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3 mHealthy Behavior Studies

Lessons from a systematic review

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Background

In early 2010, my article entitled 'Text messaging as a tool for behavior change in disease prevention and management' was published in the peer reviewed journal, *Epidemiologic Reviews* (Cole-Lewis and Kershaw, 2010). This article was a systematic review of the peer-reviewed literature on behavior change interventions for disease management and prevention delivered through mobile text messaging through June 2009. As a requisite to be included in the review, the studies had to be randomized or quasi-experimental controlled trials of interventions that used text messaging as the primary mode of communication for disease prevention or management. Quality of study design was assessed using a standardized measure based on nine methodological characteristics and given a score of zero to 100 per cent.

Twelve studies met the inclusion criteria, with the earliest date of publication being 2005. The five disease prevention studies targeted preventive medication adherence, weight loss, physical activity, and smoking cessation. Of the seven disease management trials, only one targeted asthma management while the others focused on diabetes. The largest sample size was 1,705, but all other sample sizes ranged from sixteen to one hundred and twenty-six participants. The average age of participants in the study ranged from fifteen to forty-five years, with four studies specifically targeting adolescents and young adults. Intervention length ranged from three to twelve months, no studies had long-term follow-ups, and the frequency at which messages were sent varied greatly.

Only nine of the twelve studies included in the review were sufficiently powered to detect a difference in the intervention conditions. Of those nine, eight studies suggested that text messaging was a useful tool for behavior change. The utility of text messaging was supported for users of different ages, nationalities, and minority status. Only one of the nine countries represented in this study is considered a developing country. The review recorded characteristics of each intervention and attempted to identify gaps and issues in the literature, as well as best practices for

researchers and practitioners. Issues identified include lack of scientific rigor, little representation of developing countries, and lack of use of behavioral theory.

Conducting the systematic review

The idea for this chapter was born out of my frustration as a public health doctoral student interested in the emerging field of mHealth in an environment where very few were yet engaged in it. Living in the academic research world, I found that whenever I would bring mHealth-related ideas into a discussion, my colleagues and professors would at least entertain my idea, perhaps even award the idea with the description of ‘novel’ or ‘innovative’, and then proceed with a litany of questions. They would rattle off the laundry list of common questions about the utility and feasibility of mHealth (for example cost of and access to mobile phones, level of general interest, issues of privacy and retention, and methods for evaluation). I would then reply to each of their points with facts about mobile phones and theories for why mHealth could be a catalyst to help solve many problems of the world. Regardless, no matter how many counterarguments I developed, or examples I provided of mHealth-related projects from websites of organizations with mHealth programs, there was one magic term my colleagues could always use to shut me down— ‘evidence base’. I knew that once they asked for the evidence base, I would be stumped, because despite my conviction, I was also searching for evidence to substantiate the use of mHealth.

In my search to understand as much as possible about mHealth, I realized that there was a considerable amount of evidence in practice and gray literature, but I had trouble finding a true consensus in the peer-reviewed literature, which was sparse, at best. In the academic research world, novelty and innovation is encouraged. However, novelty and innovation with no evidence is shunned. I realized the strengths of mobile phones that made mHealth such a useful resource for healthcare and led to the rapid growth of their use in different practice settings (for example ubiquity, low cost, and relative ease of application with little need for infrastructure) were also the weaknesses that resulted in lack of formal documentation and application of systematic evaluation methodologies and ultimately a weak presence in the scientific peer-reviewed literature.

I felt that the little information that did exist required synthesis to allow people to understand the state of the literature, identify strengths and weaknesses, and thus better allocate resources. Through this, the evidence base for mHealth could be built upon, fostering growth, as opposed to everyone operating in their own respective silos and repeating the same projects only to come to the same conclusion, resulting in lateral instead of vertical growth. I observed the amount of money donors were

putting into projects with the expectation of rapid results. I feared that the lack of a structured systematic approach to measuring outcomes would lead donors to lose interest and move on to the next novel idea with the assumption that mHealth does not work. Apart from my intuition, I knew there was something special in mHealth, as I bore witness to the way other industries (for example entertainment, marketing, and finance) were latching on to mobile technologies for their respective purposes. The vast majority of the industries using mobile technology are economically driven, which is a likely indication of effectiveness. Presumably, these profit-driven industries utilize mobile phones, because they are a cost-effective means of reaching their objectives.

