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Incentivizing behavior change to improve diabetes care

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Abstract

Behavioral economics refers to the study of psychological and cognitive factors that relate to decision-making processes. This field is being applied increasingly to health care settings, in which patients receive tangible reinforcers or incentives for meeting objective behavioral criteria consistent with healthy lifestyles. This paper reviews the background and efficacy of reinforcement interventions in general, and then as applied to behaviors related to diabetes prevention and management. Specifically, reinforcement interventions have been applied with some notable success toward promoting greater attendance at medical appointments, enhancing weight loss efforts, augmenting exercising regimes, improving medication adherence, and increasing blood glucose monitoring. Suggestions for promising areas of future research are provided, keeping in mind the controversial nature of these interventions.

Keywords

reinforcement; incentives; behavioral economics; diabetes

The literature is growing on the use of monetary reinforcers (or rewards) to improve health conditions with behavioral components [1]. These interventions invoke principles of behavioral economics (i.e., behavioral, social, cognitive, and emotional factors that relate to economic decisions) and behavior analysis (i.e., systematic manipulation of environmental variables that modify individual behaviors). Specifically, reinforcement interventions frequently assess healthy behaviors and provide tangible monetary-based incentives, consistent with behavioral economic principles, when clinically desirable behaviors occur.

Reinforcement interventions have demonstrated beneficial effects in treating numerous conditions, ranging from substance use disorders to obesity. They have also been applied to enhance adherence to medication and exercise regimens. As such, they have broad applicability for preventing some cases and improving outcomes of diabetes. This paper reviews the background and efficacy of reinforcement interventions as applies to patients; pay-for-performance initiatives for providers are not included in this review. The paper outlines specific behaviors that relate to diabetes prevention and care that may be amenable to change via reinforcement procedures. It also addresses some of the pros and cons around

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use of reinforcement interventions generally, as well as within the context of diabetes specifically.

A. Background

Reinforcement interventions have been applied to address clinical conditions for decades. They have a long history in the management of autism and mental retardation [e.g., 2] and more recently in the treatment of substance use disorders in the United States (US) [3,4] as well as the United Kingdom (UK) [5]. In this context, substance use is objectively assessed on a regular basis using breath or urine samples, and each time patients demonstrate abstinence, they receive immediate tangible rewards, such as vouchers exchangeable for retail goods and services or the chance to win prizes worth about £0.60 to £60 in value [6].

Numerous randomized clinical trials [7–9] as well as independent meta-analyses [3,4] demonstrate the strong impact of reinforcement interventions for reducing use of cocaine and other stimulants, opioids, alcohol, marijuana, and cigarette smoking. Nationally-based, multi-center clinical trials in the US [10,11] found that adding reinforcement interventions to usual care procedures significantly improves objective substance use outcomes. A meta-analysis of treatments for substance use disorders [12] found that reinforcement interventions yield the largest effect size of all psychosocial treatments. Recently, the Veterans Administration in the US called for implementation of reinforcement interventions in its substance abuse treatment clinics nationwide, leading to their wide-scale dissemination [13].

These procedures are based upon well-established behavioral analytic and behavioral economic principles. First, a behavior that is reinforced is likely to increase in frequency [14]; thus, reinforcing submission of negative urine samples increases the chances of future abstinence. Second, because individuals overvalue more proximal events and subjectively discount the value of delayed events [15], provision of reinforcers immediately upon demonstration of the behavior targeted for change is critical. Interventions that provide reinforcers delayed in time are less often effective, or even ineffective, in changing behavior [3]. Third, people tend to overvalue low probability high magnitude events [16], and this principle can be invoked to reduce overall costs of reinforcement interventions. Provision of occasional large value reinforcers can lead to behavioral change at relatively low costs [17].

These same behavioral economic principles may explain why some individuals engage in behaviors that increase their risk for diabetes and its adverse consequences. For example, eating dessert has instantaneous positive gustatory effects, while declining it is associated with few temporally proximate benefits. Exercising can be painful and has little immediate positive consequences, especially in sedentary individuals. The benefits of eating less and exercising more are delayed in time (weight loss and fitness take weeks or months to achieve) and are relatively abstract (feeling “better”). Similarly, potential adverse consequences of overeating and a sedentary lifestyle are long delayed in time and uncertain, as clearly not everyone who overeats and is inactive develops diabetes or has a heart attack; thus, these long-term consequences are heavily discounted in day-by-day decision making processes.

