Journal of the American Medical Informatics Association, 26(11), 2019, 1385–1388
doi: 10.1093/jamia/ocz131
Advance Access Publication Date: 2 August 2019
Perspective

Perspective

The role of a clinician amid the rise of mobile health technology

William E Yang ,[1] Lochan M Shah,[1] Erin M Spaulding,[2] Jane Wang,[1] Helen Xun,[1] Daniel Weng,[1] Rongzi Shan,[3,4] Shannon Wongvibulsin,[1] Francoise A Marvel,[3] and Seth S Martin,[1,3]

[1]Johns Hopkins University School of Medicine, Baltimore, Maryland, USA, [2]Johns Hopkins University School of Nursing, Baltimore, Maryland, USA, [3]Ciccarone Center for the Prevention of Cardiovascular Disease, Division of Cardiology, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA and [4]David Geffen School of Medicine at UCLA, Los Angeles, California, USA

Corresponding Author: William E Yang, MD, Johns Hopkins University School of Medicine, 4940 Eastern Ave, Baltimore, MD 21224, USA; wyang@jhmi.edu

Received 1 March 2019; Revised 5 June 2019; Editorial Decision 1 July 2019; Accepted 4 July 2019

ABSTRACT

Mobile health (mHealth) interventions have demonstrated promise in improving outcomes by motivating patients to adopt and maintain healthy lifestyle changes as well as improve adherence to guideline-directed medical therapy. Early results combining behavioral economic strategies with mHealth delivery have demonstrated mixed results. In reviewing these studies, we propose that the success of a mHealth intervention links more strongly with how well it connects patients back to routine clinical care, rather than its behavior modification technique in isolation. This underscores the critical role of clinician-patient partnerships in the design and delivery of such interventions, while also raising important questions regarding long-term sustainability and scalability. Further exploration of our hypothesis may increase opportunities for multidisciplinary clinical teams to connect with and engage patients using mHealth technologies in unprecedented ways.

Key words: mHealth, clinician-patient relationship, doctor-patient relationship, behavioral economics

CLOSING THE GAP WITH MHEALTH

In the current age of evidence-based medicine, patients can benefit from an impressive spectrum of risk-reducing therapies. Yet, clinical efficacy and effectiveness is limited by barriers that hinder adherence to guideline-directed medical therapy. In particular, motivating patients to adopt a healthy lifestyle has proven to be challenging. The small but growing body of literature on mobile health (mHealth) interventions demonstrate their promise in addressing these gaps, in turn improving patient outcomes, reducing healthcare utilization, decreasing costs, providing abundant data for research, and increasing patient satisfaction. However, the results of these studies have been mixed, raising the question: what makes a mHealth intervention effective?

ARE BEHAVIORAL ECONOMICS THE SECRET SAUCE FOR MHEALTH EFFECTIVENESS?

Recent mHealth studies have utilized smartphone applications and text messaging to incorporate behavioral economics–based tools into patient care, including financial incentives (rewards for adherence and penalties for nonadherence), commitment contracts (upfront financial deposit is lost if a goal is not met), and social networks (collective peer commitment to a healthy behavior with or without financial incentives).[1] Trials that have demonstrated positive results include the ACTIVE REWARD study (Loss-Framed Financial Incentives and Personalized Goal-Setting to Increase Physical Activity Among Ischemic Heart Disease Patients Using Wearable Devices: The ACTIVE REWARD Randomized Trial), a

randomized controlled trial of 105 patients. This study demonstrated that combining wearable fitness trackers with daily feedback and risk of losing a reward significantly increased physical activity in ischemic heart disease patients, when compared with a control group with a wearable device alone.[2] Patients in the intervention group walked 1066-1501 steps compared with 92-385 steps in the control group during the ramp-up, maintenance, and follow-up phases of the study. Another recent high-profile trial of around 6000 smokers found that financial incentives, combined with a motivational text-messaging service, resulted in a higher rate (2.0%-2.9%) of sustained abstinence from smoking than did usual care (0.1%), free access to cessation aids (0.5%), or free e-cigarettes (1.0%).[3]

Despite these positive results, other studies that assessed the effectiveness of mHealth interventions raise doubts regarding the benefit of behavioral economics strategies. A study of 19 truck drivers found that a mHealth financial incentive program led to nonsignificant increases in physical activity and a small statistically significant increase in fruit and vegetable consumption.[4] However, participant feedback revealed that the financial incentives themselves were not very motivating, which was objectively supported by the majority of drivers progressing no further than the second of 5 reward tiers. Similarly, the HeartStrong study (Effect of Electronic Reminders, Financial Incentives, and Social Support on Outcomes After Myocardial Infarction: The HeartStrong Randomized Clinical Trial), a randomized clinical trial of 1509 acute myocardial infarction patients, found that providing electronic pill bottles, lottery incentives, and extra social support did not improve medication adherence.[5] The authors discuss a number of possibilities as to why there were no differences, one of them being that clinicians were not directly involved in the intervention.

