (% female)	Control: 8 Peer mentor group: 0 Financial incentive group: 10	2008–09: 73 2009–10: 72 2010–11: 71 2011–12: 71	52
Race (% Caucasian)	0	2008–09: 62 2009–10: 61 2010–11: 58	70

	Long, USA[69]	Misra-Hebert, USA[68]	Myers, USA[73]
		2011–12: 58	
Ethnicity (% Hispanic)	0	NR	12
INTERVENTION CHARACTERISTICS			
Strategy	Financial incentives	Financial incentives	Message-framing
Program details	Peer mentor group: mentor had controlled T2DM and was trained in motivational interviewing; weekly mentor-mentee telephone calls encouraged. Financial incentives: $100 for 1 point HbA1c decrease or $200 for 2 point decrease or HbA1c ≤ 6.5% at 6 months	2008–09: fixed $100 incentive to participate in a disease management program 2010: fixed $300 incentive 2011–12: up to 30% health insurance premium discount based on participation and achievement of clinical goals (HbA1c < 7%)	Participants received health messages framed by valence (gains vs losses) crossed with temporal proximity (immediate vs distal) in four frames, surveys sent via mail
Duration	6 months	4 years	1 time intervention
Primary outcomes	Change in HbA1c at 6-months: Peer support: −1.07 (95% CI −1.84 to −0.31)* Incentive: −0.45 (95% CI −1.23 to 0.32)	The change in HbA1c was not significant between EHP members and non-employee comparison group	There were no significant differences in the intention to increase physical activity among frames

	Raiff, USA[66]	Sen, USA[67]
REACH		
Enrolled	3	75
Analyzed	3	75
Study population	T2DM patients of a local endocrinology clinic.	Primary care medical home patients
Study design	Multiple baseline design	3-arm randomized controlled trial: **1** No incentive (control) **2** Low-lottery incentive: ($1.40/day) **3** High-lottery incentive ($2.80/day)
Recruitment	Participants recruited during routine office visits	Eligible participants contacted by study team
Screening	Medical record review	Medical record review
Eligibility	T2DM; age 30–75 years; oral T2DM treatment requiring ≥2 daily doses; missed ≥ 1 dose in past 7 days; HbA1c 7–10%	Age18–80 years; HbA1c ≥7.5%
PARTICIPANT CHARACTERISTICS		
Mean age in years (SD)	45	Control: 54.1 (2.0) Low-incentive: 54.7 (2.1) High-incentive: 54.3 (1.9)
Mean baseline HbA1c (%)	NR	Control: 9.3 (0.3) Low-incentive: 9.3 (0.4) High-incentive: 9.8 (0.3)
Gender (% female)	33	Control: 61 Low-incentive: 67

	Raiff, USA[66]	Sen, USA[67]
		High-incentive: 65
Race (% Caucasian)	33	Control: 25 Low-incentive: 29 High-incentive: 27
Ethnicity (% Hispanic)	NR	NR
INTERVENTION CHARACTERISTICS		
Strategy	Financial incentives and patient reminders	Financial incentives
Program details	Baseline phase: electronic medication dispenser used to monitor medication adherence; $10 for completion (regardless of adherence) Treatment phase: text message reminders if medication was not taken within user-specified timeframe; financial reward for adherence started at $1.00 and increased by $0.20/day; $1.50 bonus for every 3 days of adherence; non-adherence reset reward to $1.00	All participants received 3 devices for self-monitoring: (1) glucometer; (2) blood pressure cuff; (3) digital scale; device data electronically transferred to study website; incentive-arm participants selected a 2-digit number between 1 to 99 at start of the study; the study's website randomly selected a number within this range each morning and participants could win if they had used all devices on the day prior
Duration	Baseline: 8–12 days; Treatment: 21–23 days	12-weeks
Primary outcomes	Daily medication adherence rates increased during the treatment phase compared to the baseline phase *	Low- and high-incentive participants had significantly higher rates of device adherence than control participants (low incentive: 81%, high incentive: 77%, control: 58%) * Adherence declined upon discontinuation of the incentive, particularly among high-incentive participants

* $p < 0.05$

NR = not reported