INTRODUCTION
Mobile health (mHealth) is an emerging field devoted to the use of mobile and wireless devices to affect health outcomes, health care services, and health research. Despite great promise, little research has examined its effectiveness. It is the authors’ view that the full potential of mHealth has yet to be realized in research and practice. This Perspective article explores when and for whom mHealth approaches are effective, strengths and limitations of commercially and academically generated apps, research design considerations, and public–private partnerships. These topics have implications for researchers and practitioners who wish to advance the science and practice of mHealth.

Key Words: mHealth, mobile health, behavior change, dietary change, technology (J Nutr Educ Behav. 2016;48:213-218.)

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ABSTRACT
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INTRODUCTION
Mobile health (mHealth) is an emerging field devoted to “the use of mobile and wireless devices to improve health outcomes, healthcare services and health research.” Including short-message service (text messages), mobile software applications (apps), sensors, wearable devices, and other wireless monitors. As a key area of public health research and practice, mHealth emerged in response to the proliferation of mobile technologies and their ubiquitous uptake. Today, 90% of Americans own some kind of mobile device and nearly two thirds own a smartphone. The increased prevalence of smartphone ownership is particularly evident among ethnic minorities; indeed, 71% of US Hispanic people and 70% of non-Hispanic black people own smartphones. Similarly, lower-income populations are also high adopters; half of those living in households earning < $30,000 annually own smartphones. Since the 2007 release of the iPhone and the subsequent launch of the App Store in 2008, the use and uptake of smartphones and their apps have exploded. The market boasts apps for a range of devices and operating systems, most notably Android (1.5 million apps), Windows (300,000 apps), and Apple (1.4 million apps). Among these are tens of thousands of health and fitness apps, including those that target nutrition and dietary behaviors.

In 1 month, about 46 million US adults—one third of all smartphone owners—use a health or fitness app, including nutrition apps. A variety of apps allow users to track daily food intake and many also provide information about macronutrients and micronutrients. Others have been designed to help users find recipes matched to health risks and food sensitivities, create grocery lists, and engage in other aspects of meal planning. Whereas much of this technology still relies on self-report and user input, there is a movement toward integration with mobile phone camera features and other visual data capture devices to derive more objective data regarding dietary intake. On a larger scale, sensor technology is being used to assess food environments and can be employed to determine, for example, the effects of changes in food policy on the availability and accessibility of healthier food options. The most popular nutrition-oriented standalone apps are Calorie Counter and Diet Tracker, both from MyFitnessPal, which had nearly 9 million users as of 2014.

CURRENT ISSUE/ CONTROVERSY
Despite the great promise of mHealth, little rigorous research has examined the effectiveness of mHealth products or when, how, and for whom these commercially available technologies are likely to be most effective. In response to insufficient empirical evidence, many academics and practitioners have resorted to developing their own apps, often in the absence of multidisciplinary collaborations from fields such as human–computer interaction and user-centered design. The unfortunate result is an overwhelming majority of mHealth tools developed via traditional research
methodologies and mechanisms that have been used only briefly and compulsorily by participants within the context of research studies. Because commercial and scientific efforts have evolved largely in parallel, to date, the field of mHealth has not been able to live up to the public health promise these technologies afford. It is the authors' view that the question of whether and how mHealth can affect health behavior—particularly, dietary behavior—cannot be answered by building another app, but rather by understanding that the best app or technology-based approach for dietary behavior change is relative, and the full potential of these technologies has yet to be realized in both research and practice.

DISCUSSION
Choosing an App
Both the proliferation of available technologies and the lack of rigorous scientific evaluation of commercially available apps have made it difficult for researchers, practitioners, and end users to determine the most appropriate app or set of apps to use. To further complicate matters, in the area of nutrition tracking, apps use different databases for calculating caloric, macronutrient, and micronutrient information. Thus, it is often difficult to compare apps, and commercial entities are often unwilling or unable to share the proprietary information on which their apps are built, including nutrition databases. In the area of nutrition intervention, there is a dearth of scientific research that has rigorously evaluated whether, how, and for whom these apps work to elicit desired behavior change. Furthermore, although there are often similarities between apps—particularly focused on tracking—there are often key differences, including the ways in which nutrition information is presented and when, whether, and how feedback is delivered to the user. The past 5 years have seen an increase in peer-reviewed reports in which researchers identified samples of apps (typically from the iTunes or Android app stores) targeting diet or physical activity behaviors and/or weight management, coded them based on a priori criteria, and then described and/or ranked apps based on the proportion of evidence-based or evidence-informed elements contained in them. Across multiple criteria and reports, the majority of apps lacked evidence-based elements or alignment with expert recommendations and practices. Many have interpreted the findings of these types of reviews as confirmation that commercially available apps do not work. However, it may be worth considering that whereas at face value these apps do not reflect best practices taken from intensive, in-person behavioral interventions, they may still operate on putative mediators known to be on the pathway to behavior change (eg, self-efficacy, internal motivation, readiness to change) and potentially health behavior. It is also possible, indeed likely, that the approaches and techniques that work best in technology-based interventions differ somewhat from those that have been demonstrated to be most efficacious in more traditional intervention modalities. For example, mHealth tools have the capacity to engage with users in real time in highly tailored ways, based on data from the user, including factors such as activity levels and geographic information system information. Furthermore, because users have different relationships with their mobile devices and different expectations about what those devices can deliver, apps can use gamification and other approaches not available to in-person interventions.