These mixed results highlight the reality of behavioral economics: a powerful tool that, when used in isolation, has limitations in improving patient outcomes. The results associated with the minimal clinician involvement in both the truck driver and HeartStrong studies suggest the importance of a more powerful tool in promoting mHealth effectiveness: the clinician-patient relationship.

CLINICIANS ARE A KEY INGREDIENT TO MHEALTH SUCCESS

mHealth studies demonstrating improved patient outcomes have frequently incorporated some level of clinician involvement. Here, we define clinicians broadly to include not only physicians, but also advanced practice clinicians, nurses, pharmacists, physical therapists, and health coaches, among others. While in the ACTIVE REWARD study, patients were contacted during cardiology outpatient visits, the aforementioned smoking cessation trial used health coaches to recruit employees through an employer wellness program. Importantly, certain mHealth trials that show promise did not use behavioral economics, but instead focused on incorporating personalized connections to routine care. An example is the mActive trial (mActive: A Randomized Clinical Trial of an Automated mHealth Intervention for Physical Activity Promotion),[6] which demonstrated increased physical activity in those receiving the mHealth intervention. Every patient was enrolled through a cardiologist, and coaching text messages specifically included the patient's cardiologist's name. Another mHealth trial, TEXT ME (Effect of Lifestyle-Focused Text Messaging on Risk Factor Modification in Patients With Coronary Heart Disease: A Randomized Clinical Trial), demonstrated an improvement in cholesterol and other cardiovascular risk factors.[7] The intervention text messages patients received were signed "Westmead Hospital." These positive trials all provided a personalized link to clinical care (eg, to a doctor, hospital, or wellness program), suggesting that mHealth effectiveness may be related to keeping patients connected to care rather than with a specific provider.

In this context, we believe that the clinician-patient relationship in mHealth should not be underestimated, as both an essential part of a therapeutic intervention and a potential limitation to scalability. In some mHealth studies, the extra support of a clinical research team may be critical to positive outcomes in a trial. Yet, this may not be replicable in a real-world application of the same intervention. For example, in an mHealth study enrolling twenty patients with peripheral artery disease, staff remotely monitored step counts weekly and called participants who did not meet their goals.[8] While practical for a dedicated staff and small patient population, this is difficult to scale to large-scale clinical practice on a long-term basis due to the exhaustive resources necessary to sustain such a practice. Thus, the increased clinician-patient face time and connection in these clinical trials may be a confounding variable and may be difficult to scale to real-world clinical practice. This should be a consideration for translating mHealth trials to routine practice, raising questions of how much clinician involvement is necessary to achieve intended clinical outcomes and what the critical points are at which clinicians must be engaged.

In our view, increased clinician-patient interaction should be the rule, rather than the exception. Thoughtful mHealth intervention design can directly aim to facilitate and strengthen the human connection between patients and clinical care teams, while remaining scalable and reproducible. For example, interventions may facilitate routine follow-up appointments through reminders, integrate with electronic health records to provide personalized experiences, or collect clinical data that can support clinical decision-making. In other words, mHealth is best used to enhance, rather than replace, existing relationship-based clinical care.

FROM INGREDIENTS TO SOUP FOR THE MASSES

The likely synergy between clinicians and mHealth demonstrates a need to design and conduct pragmatic trials. These trials could compare non-integrated mHealth interventions, as well as different methodologies of integrating mHealth interventions into routine care. Before widespread clinical adoption can occur, determining how best to implement mHealth interventions, including how patients will optimally interface with each member of a clinical care team, is a major stepping stone yet to be undertaken. Such studies will need to consider all stakeholders, including clinician and patient perspectives. Furthermore, it is likely that mHealth interventions will facilitate a greater role for nonphysician clinicians, so incorporating their perspectives will be especially important.

One possible way for a clinical team to engage patients is through "app prescriptions." The idea of nonpharmacologic prescriptions has been explored with smoking cessation,[9] exercise,[10] and diet[11]; its utility may likewise translate to modern mHealth interventions. Once an app is prescribed, it can be used to coordinate patient care, help patients follow guideline-directed therapy, and encourage sustained patient self-management. For example, during hospitalization, after a smartphone app has been prescribed to a patient, nurses could assign patient-specific education

on their health conditions and medications, while physical therapists could use the app to assign exercises with corresponding video demonstrations. Similarly, in the outpatient setting, clinicians could prompt patients during visits by simply asking if they are finding the app helpful. Symptoms, vital signs tracking, and medication adherence data could be used to facilitate conversation,[12] or target more socially isolated patients.[12] Prescribing an app, and then using a team-based approach to engage patients could emphasize to patients the importance of the app as a part of their care.

