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TEXT-MESSAGE REMINDERS PLUS INCENTIVES INCREASE ADHERENCE TO ANTIDIABETIC MEDICATION IN ADULTS WITH TYPE 2 DIABETES

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Abstract

Some adults with Type 2 diabetes mellitus have difficulty adhering to their oral medication regimens. The current study used a multiple baseline design with 3 adults with Type 2 diabetes. Medication taking was monitored remotely in real time via an electronic pill bottle. During the intervention, monetary incentives were delivered contingent on evidence of adherence to taking medication at specified times. Text-message reminders were also sent if medication was not taken. Adherence increased for all participants. Future studies should separate the relative contributions of text-message and incentive components of the intervention.

Keywords

contingency management; incentives; medication adherence; text message; Type 2 diabetes mellitus

Many adults with Type 2 diabetes mellitus have difficulty adhering to their prescribed oral medication regimens (Donnan, MacDonald, & Morris, 2002). Greater adherence with oral antidiabetic medication (e.g., Metformin) in adults with Type 2 diabetes is correlated with lower glycated hemoglobin (A1C), the gold standard measure of glycemic control that reflects diabetes management over the previous 3 months (Rozenfeld, Hunt, Plauschinat, & Wong, 2008). Not only is it important to take the correct number of doses per day, but it is also important to take medication during specified time windows to maintain stable blood glucose levels throughout the day (American Heart Association, 2016). Medical complications associated with diabetes (e.g., cardiovascular disease, retinopathy, neuropathy, nephropathy, death) can be minimized with intensive glycemic control, particularly when A1C values are over 7% (American Diabetes Association, 2014; Holman, Paul, Bethel, Matthews, & Neil, 2008). In addition to the negative effects of these medical complications

on an individual's quality of life and life expectancy, these complications also result in excessive costs, both in terms of direct medical expenses for the individual and insurance companies and the indirect costs associated with lost productivity (Dall et al., 2010).

Providing incentives in the form of contingent monetary vouchers has been effective at increasing blood glucose testing (Raiff & Dallery, 2010), asthma medication (Burkhart, Rayens, Oakley, Abshire, & Zhang, 2007), HIV antiretroviral medication (Moore et al., 2015), and antihypertensive medication adherence (Petry, Alessi, Byrne, & White, 2015), and are therefore worth investigating to increase adherence with oral antidiabetic medication regimens in adults with Type 2 diabetes. One factor that is particularly important with contingency management (CM) interventions is the immediacy of the consequences relative to the occurrence of the target response (in this case, medication taking; Roll, Reilly, & Johanson, 2000). To overcome this barrier, the current study involved delivery of CM with a real-time medication-monitoring device, Wise-pill, which transmits a signal via short message service to a server so that researchers can be notified immediately when the pill container is opened. Real-time monitoring allowed us to provide more immediate feedback and incentives by sending a text message to the participant's mobile phone when adherence was observed. Furthermore, because we were able to monitor medication adherence in real time, this was the first study to investigate the combined effects of pairing text-message reminders in the context of a CM intervention. Participants in the current study were sent tailored text-message reminders when, and only when, the Wisepill device did not detect pill taking during a specified time window.

METHOD

Participants

Participants were recruited during their routine doctor visits at a local endocrinology clinic. To be eligible, individuals (a) had to be 30 to 75 years of age, (b) have a text-enabled mobile phone, (c) have a Type 2 diabetes diagnosis, (d) be prescribed oral antidiabetic medication for more than 3 months that required at least two doses per day, (e) have missed at least one dose in the past 7 days, (f) have an A1C value of 7% to 10%, (g) have no diagnosis of a mental health condition in the last 6 months, and (h) not be pregnant. We recruited one Caucasian woman (DS001) who was 51 years old, took oral antidiabetic medication thrice daily, and had been diagnosed with Type 2 diabetes at the age of 21 years; one African-American man (DS003) who was 42 years old, took oral antidiabetic medication twice daily, but did not report the age at which he had been diagnosed; and another African-American man (DS006) who was 43 years old, took oral antidiabetic medication twice daily, and had been diagnosed at the age of 38 years.

Materials

Participants were loaned a Wisepill portable medication dispenser (30 mm by 60 mm by 130 mm; 130 g) that could hold up to 60 small pills at one time to track their medication adherence in real time. The Wisepill dispensers contain a mobile phone communication chip that sends a wireless signal to a central management system (Wisepill web server) every time the dispenser is opened. We were able to monitor medication adherence remotely and

in real time using this web application. The application also contains an automated text-messaging feature that can be programmed to send customized messages to participants' mobile phones if a dose was not taken during a user-defined time period.

