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A Behavioral Economics-Based Telehealth Intervention to Improve Aspirin Adherence Following Hospitalization for Acute Coronary Syndrome

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Abstract

Purpose: A significant number of patients with acute coronary syndrome (ACS) are nonadherent to aspirin after hospital discharge, with an associated increased risk of subsequent cardiovascular events. The purpose of this pilot study was to test the efficacy of a telehealth intervention based in behavioral economics to improve aspirin adherence following hospitalization for ACS.

Methods: We enrolled 130 participants ($X=58\pm10.7$ years of age, 38% female, 45% black) from two hospitals. Patients were eligible if they owned a smartphone and were admitted to the hospital for ACS, prescribed aspirin at discharge, and responsible for administering their own medications. Consenting participants were randomized to the intervention or usual care group. The intervention group was eligible to receive up to \$50 per month if they took their medicine daily, with \$2 per day deducted if a dose was missed. All participants received an electronic monitoring (EM) pill bottle containing a 90-day supply of aspirin, which was used to measure adherence calculated as the proportion of prescribed drug taken using the EM device. Based on the skewness in the adherence distribution, quantile regression was used to evaluate the effect of the intervention on median adherence over time.

Results: After 90 days, adherence fell in the control group, but remained high in the intervention group (median adherence 81% vs. 90%, $p=0.18$). Rehospitalization was higher in the control group (24% vs. 13%, $p=0.17$).

Conclusion: A loss aversion behavioral economics-based telehealth intervention is a promising approach to improving aspirin adherence following hospitalization for ACS.

Keywords

medication adherence; behavioral economics; loss aversion; technology; myocardial infarction; unstable angina; randomized controlled trial

In patients with acute coronary syndrome (ACS), adherence to secondary prevention medications is poor. Approximately 24% of ACS patients do not fill their cardiac medications within 7 days after discharge,¹ adherence rates are typically around 60–75% (and may be worse for aspirin).² During the first year, 10% to 20% of patients discontinue prescribed medications.³ Medication nonadherence is associated with increased cardiovascular readmissions, morbidity, and mortality.¹

Investigators have tested numerous informational and behavioral interventions to improve medication adherence, but adherence is inconsistently influenced by these approaches.⁴ Recent evidence suggests that technology may help address adherence;⁵ however, results have been mixed.⁶ One reason may be that reminders and monitoring do not directly address motivation to adhere. Another potential barrier is lack of patient engagement.⁷ Economics may facilitate patient motivation and engagement by reducing cognitive and emotional barriers to healthy behavior and restructuring environments to facilitate better choices.⁸

Behavioral economics (BE) is an approach to modifying behavior that is based on the theory that rewards such as financial incentives can improve behavior through countering present-biased preferences.⁹ BE is based on the premise that people make errors in judgement, and systematic errors or biases recur predictably in particular circumstances.¹⁰ BE is thought to stimulate motivation using knowledge of decision-making biases such as present bias, mental accounting, loss aversion, anticipated regret, the intent-behavior gap, and bounded rationality to maximize medication adherence.¹¹ With the belief that people are motivated by incentives, with more sensitivity to losses than gains, BE interventions are typically in the form of financial incentives and nudges. In this study, our aim was to determine if a BE-based telehealth intervention could improve low-dose aspirin adherence in patients following hospitalization for ACS.

Methods

The aim of this pilot randomized clinical trial (RCT) was to compare the efficacy of a mobile application (“app”) rooted in behavioral economics created by Wellth, a health-based mobile application development company, on medication adherence. We hypothesized that participants randomized to receive the intervention would have better medication adherence and fewer rehospitalizations over a 90-day follow-up period. The Institutional Review Board at the University of Pennsylvania approved the study and all participants provided written informed consent.

Sample

We sought a sample of 140, estimated to provide 80% power to detect a 10% absolute difference in medication adherence defined as the proportion of prescribed drug taken (%PDT) between intervention and control arms, assuming an interclass correlation coefficient (ICC) of $\rho=0.95$ among 3 measurements per person, $\alpha = 0.05$, a standard deviation of adherence of 0.2, and 10% dropout. The 10% difference represents the clinically meaningful difference in medication adherence identified in prior research.¹² This systematic review found that for every 10% increase in medical adherence an additional 6.7% of cardiovascular events could be prevented over 10 years.

We enrolled 130 participants from two acute care hospitals in Philadelphia, Pennsylvania. Patients were eligible to participate if they were over 21 years of age, admitted to the hospital for acute myocardial infarction (MI) or unstable angina, prescribed once-per-day aspirin at discharge, and responsible for administering their own medications. They needed to own a smartphone with a sufficient data plan or home Wi-Fi to enable app use and avoid overage charges, adequate vision, and be able to speak and understand English. Patients were excluded if they were diagnosed with MI following a non-cardiac admission, were discharged to any facility other than home, had cognitive impairment or untreated mental illness, were unable to operate their smartphone and/or the app, or had a life expectancy less than 6 months. Patients were considered technically proficient in using the app if they reported using other apps to perform tasks that are more complex than placing and receiving regular phone calls (e.g., using social media, responding to emails, or reading the news on their phone) and they could complete a successful medication check-in through the app. All participants were provided with an electronic monitoring (EM) pill bottle containing a 90-day supply of aspirin (90 pills), which was used to measure adherence.