NOT ALL SUNSHINE AND RAINBOWS: IMPLEMENTATION CHALLENGES

At present, mHealth hardware and software is largely created by nonclinicians, which may present challenges to leveraging the clinician-patient relationship and clinical workflow integration unless development teams collaborate with clinicians early during mHealth development. Specifically, frontline clinicians should be encouraged to drive the iteration of these tools and partner with industry in development to provide valuable input in the following areas: (1) clinical need, (2) deployment process, (3) type and frequency of data reporting, and (4) clinical decision support algorithms. Early clinician engagement can also encourage adoption and maximize positive impact of an intervention.

Driving clinician and patient adoption of mHealth interventions presents additional financial challenges. The question of who should bear the cost of an intervention remains unresolved. While traditional medical drugs, treatments, and devices are often paid for by health insurance, little precedent exists for reimbursement of software and the consumer hardware on which it runs. For example, if a mHealth app requires the use of an internet connection, should patients be required to purchase their own internet service? The answers to such questions have implications for health equity, especially as mHealth has been recognized as a tool that could be used to reach medically underserved communities. As mHealth will drive a continued shift away from encounter-based fee-for-service health care, reimbursement of clinicians must also be updated to match this shift.

Moreover, clinicians and nurses are increasingly burdened by regulatory requirements and time-consuming use of electronic health records. The limited capacity for health providers to take on additional responsibilities related to and process data generated by mHealth tools is an important consideration for efficacy and scalability. Similar concerns exist with remote patient monitoring; a clinical trial of remote monitoring in congestive heart failure patients showed no reduction in mortality, which may have been due to a limited ability of the clinical team to provide feedback to stable patients.[13] Successful mHealth adoption requires careful consideration of what parts of a mHealth intervention should be "high touch" while automating other parts. For example, automated deployment and fully digital onboarding can minimize the need for additional human resources and time reserved for managing the mHealth intervention itself, enabling clinicians to practice at the top of their license and training. Use of predictive machine learning algorithms may also assist clinicians in caring for a larger patient population by automating and personalizing advice for a majority of patients, while identifying high-risk patients or clinical situations who may require timely attention from a clinician.

THE VIRTUAL CLINICIAN: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

The growth of real-time data collection as well as advancements in computing and machine learning algorithms provide ample opportunities for clinicians to develop "precision behavior change" interventions. Collaborating across disciplines, from medicine and behavioral sciences to engineering and computer science, facilitates delivering individualized interventions to patients in their day-to-day lives in the "right context at the right time."[14] The use of machine learning to personalize dietary advice for patients with diabetes recently demonstrated promising results,[15] suggesting that personalization is one of the key tools of a clinician in improving patients' health that may be emulated by an algorithm.

Marginalized patient populations may also benefit from artificial intelligence–based mHealth interventions. Many of these communities may suffer from historic or current distrust of their local medical establishment, preferring to avoid direct clinician contact. Other patients may feel uncomfortable asking questions of clinicians due to the personal and sensitive nature of some health conditions, or for fear of appearing unknowledgeable. A previous study of hospitalized patients with depressive symptoms found many patients preferred receiving discharge instructions from an empathic computer-animated conversational agents rather than their doctors or nurses.[16]

While a full discussion of the capabilities of machine learning algorithms is outside the scope of this manuscript, we recognize that machine learning offers opportunities to augment the clinician's role in personalizing patient care, and in some cases may function as a virtual alternative to a human clinician.

CONCLUSION

In summary, recent mHealth studies have demonstrated great potential for improving patient health. It is likely that mHealth interventions are most effective in the context of enhancing current clinical practices, rather than independent of routine clinical care. The potential synergies between mHealth and routine clinical care merit further scientific study. Overall, future mHealth work should ideally encourage clinician-patient partnerships and engagement to optimize the capabilities of mHealth in improving patient outcomes.

FUNDING

This work was supported by National Institutes of Health/National Institute of Nursing Research F31DR017328, Ruth L. Kirschstein National Research Service Award (to EMS), and National Institutes of Health/National Institute of Nursing Research T32, NR012704, Pre-Doctoral Fellowship in Interdisciplinary Cardiovascular Health Research (to EMS); the Johns Hopkins School of Medicine Medical Scientist Training Program (National Institutes of Health: Institutional Predoctoral Training Grant - T32) (to SW), National Institutes of Health Ruth L. Kirschstein Individual Predoctoral NRSA for MD/PhD: F30 Training Grant (to SW), and the Johns Hopkins Individualized Health (inHealth) Initiative (to SW). The funders had no role in decision to publish or preparation of this manuscript, and the remaining authors received no specific funding for this work.