When and for Whom mHealth Is the Best Solution
The explosive development and uptake of mobile technology present the opportunity for unprecedented reach into populations typically not represented in traditional randomized clinical trials and who often do not access traditional clinical services. However, the main criticism of mobile health is that although an overwhelming majority of US adults have smartphones and access to mHealth tools, the early adopters of these technologies have been those who already engage in the health behaviors targeted by these apps or are similarly uniquely motivated to track and log their health behaviors (see the Quantified Self movement). Less is known about for people for whom technology-based interventions are likely to be particularly effective and how best to engage those individuals in such interventions. Although the so-called “digital divide” continues to narrow, older adults are still somewhat less likely to use smartphones and less likely to turn to technology for health advice and support; at the same time, they are more likely to have multiple morbidities. Thus, what they need from an mHealth solution may be different from and more complex than that required for younger individuals.

It is also unclear when in the behavior change continuum mHealth solutions may be most effective. Randomized clinical trials often require participants to be in the contemplation or early action stages, using the Stages of Change typology. Although this is certainly beneficial for statistical power, the net result for science is an evidence base that is exclusively about those who are already near or on the path to change. Because mHealth offers interventions with a lighter touch that can be incorporated into an individual’s daily routine, it may be that these types of interventions are particularly effective for engaging people who are in precontemplation or early contemplation stages of change and helping them to establish an understanding of their baseline behavioral patterns, to jump start broader behavior change. Alternatively, it may be that mHealth tools are optimal to facilitate or maintain health behaviors that are initiated via more traditional intervention modalities.

mHealth and Long-Term Behavior Change
Although not unique to mHealth interventions, the question of whether these technology-based tools facilitate long-term behavioral maintenance is also worth considering. The feasibility of mobile methods for diet and physical activity behavior change is well-established for short-term research
Although it may not be necessary for users to stay engaged with an mHealth tool to support dietary behaviors for the remainder of their lives, little is known regarding the ideal length of time to use an app, the frequency with which it needs to be used or how, and what types of data are likely to support users in behavioral change or maintenance of change. The fact that users may work with a particular app or device for a brief period of time and then later return to it is often viewed by the research community as a failure. However, the authors suggest that this indicates a remarkable success. Health behavior change and weight management are difficult to achieve, and the path to behavioral maintenance is characterized by trial and error. In traditional randomized clinical trials using intensive intervention approaches, nonadherent participants become a statistic. Apps and other mHealth tools are uniquely positioned in the real world to meet people where they are at multiple stages along the health behavior change continuum. This is a real strength of these tools, with great potential for public health gain. Perhaps an appropriate benchmark of success of a nutrition-based app is not whether someone uses it continually for weeks or months but rather whether the app creates the kind of experience in which a user is interested in returning to use it at points of struggle or failure rather than abandoning the health behavior change attempt altogether. It is also worth considering the value of incremental change facilitated by mHealth tools. Incremental change in the direction of increased intake of fruits, vegetables, and whole grains, decreased intake of added salt and sugar, and even slowing or halting weight gain not only have the potential to yield significant public health improvements but may also support end users' self-efficacy, thus encouraging further progress toward health behavior change.

Challenges for Researchers and Practitioners

Although they are often more scientifically sound in their approach, the mHealth resources originating from academics frequently lack visual appeal, intuitive user interfaces, and a user experience likely to yield long-term engagement. Indeed, I recent review of weight-loss apps found that the ones that appeared more scientifically robust (ie, they contained more evidence-based content and behavioral techniques) were actually the least popular among consumers. Furthermore, because such tools are developed within the temporal and financial limits of grant-funding cycles, they are often developed for the purposes of achieving research study aims that do not include long-term plans for ongoing modification (eg, in response to changing technologies) or scalability. Thus, mHealth resources produced through research efforts tend to fade into obscurity once grant funding has been exhausted, rarely (or never) to be used again.