Eligible and consenting patients were randomized to the intervention or usual care group, with randomization stratified by study site. All participants received \$20 on enrollment and an additional \$20 at 90-days, contingent on completing a brief follow-up phone call and returning the EM device in a prepaid envelope.

Intervention

The intervention group participated in a 90-day adherence promotion program based on behavioral economics. With a focus on loss aversion, the intervention group was eligible to receive up to \$50 per month if they took their medicine daily, with \$2 per day deducted if a dose was missed. Participants' earnings were paid out in lump sums monthly, minus penalties incurred. The intervention was designed to prevent adversely incentivizing over-medication by penalizing for not taking medications rather than rewarding for taking medications.

The intervention was delivered through the Wellth mobile phone application. Daily electronic messages reminded participants to take their aspirin at a time prespecified by the participant. Within a 12-hour window, participants were required to upload a photo of the pill in their hand through the Wellth app on the phone. Presumably the pill was ingested

after the photo was taken. The app ceased to offer financial incentives for medication check-ins after 90 days of follow-up.

Control Arm

Participants in the control arm used the same EM device used in the intervention arm but they did not receive the compensation for adherence.

Measurement

We assessed adherence daily and summarized it in three 30-day intervals for each person. Medication adherence was calculated as the proportion of prescribed drug taken or %PDT¹³ monthly using the EM device. We initially used an EM device manufactured by CleverCaps® (Compliance Meds Technologies, Miami FL), but later switched to the Medication Event Monitoring System (MEMS) (Aardex Ltd, Zug, Switzerland). Both devices provided the same information on pill bottle opening. We monitored a single drug, low-dose aspirin, preloaded into the device by a pharmacist. Diaries were provided to participants to record accidental openings and electronic errors. This information was used to manually correct the EM data by removing phantom openings and inserting electronically registered events. Days in the hospital during the study period were removed prior to analysis.

Data collected from participants at enrollment included basic demographic information. Clinical information (e.g., prior MI, history of coronary artery disease, prior coronary artery bypass grafting or percutaneous intervention, risk factors) and rehospitalization events were collected from the electronic medical record.

Data Analysis

All analyses comparing outcomes by arm were done using intention to treat principles. The investigators were blinded to group assignment and all outcome data until study completion. Sociodemographic and clinical data were summarized and compared by arm using mean ($\pm$ standard deviation) for count and continuous variables and frequency (percent) for categorical variables. Differences in participants' characteristics by arm were assessed by standardized mean differences, where a standardized mean difference ≥ 0.1 indicates imbalance. Percent adherence was calculated in each period as the number of days a pill was taken divided by the total number of days in that time period, excluding emergency department hospital visits. Adherence was summarized and graphically displayed by arm and 30-day intervals using standard descriptive statistics for location and spread.

Based on the skewness in the adherence distribution, quantile regression was used to evaluate the effect of the intervention on median adherence over time. The model included 30-day period, arm, and the period-intervention interaction. Standard errors, confidence intervals, and p-values were determined by the nonparametric bootstrap with resampling by participant to account for within-participant correlation of adherence outcomes. Covariate-adjusted models included factors with standardized mean differences of ≥ 0.1 . Rehospitalization was compared by arm using Fisher's Exact test and Kaplan-Maier curves with log rank test in time-to-event analysis.

Results

The 130 participants were randomized to intervention (n=62) or control (n=68). Sociodemographic and clinical characteristics are shown in Table 1. Of those randomized, 34 (26%) were lost due to technical cap failure, failure to return the cap, or withdrawal, leaving 96 (n=46 intervention, n=50 control) analyzable participants to evaluate the intervention effect. Median adherence was high in both arms at 30 days, declined to 0.81 by 90 days in the control arm, and remained high (0.90) in intervention arm (Figure 1).

Quantile regression analysis confirmed a decline in median adherence in the control arm, with median adherence estimated to decline by 0.05 each period ($p=0.16$, 95% CI $-0.11-0$). Estimated change in median adherence per period in the intervention arm was -0.0023 ($p=0.92$, 95% CI $-0.08-0.02$). The difference in adherence trend by arm, however, was not statistically significant (estimate=0.04, $p=0.18$, 95% CI $-0.03-0.11$). Estimates from covariate-adjusted models were similar. Rehospitalization occurred in 16 (23.9%) participants in the control arm and 8 (13.1%) in the intervention arm ($p=0.17$ Fisher's Exact), with corresponding slightly shorter time to hospitalization observed among control participants ($p=0.14$).

Discussion

Although underpowered to detect significant group differences primarily because of high rates of electronic cap failures, this study demonstrated a promising trend in adherence consistency over time in the intervention arm that was not seen in the control arm. This result is important because much has been written about the contribution of habits in promoting medication adherence, but few interventions have been developed to help patients cultivate better medication taking habits. Use of an innovative behavioral economics approach to motivating healthy behavior may be an efficacious approach to promoting habits.

