EDITORIAL

Loss-Framed Financial Incentives With a Wearable Device for Secondary Prevention of Ischemic Heart Disease: Stepping Up to the Challenge?

Jessica R. Golbus, MD; Brahmajee K. Nallamothu, MD, MPH

Market surveys suggest wearable device sales exceeded 16 billion dollars in 2016 and are projected to exceed 44 billion dollars in 2020.[1] Spawned by growth in the commercial technology sector, these devices have become increasingly affordable and less obtrusive, all while promising consumers the ability to collect more varied and comprehensive information.[2] In 2016, it was estimated that 10% of US adults owned at least 1 wearable fitness device.[1] In light of their potential to increase physical activity and improve health outcomes, use of these devices has expanded from the commercial sector to health care, with a focus on chronic disease management.[3] Although expansion of these devices has been met with enthusiasm, leaders in health care have cautioned against their widespread adaptation until further studies can been conducted on their accuracy and reliability in collecting data, as well as their efficacy in promoting sustained behavioral change in patients with a range of disease processes.[2,4]

In this issue of the *Journal of the American Heart Association* (*JAHA*), Chokshi et al present a novel approach to secondary prevention of ischemic heart disease, combining loss-framed financial incentives with personalized step goals in an effort to increase physical activity.[5] The study, conducted at 4 hospitals in and around Philadelphia, PA, enrolled 105 patients with a history of an acute coronary syndrome or who underwent coronary angiography for suspected ischemic heart disease. Patients already enrolled in cardiac rehabilitation were excluded. After enrollment, all patients received a wrist-worn wearable device previously demonstrated to accurately track step counts. Baseline step counts were collected for 2 weeks in all patients. Patients randomized to the control arm had their step counts passively monitored for 24 weeks, whereas those randomized to the incentive arm followed a guided protocol with increasing physical activity goals. For the 8-week ramp-up period, patients in the incentive arm received a daily step goal that increased gradually by 15% each week. This was followed by an 8-week maintenance phase and finally an 8-week follow-up phase. During the ramp-up and maintenance phases, each individual in the incentive arm received $14 weekly, although they had $2 deducted from their account for each day they failed to achieve prespecified step goals. The primary outcome was the mean number of steps per day, with a prespecified subgroup analysis in those who underwent catheterization within 90 days of enrollment. Multiple imputation was used for missing values and for patients with a daily step count of <1000.

Patients were well balanced with respect to their baseline characteristics. Health-related quality of life was low, although similar, in both study arms, and 74.3% of patients enrolled in the trial within 90 days of cardiac catheterization. Baseline daily step counts did not differ, on average, between the control (6577 ± 3084 steps) and the incentive (7205 ± 3246 steps) arms. Patients enrolled in the incentive arm increased their mean daily step counts in both the ramp-up and maintenance phases, although they experienced a decline in step counts in the follow-up period. In contrast, in the control arm, patients' step counts declined after week 6. These differences were statistically significant in the main model adjusted for study arm, baseline step count, and calendar month, with step counts differing between the incentive and control arms by 1061 steps/day (95% confidence interval, 386–1736 steps/

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From the Division of Cardiovascular Diseases, Department of Internal Medicine, University of Michigan, Ann Arbor, MI (J.R.G., B.K.N.); Michigan Integrated Center for Health Analytics and Medical Prediction, Ann Arbor, MI (B.K.N.); and The Center for Clinical Management and Research, Ann Arbor Veterans Affairs Medical Center, Ann Arbor, MI (B.K.N.).

Correspondence to: Jessica R. Golbus, MD, University of Michigan Health System, 2396B CVC SPC 5853, 1500 E Medical Center Dr, Ann Arbor, MI 48109-5853. E-mail: jgolbus@med.umich.edu

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day), 1368 steps/day (95% confidence interval, 571–2164 steps/day), and 1154 steps/day (95% confidence interval, 282–2027 steps/day) in each of the 3 phases, respectively. In a second model fully adjusted for baseline characteristics, mean step counts differed significantly in only the maintenance and follow-up phases. Despite having lower power, a subgroup analysis of patients undergoing cardiac catheterization within 90 days of study enrollment showed significant differences in step counts across all 3 phases of the trial. Only 8 patients enrolled in cardiac rehabilitation during the course of the study period.