The limited evidence regarding the effectiveness of commercially available mHealth resources should not be taken to mean that they do not work, but rather that they have not been studied in a robust scientific manner. That being said, traditional methodologies, which tend to be more static in nature (ie, research plan is developed, decided upon, and executed) may not be appropriate in the more nimble landscape of mHealth. Indeed, part of the broad commercial appeal—and potential reach—of many mHealth resources is their adaptability (ie, apps are constantly updated to allow for bug fixes, improved or additional functionality, and enhanced user experience). Furthermore, mHealth resources in the commercial space are being used by the public and not within the confines of tightly controlled clinical trials. This means that there may be a greater diversity of users than is typical of clinical trial participants and also that there may be other biases inherent in these populations (eg, those who use these technologies may be different from those who are more technology averse).

Thus, research methodologies for mHealth need to take into account the capacity for flexible design and populations that are different from those typically engaged with more traditional methods.

Another consideration for mHealth research is that, whereas there is a capacity for a broad reach, these tools often do not offer intervention intensity commensurate with the behavioral interventions most often studied in clinical trials. Therefore, the outcomes that are most appropriate for determining the effectiveness of mHealth tools may differ from those considered in more traditional intervention approaches. For example, most behavioral interventions would strive to see outcomes such as achieving dietary guideline recommendations or reducing body mass index; however, in the context of the broad reach of mHealth, more modest outcomes indicative of incremental change may be sufficient to yield significant public health gain.

Limitations of Commercial Apps

Despite the many benefits of using commercially available apps, there are also some noteworthy limitations. Although recent advances have allowed for a greater capacity to search for and capture nutrition data, nutrition tracking apps remain burdensome for end users. This reduces the likelihood that users will consistently use the app over time to track food intake. Another limitation of commercially available apps is that their output is frequently focused on quantifying calories and macronutrient and micronutrient intake to the exclusion of other, equally important dietary information. Indeed, often the most useful information for practitioners and end users may be about dietary patterns and nutrition behaviors including intake of food groups such as fruits, vegetables, and whole grains or sources of added sugars. In addition to ease of tracking, additional benefits of focusing on patterns of behavior rather than nutrients per se may be an easier set of behavior changes to execute over the long term.
Of note, the overwhelming majority of commercially available apps focus primarily on making nutrition changes for the purpose of weight loss. In the context of a national and global obesity epidemic, the market and clinical and public health demand for weight management tools, including those that leverage mobile technology is certainly important. However, other nutrition-related issues should remain a focus of research and practice, including insufficient intake of fruits, vegetables, legumes, and whole grains and overconsumption of sodium, saturated fats, and added sugar, and the management of widespread chronic conditions including diabetes and hypertension. Even in the absence of chronic health conditions, all individuals benefit from healthy dietary intake. Thus, the overwhelming focus of commercially available apps on weight management is limiting.

Advancing the Science and Practice of mHealth Through Public–Private Partnerships

As noted earlier, one reason why commercially developed apps lack an evidence base and academically developed apps lack commercial appeal is that the 2 have been operating largely in parallel. Although building more apps may seem like an intuitive solution, this addresses the symptom rather than the root cause. Therefore, the authors suggest that academics and practitioners form strategic partnerships with industry, particularly app developers. Although academics and clinicians possess a wealth of knowledge regarding nutrition and behavioral interventions, they are not trained to deliver that information and intervention content via mHealth tools. Experts in human–computer interaction and user-centered design are much better equipped to take the information and skills that clinicians and academics possess and translate them into apps that are more likely to connect with end users in ways that foster long-term use. In addition, professionals in the app development space are likely to think in terms of adaptable products that change over time rather than a single static build-out that does not change in response to advances in technologies and user and market demands. This is critical to creating sustainable user engagement and potentially long-term behavior change.

There are already thousands of nutrition-related apps available in the commercial space, and although achieving substantial market share may not be a primary aim for clinicians and academics, it is important for whatever tools that are developed to be likely used at scale. There is also a significant opportunity to capitalize on technologies that have already been developed, rather than starting from scratch. Public–private partnerships also afford tremendous opportunity for research. Conducting research with commercially available apps can open the door for data sharing and mutual benefit by which apps are improved over time. Across the mHealth landscape, researchers and clinicians have often remarked that app developers are not open to such collaborations. In part, this may be because developers have a commercial interest in the sustainability of their product and are often hesitant to allow researchers access to data that suggest their product does not work. In addition, commercial entities are often concerned about data privacy and security, and there is a potential that consumers will find it off-putting for their data to be used in research settings.