The scientific and clinical relevance of this study is linked to the scale of the problem. Poor medication adherence is an intractable problem estimated at 40–60% of people prescribed medication for a chronic condition.^{14–16} As the US surgeon general, C. Everett Koop, famously noted in 1985, “Drugs don’t work in patients who don’t take them.” Yet, years later we remain unable to combat medication nonadherence. Although numerous interventions designed to improve adherence have been tested, only modest benefit has been achieved to date.

Since Richard Thaler won the 2017 Nobel Prize in economics for developing BE, BE has been used in a variety of fields, including healthcare. Companies in the US are partnering with healthcare insurers and providers to incentivize people to change behavior, combining mobile technologies with concepts from BE to help patients keep track of their most important health activities and stick with them over time. Thus, the promising intervention tested in this pilot study has potential for wide-spread application.

Limitations include the inadequate sample size (due in part to missing outcome data from technical cap failures) and concern that telling patients that their medication dosing is being

monitored could influence behavior (although both arms were monitored). However, others have found that initially behavior may be briefly influenced by monitoring, but the effect on behavior is minimal and short-lived.¹⁷

Future research is indicated using a larger sample size and Bluetooth-enabled EM devices to ensure complete ascertainment of adherence. Examining the effects of discontinuing interventions like this on subsequent adherence is needed.

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Five key points:

1. Medication adherence continues to be a challenging issue.
2. Interventions tested to date are rarely effective.
3. Behavioral economics is a promising approach to changing behavior.
4. Adherence to once daily aspirin remained high over time in study participants receiving a behavioral economics-based telehealth intervention.
5. Rehospitalization was lower in the intervention group compared with the control group.

Figure 1. Median adherence by arm and month

Figure 1 illustrates that median medication adherence remained high and consistent in the intervention group over the 90-day follow-up period. In the control group, adherence to the prescribed aspirin declined steadily over time.

Table 1.

Demographic and Clinical Characteristics by Study Arm

		Total	Control	Intervention	SMD[*]
	N	130	68	62	-
	Age	58.4 (10.7)	57.3 (10)	59.5 (11.3)	0.21
	Number of Illnesses	4 (2.2)	4.3 (2.3)	3.7 (2)	0.26
Sex	Male	80 (61.5%)	43 (63.2%)	37 (59.7%)	0.07
	Female	50 (38.5%)	25 (36.8%)	25 (40.3%)	0.07
Race	Black	59 (45.4%)	34 (50%)	25 (40.3%)	0.19
	White	63 (48.5%)	30 (44.1%)	33 (53.2%)	0.18
	Other	8 (6.2%)	4 (5.9%)	4 (6.5%)	0.02
Married or Living with Partner	No	67 (51.5%)	33 (48.5%)	34 (54.8%)	0.13
	Yes	63 (48.5%)	35 (51.5%)	28 (45.2%)	0.13
Live with others	No	23 (17.7%)	10 (14.7%)	13 (21%)	0.16
	Yes	107 (82.3%)	58 (85.3%)	49 (79%)	0.16
Have someone to confide in	No	2 (1.5%)	1 (1.5%)	1 (1.6%)	0.01
	Yes	128 (98.5%)	67 (98.5%)	61 (98.4%)	0.01
Education	< High School	6 (4.6%)	4 (5.9%)	2 (3.2%)	0.13
	High School or Trade School	43 (33.1%)	26 (38.2%)	17 (27.4%)	0.23
	At least Some College	81 (62.3%)	38 (55.9%)	43 (69.4%)	0.28
Employed	No	71 (54.6%)	39 (57.4%)	32 (51.6%)	0.11
	Yes	59 (45.4%)	29 (42.6%)	30 (48.4%)	0.11
Income Adequacy	Comfortable	59 (45.7%)	30 (44.1%)	29 (47.5%)	0.07
	Enough to Make Ends Meet	41 (31.8%)	20 (29.4%)	21 (34.4%)	0.11
	Not Enough to Make Ends Meet	29 (22.5%)	18 (26.5%)	11 (18%)	0.2
Insurance (Highest Level)	Individual or Employer Sponsored	55 (42.3%)	25 (36.8%)	30 (48.4%)	0.23
	Medicare/Medicaid/Military	71 (54.6%)	40 (58.8%)	31 (50%)	0.18
	Uninsured/Other	4 (3.1%)	3 (4.4%)	1 (1.6%)	0.16
Perception of Health	Very Good or Excellent	15 (11.5%)	10 (14.7%)	5 (8.1%)	0.21
	Good	55 (42.3%)	25 (36.8%)	30 (48.4%)	0.23
	Satisfactory or Poor	60 (46.2%)	33 (48.5%)	27 (43.5%)	0.1

* Standardized Mean Difference, a measure of effect size. SMD is the difference in the group means divided by the pooled standard deviation. Differences >0.1 are considered to indicate imbalance.