Given my stance on mHealth, I realized that I was approaching the project with a potential bias. It was apparent that deep inside, I was rooting for mHealth. I realized the danger that this bias could pose to the scientific process, and therefore I became more determined to ensure that the methodology of the systematic review was scientifically sound. Furthermore, I braced myself with the reality that I could be completely wrong about mHealth, and in effect sought out to prove the opposite of what I believed (alternate hypothesis) – mHealth is not an effective tool for behavior change in disease prevention and management.

The paper was my small contribution to the vast amount of information available on mHealth. It is in no way exhaustive, but I hoped that it would give me some clarity and guidance as to what direction to move next. I specifically chose to focus on randomized controlled trials (RCTs) because they are typically considered the gold standard in scientific research. I am aware that much of the work that is being done in mHealth has not yet made it to the peer-reviewed literature, and that a majority of the work that does make it is not in the form of an RCT due to cost and methodological issues. Although I knew I would be missing some better-known projects, I also knew that the glaring omission of mHealth projects that people are most familiar with was just as powerful as including them in the paper.

I wanted to keep my methodology for the systematic review as rigorous as possible, and I knew the best way to do that was to streamline my ideas and focus on contributing something that had never been done before. I decided to limit the review to text messaging to highlight the utility of mHealth around the world for people of every socioeconomic status. Up to this point, I had found that when I explained mHealth to people, their first assumption was that mHealth could only be useful for people using iPhones or BlackBerrys, but given the successes that I had observed related to text messaging, I knew that this was not the case and wanted to make that point.

The decision to study disease prevention and disease management interventions separately came to me because each requires a different set of

assumptions and actions. The motivators for engagement with an mHealth system will be different for someone who is actively managing a chronic condition as opposed to someone who is working to change a behavior to prevent the onset of a disease. In behavior change, we understand that the approach to behavior change differs depending on whether the condition of interest is primary, secondary, or tertiary. Therefore, we expected no difference when dealing with behavior change delivered via mHealth.

In order to ensure the most rigor for my review, I gathered resources that outlined the guidelines for literature reviews including the Cochrane Handbook for Systematic Reviews of Interventions, QUORUM guidelines, and the Handbook of Research Synthesis (Cooper and Hedges, 1994; Moher, Cook, Eastwood, Olkin, Rennie, and Stroup, 1999; Higgins and Green, 2009). I knew that I would need to tease apart the details of each intervention in order to correctly interpret the outcomes of a study. I had to understand exactly what type of service was delivered, how the service was delivered, and how the outcomes related to the service were measured. The Cochrane Handbook and similar resources allowed me to develop a systematic approach to the compilation of this data that would allow comparison between different interventions, while taking into account issues such as quality of study design.

In addition to general resources on how to conduct a rigorous literature review, I utilized other examples of literature reviews to better understand how to tailor the literature review guidelines to mHealth specifically. In this case, I did not limit myself to mHealth reviews. I also included reviews of interventions delivered via landline phones, the internet or computers through CD-ROM, as well as reviews of behavior change and health communication literature. Through these resources, I learned how to operationalize nuances specific to information communication technologies (ICTs). For instance, systematic review guidelines recommend a quality review of studies, since each study is not conducted with the same rigor; this should be taken into account when interpreting results. I soon realized that there were little to no published systems for quality review of mHealth interventions, but instead of creating a new one from scratch I was able to borrow and adapt an existing system from electronic health (eHealth) literature (Norman, Zabinski, Adams, Rosenberg, Yarooh, and Atienzan, 2007). This was an important lesson learned – while mHealth is relatively new, there remain many lessons to be drawn from other related bodies of literature. It is not always necessary to reinvent the wheel.