These concerns can be overcome. What is required is a shift in thinking and patience in developing these partnerships. It may be helpful for researchers to think in terms other than a dichotomous outcome for the question of whether an app works (ie, yes or no). Currently available apps have a wealth of data contributed by thousands (often tens of thousands) of people. The wealth of data provided by users and within user databases could allow for the development of user profiles that help to better clarify when and for whom apps seem to be most efficacious. This shifts the simplified question of whether an app works to the more nuanced question of under what circumstances and for which people are apps most likely to work. This an interesting question for science and practice, but even more important, it offers value to industry partners who can then use this information to target their product to specific user populations and make modifications to reach those who are not currently engaged, thus increasing market share.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The topics discussed here have implications for researchers and practitioners who wish to identify and use the best (ie, most appropriate or efficacious) app to intervene with their participants and patients. To date, there is no reference standard app or criterion against which to compare to determine an app’s efficacy for encouraging or supporting dietary behavior change. In the absence of formal guidance and regulatory oversight, an understanding of the behavioral health evidence base is critical when making recommendations to clients or patients. The literature is replete with examples of evidence-based behavior change techniques used in traditional face-to-face diet and physical activity interventions that can and should be a part of any app purporting to influence dietary behavior. Clinical judgment and familiarity with evidence-based practices can also serve app end users, typically practitioners and their clients. The final section of this Perspective includes considerations to help researchers and practitioners identify the best app.

Choosing the Best App

**Consideration 1: Will people use it to improve their health?** Many factors influence whether people will use a mobile app to improve their health. Among the first and most critical is the motivation to initiate change in behavior. Cost can also be a significant consideration. For instance, the most popular apps are offered as “freemium” versions, in which desirable features come at a price. Once installed and initiated, it is clearly important to remember to use the app, as it is to keep up with routine maintenance including charging the device and updating critical software. Assuming that all of these factors are
Consideration 2: Will its use result in a measurable behavior change? Examples of clinical outcomes pertaining to nutrition and dietary behavior include body weight, lifestyle choices for health promotion such as increasing fruit and vegetable intake, and influencing diseases and conditions such as carbohydrate counting in diabetes. It is important to work with the client or patient to decide the clinical end point of interest. The app should have the potential to influence these end points directly, ideally through the use of evidence-based behavior change techniques, features, or functions, or an established intervention framework. Determine whether these elements or techniques are evident, keeping in mind that some elements and techniques are stronger predictors of behavior change than others (eg, self-monitoring, goal setting, and social support). Furthermore, there may be techniques and approaches to behavior change that are effective in the mHealth space that have not emerged from the traditional randomized clinical trial literature.

Consideration 3: Will it result in clinically significant improvement in health? Ideally, the factors targeted by the app should also be predictive of the health outcome of interest so that the activities, strategies, and information promoted by the app have the greatest potential to exert a clinically significant impact. Identify the evidence-based correlates or predictors of the clinical end point and ensure the app appropriately targets these factors. For example, correlates of eating behavior include but are not limited to food preferences, availability and accessibility, convenience, cost, variety, energy density, portion size, and rate of eating. Clinically significant improvement in health also highly depends on factors beyond the reach of the practitioner and not necessarily addressed by the app, including individual parameters such as age, gender, self-efficacy, knowledge, the immediate social environment (eg, social support from friends, family, partner, role models, cultural background), the physical environment (eg, access and transportation to resources in and out of the home), and the meta-environment, which includes programs, policies, governance, and legislation that affect the behaviors in question.

Consideration 4: Will it work in the real world? The answer to this question is complex. Persistent real-world use depends on many interrelated factors including the degree of engagement with the app, app functionality, aesthetic appeal, and credibility, and a subjective, hard-to-define global assessment of quality that is unique to individual user preferences (eg, think about the star rating that each app receives). Although there is no clear path to evaluating the potential for real-world performance, several research-driven evaluation frameworks have emerged that may help researchers and consumers identify apps that have a greater likelihood of resulting in behavior change. Among these, the Mobile App Rating Scale by Stoyanov and colleagues offers an objective approach to classifying and rating the quality of mobile health apps. The MARS tool includes 5 categories of criteria for assessing app quality, which include 4 objective quality scales users can use to rank engagement, functionality, aesthetics, and the quality of information (including credibility) and 1 subjective quality scale that assesses global appeal of the app using criteria similar to ones used by developers to obtain feedback (eg, number of stars, whether the user would recommend to others). Find the checklist at: http://mhealth.jmir.org/article/downloadSuppFile/3422/14733. Notably, the optimal amount of time for someone to engage with an app to yield behavior change or gain enough information, or to provide the opportunity or capability to facilitate behavior change is unknown.

REFERENCES


CONFLICT OF INTEREST

The authors have not stated any conflicts of interest.