Procedure

After an initial screening, participants attended an intake appointment to provide informed consent and completed a battery of questionnaires on demographics, general health history, and diabetes-specific history. Next, a research assistant trained participants on appropriate use of the Wisepill dispenser, reviewed the study procedures, and delivered a short verbal quiz to ensure understanding. Participants were instructed to fill the device with their medication at the start of the study and to refill the device after taking the last pill in the container. Each participant provided ranges of 2 to 4 hr during which he or she would take the medication (e.g., the first dose between 7:00 and 10:00 a.m. and the second dose between 8:00 and 11:00 p.m.). Medication adherence was defined as a Wisepill electronic medication event recorded during these individually specified ranges. At intake, each participant also constructed a customized message to be received on his or her mobile device during part of the intervention if he or she had not taken the medication halfway through the specified dose interval. At the conclusion of the study, participants returned the dispenser and answered questions about whether they experienced any adverse medical events during the study and the acceptability of the intervention. The acceptability survey included close-ended questions (e.g., "How helpful was the treatment in getting you to take your medication regularly?") that were rated on a 7-point Likert scale (1 = *not helpful*, 7 = *very helpful*) and open-ended questions about what they liked most and least. Questions dealt with both the overall treatment and individual components (e.g., vouchers, dispenser, text messages).

Experimental Conditions

We used a nonconcurrent multiple baseline design across participants. During baseline, participants were instructed to take their medication as usual using the Wisepill dispenser. Medication adherence was monitored, but there were no contingencies in place for taking medication, and no text message reminders were sent. The baseline phase for each participant varied from 8 to 12 days, and \$10.00 was paid for completing it, irrespective of adherence. On the last day of baseline, a research assistant contacted each participant to notify him or her that the following day would mark the beginning of the treatment phase. During this phase, which lasted 21 to 23 days, participants received automatic text reminders from the Wisepill web application if a dose was not taken halfway through their designated time window (e.g., a text would be sent at 8:30 a.m. if a participant had not taken his or her dose between 7:00 and 10:00 a.m.). Participants could also earn vouchers for adhering to their medication regimens. An escalating payment schedule with bonus and reset contingencies was used based on daily adherence. Vouchers began at \$1.00 and increased by \$0.20 for each consecutive day of adherence. For every third day of perfect adherence, participants earned a \$1.50 bonus. If a dose was missed or taken outside the specified time interval, no voucher was awarded, and future earnings were reset to the initial \$1.00 amount. After a third consecutive day of perfect adherence, the amount was reinstated to the highest amount before the reset. Each morning during the treatment phase, participants received text messages that indicated how much they earned the previous day, their cumulative earnings to

date, and the amount that could be earned for that day if all doses were taken on time. Participants could earn from \$73.50 to \$84.10 for adhering to their medication regimens during the treatment phase, depending on phase duration. Participants could earn an additional \$10.00 for returning the equipment and completing follow-up questionnaires.

RESULTS AND DISCUSSION

Figure 1 shows that participants frequently failed to adhere to their daily medication regimens during baseline. DS003 and DS006 adhered on 50% of days, whereas DS001 did not adhere on any days. After introduction of the treatment, however, medication adherence increased substantially. Daily adherence rates for DS003, DS001, and DS006 were 95.4%, 91.3%, and 71.4%, respectively. Although participants did not take their doses on time during baseline, they took a high percentage of the scheduled doses at some point during the day, as shown in Figure 1 (81.3%, 96.7%, and 79.2%, for DS003, DS001, and DS006, respectively). Figure 2 shows that the intervention significantly increased the precision with which participants took their daily doses in the designated time window (Figure 2, left: mean percentage of doses taken on time during baseline = 75%, 26.7%, and 66.7%, vs. treatment = 97.7%, 97.1%, and 85.7%; Figure 2, right: mean time outside window during baseline = 88, 100.9, and 19.3 min vs. treatment = 0, 16, and 0 min for DS003, DS001, and DS006, respectively). Reducing inconsistencies in the time when oral antidiabetic medications are taken is important for increasing medication adherence and for maintaining stable blood glucose levels (American Heart Association, 2016; Vervloet et al., 2013).