The authors of this study should be commended for using a novel approach for promoting behavioral change. Although prior studies have used behavior change techniques in patients with ischemic heart disease, including use of gain-framed incentives, this is the first study to use information from wearable devices combined with loss-framed financial incentives to increase physical activity in patients with ischemic heart disease. An approach of loss-framed incentives incorporates principles from psychology and exploits common decisional errors, including loss aversion or individuals' preferences for immediate over delayed gratification.[6] In the incentive arm, step counts increased in excess of 1000 steps/day relative to the control arm in all 3 phases of the trial when analyzed using the main model. Summed over the 24-week study period, this would equate to an average step count difference of 200 648 steps. Furthermore, despite having lower power, the results remained significant in the subset of patients having undergone cardiac catheterization within 90 days of enrollment. Because these are the patients most likely to be referred for cardiac rehabilitation, they may represent a uniquely motivated group of individuals, and further studies should explore the potential for this technology to be used in those unwilling or unable to enroll in cardiac rehabilitation.

Although results of this exploratory study remain promising, caution must be exercised before broadly expanding an approach of loss-framed incentives combined with wearable devices. First, the results may not be generalizable to the larger population of patients with ischemic heart disease. The authors report difficulty with patient enrollment, necessitating expansion of their inclusion criteria. Patients overall had low health-related quality-of-life scores and were required to own a smartphone or tablet and to use the study website to complete study-related questionnaires. By requiring that patients have access to and be facile with health information technology, the study selected for patients who are younger, more affluent, and more educated than the population at large.[7] Furthermore, few patients had reduced ejection fractions (average ejection fraction, 57.8±9.2% in the control arm versus 58.2±9.6% in the incentive arm), suggesting that these patients may be at lower cardiovascular risk than patients with ischemic heart disease and systolic dysfunction. Additional studies are warranted to ascertain the safety and efficacy of this approach in a higher-risk population with heart failure. Second, the authors report a high percentage of missing data secondary to a combination of patient nonadherence and device mismeasurement. In the control arm, 15.4% and 40.0% of step counts were missing in the ramp-up and maintenance phases, respectively. Similarly, in the incentive arm, 11.6% and 23.9% of step counts were missing in each of the 2 phases, respectively. Although the results were largely concurrent in both the imputed and unimputed analyses, nonadherence has the potential to mitigate the impact of wearable devices on long-term health-related outcomes. Unfortunately, challenges to patient adherence are shared broadly by users of wearable devices, with 1 study reporting that more than half of individuals who purchase a wearable device will stop using it.[4] Whether similar patterns of nonadherence will be observed with more integrated devices, such as smartwatches, combined with financial incentives remains to be determined.

Although this exploratory trial offers promising short-term results, questions remain unanswered. First, future studies are necessary to demonstrate that the increased step counts observed in the incentive arm remain durable in the absence of financial incentives. In the main analysis of this trial, step counts increased during the ramp-up and maintenance phases and then began to decrease towards the end of the maintenance phase and throughout the follow-up phase. Whether patients' step counts would continue to decrease after 24 weeks remains to be determined. Second, although the study provided convincing data on short-term outcomes, such as step counts, patients were not evaluated with respect to either short-term clinical outcomes, such as weight loss or health-related quality of life, or long-term cardiovascular health. Some data have suggested that patients should achieve 6500 to 8500 steps/day for secondary prevention of a myocardial infarction.[8] In the current study, patients in both the control and incentive arms walked in excess of 6500 steps/day at baseline and, thus, may have had no further mortality benefit once this minimum threshold was exceeded. Future studies will need to explore whether incorporation of additional metrics, such as heart rate or sleep patterns, could improve on these preliminary results by promoting greater patient engagement and, thus, compliance or by synergistically improving other behaviors associated with cardiovascular health. Finally, could the use of wearable devices after an acute myocardial infarction transform long-term care or potentially lead to unintended harm? As the authors note, most eligible patients do not enroll in cardiac rehabilitation, in part secondary to limited access to health care.[9] Wearable devices combined with loss-framed financial incentives may be a possible home-based alternative to cardiac rehabilitation, providing patients with the opportunity to receive personalized activity goals. It is

notable, however, that only 8 of 105 eligible patients (7.6%) enrolled in cardiac rehabilitation over the study period, an unexpected finding in this relatively affluent urban population with predicted higher levels of enrollment.[9] Future studies are, thus, necessary to demonstrate that a home-based program with wearable devices does not detract from enrollment in a formal rehabilitation program or provides results that are comparable.

In conclusion, Chokshi et al[5] should be commended for taking a novel approach to secondary prevention of ischemic heart disease through use of wearable devices with loss-framed financial incentives. Such an approach led to significant increases in step counts for patients in the incentive arm in all phases of the trial relative to patients in the control arm. Future studies are necessary to demonstrate durability of results, improved short- and long-term clinical outcomes, and synergy with cardiac rehabilitation. Although wearable devices continue to increase in popularity in the United States and worldwide, additional work is needed to see if this technology can truly step up to the challenge.

Disclosures

None.

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