AUTHOR CONTRIBUTIONS

Each author contributed substantially to the conception and design of this work, article drafts, and critical revisions of the article. Final approval of the version to be published was solicited from each author, and each agreed to be accountable for all aspects of the work in ensur-

ing that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved. Additionally, WEY took primary responsibility for communication with the journal during the manuscript submission, peer review, and publication process.

CONFLICT OF INTEREST STATEMENT

The Corrie Health Digital Platform was developed by FAM, Dr Matthias Lee, and SSM. They are also founders of and hold equity in Corrie Health, which intends to further develop the platform. This arrangement has been reviewed and approved by the Johns Hopkins University in accordance with its conflict of interest policies. Furthermore, Corrie Health has received material support from Apple and iHealth, and funding from the Maryland Innovation Initiative, Wallace H. Coulter Translational Research Partnership, Louis B. Thalheimer Fund, and Johns Hopkins Individualized Health Initiative.

REFERENCES

1. Chang LL, DeVore AD, Granger BB, *et al*. Leveraging behavioral economics to improve heart failure care and outcomes. *Circulation* 2017; 136 (8): 765–72.
2. Chokshi NP, Adusumalli S, Small DS, *et al*. Loss-framed financial incentives and personalized goal-setting to increase physical activity among ischemic heart disease patients using wearable devices: the ACTIVE REWARD randomized trial. *J Am Heart Assoc* 2018; 7 (12): e009173.
3. Halpern SD, Harhay MO, Saulsgiver K, *et al*. A pragmatic trial of e-cigarettes, incentives, and drugs for smoking cessation. *N Engl J Med* 2018; 378 (24): 2302–10.
4. Gilson ND, Pavey TG, Wright OR, *et al*. The impact of an m-Health financial incentives program on the physical activity and diet of Australian truck drivers. *BMC Public Health* 2017; 17 (1): 467.
5. Volpp KG, Troxel AB, Mehta SJ, *et al*. Effect of electronic reminders, financial incentives, and social support on outcomes after myocardial infarction: the HeartStrong randomized clinical trial. *JAMA Intern Med* 2017; 177 (8): 1093–101.
6. Martin SS, Feldman DI, Blumenthal RS, *et al*. mActive: a randomized clinical trial of an automated mHealth intervention for physical activity promotion. *J Am Heart Assoc* 2015; 4 (11): e002239.
7. Chow CK, Redfern J, Hillis GS, *et al*. Effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease. *JAMA* 2015; 314 (12): 1255.
8. Duscha BD, Piner LW, Patel MP, *et al*. Effects of a 12-week mHealth program on functional capacity and physical activity in patients with peripheral artery disease. *Am J Cardiol* 2018; 122 (5): 879–84.
9. Philips BU, Longoria JM, Calhoun KH, *et al*. Behavioral prescription writing in smoking cessation counseling: a new use for a familiar tool. *South Med J* 1989; 82 (8): 946–53.
10. Fuscaldo JM. Prescribing physical activity in primary care. *W V Med J* 2018; 98: 250–3.
11. Goddu AP, Roberson TS, Raffel KE, *et al*. Food Rx: a community-university partnership to prescribe healthy eating on the South Side of Chicago. *J Prev Interv Community* 2015; 43 (2): 148–62.
12. Fujita S, Pitaktong I, Steller GV, *et al*. Pilot study of a smartphone application designed to socially motivate cardiovascular disease patients to improve medication adherence. *Mhealth* 2018; 4: 1.
13. Koehler F, Winkler S, Schieber M, *et al*. Impact of remote telemedical management on mortality and hospitalizations in ambulatory patients with chronic heart failure. *Circulation* 2011; 123 (17): 1873–80.
14. Wongvibulsin S, Martin SS, Saria S, *et al*. An individualized, data-driven digital approach for precision behavior change. *Am J Lifestyle Med* 2019 Apr 25 [E-pub ahead of print].
15. Zeevi D, Korem T, Zmora N, *et al*. Personalized nutrition by prediction of glycemic responses. *Cell* 2015; 163 (5): 1079–94.
16. Bickmore TW, Mitchell SE, Jack BW, *et al*. Response to a relational agent by hospital patients with depressive symptoms. *Interact Comput* 2010; 22 (4): 289–98.