For patients with diabetes, following highly regimented diets and frequent blood glucose monitoring recommendations has few immediate salient benefits. Instead, the positive effects of complex diabetes care activities are years or decades delayed in time and uncertain, as some aspects of diabetes outcomes are beyond the control of the patient. For these reasons, the potential benefits of engaging in complex care activities are discounted and less likely to influence momentary decisions. These issues may be particularly salient in adolescents, who discount delayed events more than adults [18], perhaps in part explaining

the particularly poor adherence to diabetes care activities and suboptimal glycemic control in adolescents [19,20].

Reinforcement interventions re-arrange the environment so that the benefits associated with healthy behavioral choices have more immediate and concrete positive consequences. They have been extensively researched and are highly effective in encouraging abstinence from substances, which in essence reinforce the absence of a behavior. Reinforcing specific concrete behaviors, as can be the case in the context of diabetes care, is more straightforward.

The prevalence of diabetes is growing [21], and diabetes clearly leads to premature morbidity and mortality when it is not well controlled [22,23]. Diabetes is poorly controlled in about 45% of people with type 2 diabetes [24], and up to 70% of the US pediatric population with type 1 diabetes fails to meet glycemic recommendations [25]. New approaches, such as rewards for behavior changes, may improve glycemic control in patients with diabetes. Further, the increased incidence of diabetes worldwide [26] underscores the importance of exploring novel approaches. Although prevention of type 1 diabetes is not possible, many cases of type 2 diabetes can be prevented by lifestyle changes. Programs that reward people if they reach measurable health goals hold potential to reduce both the short- and long-term costs and consequences of type 2 diabetes, as well as improve outcomes in patients with type 1 diabetes.

B. Application of Reinforcement Procedures to Diabetes

Reinforcement interventions have been applied to behaviors of relevance to diabetes, including attendance at clinic appointments, weight loss, exercise, medication adherence, and blood glucose monitoring. Research in these areas is outlined, with suggestions for further study.

1. Attendance

Attendance at outpatient appointments for diabetes screening, prevention, and treatment is often suboptimal. Attendance is a behavior that can be objectively verified and reinforced. Attendance can be reinforced on an individual [27] or group [28] basis, and attendance rates increase substantially when reinforcers are provided. For example, one study [29] found that group attendance rose from a mean of less than 2 patients per week to over 14 patients per week when reinforcers were available, and these effects were achieved at costs of less than £15 per week. Similar reinforcement interventions could be applied to enhance attendance at nutritional, weight loss, or exercise groups in the context of diabetes prevention and care.

Austin and Wolfe [30] used a quasi-experimental design to evaluate the effect of reinforcement on appointment keeping and A1c testing in patients with diabetes. Patients who received a reminder letter plus a gasoline gift card worth about £4 for attending appointments came to significantly more visits for A1c testing (3.3 vs. 2.7) and had greater proportions of A1c levels at the recommended level (49% vs. 36%) than those who did not receive letters or gift cards. Although this study did not incorporate principles associated with successful reinforcement interventions such as frequent monitoring and reinforcement of behavior change, these results suggest that provision of simple reinforcers holds potential to improve diabetes care uptake and outcomes.

2. Weight loss

Reinforcement intervention can also be efficacious for promoting weight loss, an issue of direct relevance to Type 2 diabetes. Volpp et al. [31] randomized 57 overweight adults to an intervention consisting of monthly weigh-ins only or chances to win money when they met

weight loss goals over a 16-week treatment period. Patients who received reinforcement lost significantly more weight than those in the weigh-in only condition, with a mean weight loss of 1.8 kg in the control condition versus 6.1 kg for those receiving reinforcement.

Petry et al. [32] replicated and extended these results. Fifty-six overweight persons were randomized to one of two 12-week treatments: a state-of-the-art weight loss intervention--LEARN [33] with weekly supportive counseling and weigh-ins, or LEARN with weekly counseling and opportunities to win prizes for each pound lost. Patients who received reinforcement lost significantly more weight than patients in the non-reinforcement condition (6.1 vs 2.7 kg), with 64% in the reinforcement condition achieving clinically significant weight loss of 5% baseline bodyweight versus 25% in the LEARN and counseling only condition. Weight loss was associated with reductions in cholesterol and 24-hour ambulatory heart rate. These data suggest that reinforcement interventions can substantially enhance short-term weight loss, which in turn is related to changes in clinical biomarkers linked with type 2 diabetes.

However, reinforcement for weight loss may only be efficacious during the period in which reinforcers are available. Petry et al. [32] did not include a post-treatment follow-up, but Volpp et al. [31] found no maintenance of weight loss at a month 7 follow-up. John et al. [34] conducted a study to ascertain whether longer administration of reinforcers can maintain weight loss. In this study, 66 individuals were randomly assigned to weight monitoring with or without reinforcement for up to 32 weeks. As in the prior study, participants who received reinforcement lost more weight than those in the control condition (3.0 vs. 0.6 kg) during the intervention period. Follow-up data after the intervention ended, however, again indicated weight regain.