Once I dove into writing the paper, I came across a major limitation. I had originally set out to conduct a meta-analysis. This type of literature review would have allowed for the combination of data from each study in order to come to a statistical conclusion whether mHealth text messaging interventions were actually

effective. Meta-analyses require that interventions be relatively homogenous as far as outcomes measured, study designed, and methods employed. This was part of the reason I decided to define such narrow inclusion criteria for the reviews (i.e. only randomized controlled trials, only text messaging). However, the trials identified were still quite different. It soon became apparent that I would not be able to make any definitive statements on whether mHealth was more effective for one use or another (for example disease prevention versus management, young populations versus older populations).

At this point, I was unsure if the review would be worthwhile. After all, I was searching for definitive answers, and this limitation would make that impossible. I decided to push forward, in the hopes that the review could help others identify opportunities for research that would contribute to the literature and eventually provide enough data for future meta-analyses. In the end, I was happy that I did complete the review in the most systematic and rigorous way possible. Although the review did not provide the definitive answers I expected, feedback from those who read the paper after publication has led me to believe that the information provided in the review is valuable and may actually contribute to the vertical growth of the mHealth evidence base.

Lessons learned for mHealth research

The systematic review answered many questions, but it also unearthed more. The original question I sought out to answer was *‘Does mHealth work?’*. However, with the advances of mHealth and contributions such as my systematic review, it is apparent that there are several more nuanced questions that must be addressed, such as *‘How do mHealth interventions work?’*, *‘What particular aspect of an mHealth intervention is working?’*, *‘How much interaction with the mobile phone is necessary to observe a change in behavior?’*, and *‘What aspects of behavior are affected by mHealth and how?’*. Listed below are issues identified in the systematic review and lessons learned on how to address those issues:

Poor measurement as a result of no conceptual model for behavior change: In order to properly measure the impact of mHealth programs, we must first understand the pathways by which we expect to see change happen. It is important to remember that the health outcomes we expect to see are a result of a change in behavior, given interaction with a particular mHealth intervention. With no conceptualization of the proposed model of change, it can be difficult to determine what outcomes to measure. Practitioners can use logic models for intervention planning (i.e. inputs, outputs, short-term outcomes, and long-term impact). Systematic documentation of these aspects of the intervention as well as

the behavior change strategy is important, and can strengthen the evidence base for mHealth, whether in the scientific or gray literature. Resources such as the United States National Cancer Institute's Pink Book – *Making Health Communications that Work* and the Johns Hopkins University Center for Communication Programs' *A Field Guide to Designing a Health Communication Strategy* provide practical guidelines for documentation of intervention strategies that can be helpful in the systematic design of formative research, as well as process and outcome evaluations (i.e. monitoring and evaluation systems) (O'Sullivan, Yonkler, Morgan, and Merritt, 2003; National Cancer Institute, 2011).

Lack of scientific rigor: There is a glaring need for more RCTs, as this is considered the gold standard for scientific evidence. RCTs can be expensive and are often not feasible for interventions conducted at the community level for various reasons. Where RCTs are not possible, creative options that utilize rigorous study design and analysis methods can be just as informative. Study designs such as the practical clinical trial (PCT), pragmatic randomized controlled trial (P-RCT), and the recently introduced cohort multiple randomized controlled trial (cmRCT) offer solutions to various limitations of RCTs such as issues of recruitment, ethics, as well as time and money constraints and provide data most relevant to decision makers (Hotopf, Churchill and Lewis, 1999; Hotopf, 2002; Tunis, Stryer and Clancy, 2003; Relton, Torgerson, O'Cathain, and Nicholl, 2010). More traditional alternatives such as repeated measures longitudinal study design or case-control design can also be informative. No matter what type of study design is employed, if the study is well documented and systematic, the lessons learned can be applied to many other situations. Furthermore, efforts should be taken to conduct power calculations prior to implementation of an intervention to ensure that the study will be able to detect a difference in the intervention groups. A robust study design is also imperative to conduct cost and cost-effectiveness analyses necessary to determine scalability and sustainability.