There are several reasons why patients might fail to adhere with their medication regimens, but one of the most common reasons is because they forget (Lawton, Peel, Parry, & Douglas, 2008). On multiple occasions, all three participants had not taken their medications halfway through their targeted dose range and so received text-message reminders. DS006 received 13 text reminders for his 42 scheduled doses (30.9%) and adhered after receipt of these messages on seven occasions. For the 69 scheduled doses for DS001 during the treatment phase, she received 17 (24.6%) text reminders. DS001 took her medication on every occasion in which a text reminder was required, but for two doses this occurred outside her target time range. DS003 required only eight text messages for his 44 doses (18.2%) and adhered after all but one. Sending text messages when, and only when, a participant was at risk of missing a dose may have prevented participants from habituating to the messages or finding them burdensome. DS001 and DS003 each earned \$64.40 in vouchers for meeting their adherence goals, and DS006 earned \$25.70.

Overall, participants rated the intervention favorably (higher than 5 on a 7-point Likert scale), suggesting that it was helpful, enjoyable, convenient, and effective. Ratings indicated that participants would recommend it to others, enjoyed receiving text-message reminders, and liked earning vouchers for adherence. The lowest ratings (3 on the scale) were from DS001, who found the Wisepill container and treatment inconvenient. In open-ended questions, she noted that the Wisepill device was cumbersome to carry with her and to store her pills. She also did not like receiving the text messages that updated her on voucher earnings. When this study began (2011), there were few options for real-time medication monitoring, and the cost of the Wisepill device was approximately \$500. However, there are

now similar products on the market that cost considerably less and may be less cumbersome (e.g., imPak Health, \$150), and we expect this trend to continue with further technological advances.

One limitation of this study is the inability to separate the effects of the text-message reminders from the voucher deliveries because both changes were introduced simultaneously. Text-message reminders have been shown to increase adherence with oral antidiabetic medication (Vervloet et al., 2012); thus, follow-up studies will be needed to separate the relative influence of each component on adherence. Nevertheless, the current study serves as a systematic replication of previous research that has shown that tailored text-message reminders that are sent when, and only when, they are needed and contingent incentives can improve medication adherence. This is the first demonstration that the combination of the two interventions is feasible, acceptable, and effective.

Three other limitations of the study are worth noting. First, medication taking was indirectly measured via the Wisepill device. Indirect medication monitoring with pill devices is commonly used and has been shown to be more accurate than other indirect measures of adherence when compared to biochemically verified measures of adherence (e.g., pill counts; Kardas, 2005). Others have relied exclusively on real-time medication-monitoring devices to assess the feasibility and acceptability of this approach (DeSilva et al., 2013). It is possible, although unlikely, that participants opened the pill container but did not actually take the medication. Future research would be improved if participants were asked if they ever opened the container without taking the medication. It is also possible that participants opened the container and removed more than one pill. In the current study, because of the incentives for opening the container at specific times, this is less likely. Nevertheless, future research should include measures of A1C to validate improvements in adherence and to determine whether clinically meaningful decreases are obtained. Second, the duration of the intervention was brief. Because diabetes is a chronic condition, medication adherence must be sustained over a long period of time. If incentives are used, it will be important to explore sustainable approaches. For example, the Affordable Care Act supports two types of employee wellness programs: participatory wellness programs that involve providing incentives to employees for meeting a specific standard (e.g., enrolling in a treatment program) and health-contingent wellness programs that involve providing incentives when employees meet specific health-related goals (e.g., reaching A1C targets, demonstrating medication adherence; U.S. Department of Labor, 2014). These programs may offer a viable solution to supporting a more sustainable incentive-based intervention for promoting adherence.

In conclusion, the current findings serve as a systematic replication of previous research that has shown that text-message reminders and monetary incentives can be used independently to increase adherence with the correct timing of taking antidiabetic medications, particularly with nonadherent adults with Type 2 diabetes. This is the first study to combine the two interventions and to use a real-time medication-monitoring device for implementing a CM intervention for individuals with Type 2 diabetes. Future research should attempt to determine the relative impact of the tailored text-message reminders compared to incentives,

to measure clinically meaningful outcomes, to use less costly and less cumbersome devices, and to identify methods for encouraging long-term sustainability.

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Figure 1.

Daily medication adherence across baseline and treatment. White boxes indicate days in which at least one dose was missed. Gray boxes indicate days on which all doses were taken but at least one was not taken on time. Black boxes indicate days on which all doses were taken on time. White (DS003) and black (DS001, DS006) vertical lines indicate phase changes.

Figure 2.

Left: Percentage of doses taken on time during baseline and treatment. The horizontal bars indicate the mean of all participants. Right: Mean time outside the acceptable dose window for doses taken but not taken on time during baseline and treatment. The horizontal bar indicates the mean of all participants. DS003 and DS006 did not take any doses outside the time window during treatment.