These data suggest that reinforcement interventions promote initial weight loss and extending the duration of time reinforcement is offered can sustain these effects. However, once reinforcers are removed, weight loss is not maintained. Even though open-ended reinforcement of a behavior can be expensive, it is important to consider such strategies in the context of diabetes prevention and care behaviors, which require lifelong attention. Reducing patient's proportions of health care costs is one approach that could be applied to sustain reinforcement [35]. To the extent these procedures incorporate behavioral economic and behavioral analytic principles, they may hold potential to improve long-term outcomes.

3. Exercise

Reinforcement interventions can also be applied to increase exercise. Walking is the most popular form of exercise [36], and it can be reinforced via pedometer readings. Petry et al. [37] randomized 45 sedentary older adults to one of two 12-week interventions in which they were given pedometers and guidelines to walk 10,000 steps per day or that same intervention with chances to win prizes for meeting step recommendations. Mean steps increased from about 4000 steps per day at baseline to 7400 during the intervention among participants assigned to the control condition, and to 9400 among participants assigned to the reinforcement condition. In this study, significant benefits of the reinforcement persisted at a 24-week follow-up in which participants who had earlier received reinforcement continued to walk at higher rates than their counterparts in the control intervention. Moreover, significant time-by-treatment effects were noted for weight loss, blood pressure, and fitness indices, with participants assigned to the reinforcement intervention showing greater improvements in each of these parameters over time.

These findings suggest that in some contexts and populations reinforcement interventions can lead to sustained behavior change. Similar approaches may be especially helpful for patients with metabolic syndrome or those with type 2 diabetes, because increases in

exercise and fitness can improve body composition, reduce insulin resistance, lower blood glucose levels, decrease doses of anti-diabetic medications and enhance psychological well-being.

4. Medication adherence

Adherence to medications can be also improved by providing reinforcement, and this is another area of particular importance to the treatment of diabetes, especially in patients who require treatment with insulin. A meta-analysis [38] identified 21 published studies that evaluated the impact of reinforcement on medication adherence. Reinforcement interventions significantly improved adherence relative to control conditions with an overall effect size of 0.77 (95% confidence interval = 0.70–0.84). Interventions that were longer in duration, provided average reinforcement of about £30 or more per week, and reinforced patients at least weekly resulted in significantly larger effect sizes than those that were shorter, provided lower reinforcers, and reinforced patients less frequently. These results demonstrate the efficacy of reinforcement interventions for enhancing medication adherence and they underscore principles that should be considered in designing effective reinforcement interventions.

The development of reinforcement interventions for medication adherence in diabetes can be challenging. Reinforcement interventions in insulin-treated patients are difficult to institute because compliance with prescribed insulin injection regimens is virtually impossible to monitor objectively. With current “smart” insulin pumps, objective records of meal-time bolus doses can be obtained from the pump’s computer, but most insulin pump patients are not on a fixed meal schedule. For orally administered medications, medication containers with electronic caps are typically used, and reinforcement can be provided when caps are opened at the appropriate times each day [39]. Opening medication containers, however, is not necessarily consistent with consumption; these procedures may instill “cheating” behaviors, especially if applied to medications with adverse side effect profiles. Measuring and reinforcing biological indices of medication levels is possible, but cumbersome, often invasive, and unlikely to be done with sufficient frequency to engender behavior change. For these reasons, studies reinforcing adherence to diabetes medications have not been conducted, but as technology improves this may be an area in which reinforcement procedures may be beneficial.

5. Other diabetes care behaviors

Other behaviors that relate to diabetes care that have a substantial impact on metabolic control can be objectively monitored and reinforced. One such example is self-monitoring of blood glucose levels. In a pilot study, Raiff and Dallery [40] used reinforcers to increase blood glucose monitoring in four adolescents with type 1 diabetes. Rates of monitoring increased from 1.7 times per day in baseline to 5.7 times per day when reinforcers were provided. Both patients and parents rated the program highly favorably on many dimensions. Although the study was of small size and short duration (less than 3 weeks), reinforcing glucose monitoring is feasible and acceptable and may be effective in improving blood glucose monitoring frequency, which in turn may improve insulin dosing, eating and exercise decisions, thereby lowing A1c.