Lack of long-term follow-up: Studies included in this review did not conduct follow-up beyond the completion of the intervention. Interventions should attempt to conduct long-term follow-up in order to understand not only if the change in behavior was adopted, but also if the behavior was maintained. Furthermore, if measuring a health outcome that takes time to change, a longer follow-up period would allow investigators to determine if that change has actually occurred.

Little representation of developing countries in the scientific evidence: Randomized controlled trials in this review were conducted in nine countries, but only one was a developing country (Croatia) (Ostojic, Cvoriscec, Ostojic, Reznikoff, Stipic-Markovic, and Tudjman, 2005). This highlights the existing gap between the scientific literature and actual mHealth practice, as there are more

mHealth interventions in developing countries documented in the gray literature (Mechael, Batavia, Kaonga, Searle, Kwan, Fu, and Ossman, 2010). There is a need for more systematic approaches to research and better scientific representation for work being conducted in low- and middle-income countries. This could be achieved through strategic partnerships and collaborations. Furthermore, it is useful to include regional databases when conducting literature searches. For instance, *Literatura Latino-Americana e do Caribe em Ciências da Saúde* (LILACS) is a database that indexes 670 health journals from the Latin American and Caribbean. An unbiased systematic review found that in one year, 71 percent of systematic reviews published in five high-impact medical journals could have been improved by including using LILACS to identify articles for inclusion in their analyses (Clark and Castro, 2002).

Inadequate intervention descriptions: There are many nuances that differ between programs such as whether information was tailored or not tailored, or delivered through one medium or multiple media, and whether messages were delivered a set number of times or based on the user's preference. These details are important to know when attempting to understand an intervention for the purposes of replication or comparison; however, seldom will descriptions from two different interventions report on all the same features of the program. Reasons for descriptive information not being included in the literature could be the result of a program not being systematic, or omissions considering space limitations of many scientific journals. Whatever the reason for the lack of details, the fact remains that the information is not available to practitioners and researchers who would like to critically interpret interventions for replication and comparison. Therefore, there is a need for a consensus as to what intervention description factors are most important, along with creative ways to measure and report on this information; even if it means sharing it with peer working groups, at conferences, on organization websites, or as electronic addenda for scientific journals. This sort of consensus would lead to the homogeneity necessary to conduct meta-analyses of the scientific literature that provide statistical conclusions on the effectiveness of specific types of mHealth interventions; a task that the systematic review discussed in this chapter was unable to complete, due to the heterogeneity of the literature.

Lack of behavioral theory use: The majority of the interventions in the systematic review failed to identify the use of a specific behavior change theory. Literature shows that use of a behavioral theory helps to make a program more successful. Therefore, the most apparent way to overcome this limitation is to design mHealth interventions using specific behavior change models, or at least a conceptual model using behavior change techniques. By contrast, the success

of mHealth interventions despite lack of utilization of a formal behavior change theory leads to speculation, as noted in my systematic review, that there may be some unidentified aspects of behavior change theory that have been implicitly tapped by some mHealth interventions. While it is best to identify theory when the intervention is developed, there is information to be gained from those interventions with no explicit theory identified beforehand. Therefore, it may be useful to use qualitative methods to retrospectively explore interventions with seemingly little to no theoretical basis in order to determine if aspects of behavior change theory are in fact present. This is especially useful for those interventions that are developed rapidly in the field to address some specific need. Michie and colleagues have published guidelines that suggest using a formalized technique to determine if an intervention utilizes behavior change theory, and identify behavior change techniques that may not be specifically linked to an actual theory (Abraham and Michie, 2008; Michie, Johnston, Francis, Hareman, and Eccles, 2008; Michie and Prestwich, 2010). It is important to use a common taxonomy such as this when studying behavior change interventions, as it creates a common language and a metric system with which interventions may be compared. Retrospectively identifying theoretical concepts in existing interventions can also help practitioners to understand how to better include theory in their interventions. I suggest applying a mixed-methods approach to the evaluation of interventions: not only studying the typical quantitative questions such as the change in health outcomes, but also digging deep to understand the complexities of intervention components. Ultimately, whether through retrospective or prospective methods, we must determine what theoretical models are most successful for each situation, so that we may either replicate or move on to test another model.