Long et al. [41] attempted to reinforce patients for improving A1c levels directly. They randomized 118 veterans with diabetes to a usual care intervention, a peer intervention, or a reinforcement intervention in which they received about £60 for reducing their A1c moderately and £120 for reducing it to a greater degree or to the recommended level. There was no evidence that this intervention was efficacious in reducing A1c. This reinforcement intervention only provided a single opportunity to earn reinforcement, whereas most

efficacious reinforcement interventions provide multiple attempts to earn rewards. There was a long delay of 6 months between the occurrence of behaviors that impact A1c (e.g., blood monitoring, insulin dosing, and eating and exercise decisions) and the delivery of reinforcement. This study underscores that behavior analytic and behavioral economic principles need to be considered in designing successful interventions. Further, reinforcing biological outcomes may be inappropriate in some populations [e.g., 42] and perhaps especially adolescents with type 1 diabetes, because A1c can be impacted by factors beyond patients' control including illness, growth, and hormonal changes.

C. Future Directions and Challenges

Results of studies in diabetes that have been reported to date suggest that reinforcing diabetes-related *outcomes* may be more challenging than reinforcing specific *behaviors* that impact health outcomes [42]. One patient behavior that has been shown to have a major impact on lowering A1c levels in patients with type 1 diabetes is the frequency of blood glucose monitoring [20,43,44]. The new University of Connecticut-Yale "Testing for Dollars" study is examining whether monetary reinforcement will increase glucose monitoring in adolescents with type 1 diabetes and the impact of increased monitoring on A1c levels. A major advantage of reinforcing daily blood glucose monitoring is that it can be verified by meter downloads and frequently reinforced. Similarly, the introduction of devices for continuous monitoring of interstitial glucose levels has offered the potential to transform the care of type 1 diabetes by allowing a much larger proportion of patients to achieve target A1c levels more safely. However, the Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group [45] found that improved control of type 1 diabetes can only be achieved and maintained if the devices are used on a nearly daily basis. Unfortunately, many participants in that trial did not use the devices with sufficient frequency. Adherence to wearing the monitor can be verified by sensor uploads to internet-based data management systems, and this behavior could be reinforced in real time and thereby holds potential to reduce A1c levels as well.

Reinforcement interventions are particularly powerful in shaping initial behavior change, and long-term change cannot occur without initial change. Similarly to many pharmacotherapies, behavioral interventions may be efficacious only during periods they are in effect. Maintaining change may require long-term reinforcement administration or development of novel interventions to sustain effects once initial change occurs. Because diabetes prevention and care are lifelong activities, much more research is needed to evaluate how initial behavior change can lead to sustained change as well as improved biological outcomes.

The use of reinforcement interventions for initiating and maintaining behavior change is highly controversial [46]. Opponents note that these interventions may label individuals as non-compliant or be considered paternalistic, hold potential to be unfairly applied, and may have unintended effects including encouraging individuals with healthy behavior patterns to adopt unhealthy ones to access reinforcers. Reinforcers may be considered coercive in low-income and disadvantaged populations in which type 2 diabetes is common, and the converse of reinforcers, i.e., penalizing individuals for smoking, being obese, or not taking medications, unfair. Clearly, ethical and practical concerns need to be considered carefully prior to wide-scale implementation of reinforcement interventions, and only interventions with a demonstrated evidence base of effectiveness should be applied clinically.

Public attitudes towards health care incentives have been evaluated in the UK. Providing reinforcers to individuals who are perceived as not responsible for their condition are viewed most favorably [47], and therefore these procedures may be acceptable for adolescents with

type 1 diabetes. Further, reinforcing certain health behaviors such as weight loss was viewed much more favorably than reinforcing behaviors such as smoking cessation, and an increase in the effectiveness of reinforcement procedures by just 1% increased its acceptability by 9% [48].

Importantly, reinforcement interventions can be highly effective in improving patient behaviors and outcomes, which in the case of diabetes can lead to both personal and societal benefits. Although reinforcement interventions incur costs, methods to reduce costs are being evaluated such as using deposits paid for in whole or part by patients [31,34] and arranging low probability, high magnitude reinforcers [6,9]. Ultimately, reinforcement procedures may prove cost-effective [49], especially in closed health care systems in which the long-term savings of preventing diabetes and its consequences are realized by the funder [e.g., 50]. Funders of reinforcement interventions, along with the public, should carefully consider the potential benefits of adding reinforcement interventions to diabetes prevention and care. Although great progress has been made in treating diabetes and preventing many of its adverse consequences, the treatments require intensive and chronic management, and patient behaviors play a major role in determining health outcomes. Reinforcement interventions, when appropriately designed and implemented, can have pronounced effects on changing patient behaviors. Discounting the strong evidence basis of these procedures may prove unwise.

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