Access to information: Even when mHealth-related information is published in the peer-reviewed literature, we run into an issue of access. The practitioners who may benefit from the information most and have immediate application for the evidence do not always have access to the articles because scientific journal subscriptions are often costly. This highlights the importance of publishing in open access journals and communicating with others engaged in mHealth through working groups and online communities. Often, when new information on mHealth is available, people will summarize relevant information and post for others to review and comment. Existing databases of mHealth-related content can be found through online communities such as the mHealth Toolkit, mobileactive.org, and the mHealth Alliance's HUB (K4Health, 2010; mHealth Alliance, 2010; MobileActive, 2010). People seeking access to these articles should also attempt to contact the corresponding author to request a complimentary copy of the research.

So where should we go from here?

Being trained as a behaviorist and epidemiologist, I am interested in closing gaps in the loop of mHealth knowledge by exploring the full model of behavior change. The purpose of mHealth research and evaluation is to identify the pathways by which mHealth interventions influence health outcomes. In other words, we seek to understand behavior change in the context of mHealth. Behavior change sits on the pathway between mHealth interventions and health outcomes. Technology utilization is also an important component of the model of change because it influences how much of the intended behavior change content a person experiences. It is important to identify how the characteristics of the mHealth technology, utilization of the technology, and effectiveness of the content shared through the technology influence the behaviors that lead to improved health outcomes.

In the context of mHealth, there is a continuum of behaviors of interest. First, there is the *health behavior* expected to be influenced through use of mHealth. The next is the person's *technology usage behavior*, referring to the way that the person engages or interacts with mHealth-related technology. Also of importance are the *mechanisms of behavior change* that the person is exposed to through interaction with the technology, which ultimately should lead to a *health behavior change*. The final result is a change in expected health outcomes, and ideally a *sustained healthy behavior*.

When evaluating the impact of an mHealth system, we cannot skip to measuring the health outcomes of the person, without understanding their technology use behavior. Similarly, we cannot skip from use of technology to measuring health outcomes, without understanding the mechanism of change by which we expect the health outcomes to improve. It is imperative to understand the overall model of change. For example, consider the following scenarios:

Scenario 1: Patient-level mHealth Intervention

Individuals receive a phone with a behavioral intervention to help self-manage their diabetes. We expect that each individual will interact with the phone and receive the behavior change content, which will encourage him or her to improve the targeted health behaviors, and eventually lead to improved health outcomes. *If the individuals do not have improvement in diabetes health outcomes, how do we know what part of the intervention does not work?* Did each individual utilize the features available on the phone in the same way and at the same frequency? Did the behavior change content provide the theoretical techniques necessary to influence behavior? Was this behavior change content appropriate to everyone utilizing the intervention, or should it have been tailored to address participants based on some predetermined characteristics? Was the user interface aesthetically

pleasing? Were the health outcomes chosen for measurement the most appropriate, or are there intermediate psychosocial or behavioral characteristics that should have been monitored as well? Was the follow-up period long enough to observe the expected improvement in health outcomes?

Scenario 2: Provider-level mHealth intervention

Community health workers in rural villages receive mobile phones equipped with tools to improve efficiency of health delivery, and ultimately health outcomes. We expect the community health worker to make the behavior change necessary to incorporate the mobile phone into their work, which leads to the patient changing his or her behavior as instructed by the community health worker (take medication, visit health clinic, etc.). We expect these changes to lead to improved health outcomes for the entire village. *If we find that there is no change in health outcomes at the village level, how do we know what part of the intervention does not work?* Did each community healthcare worker use all the features of the mobile phone in the way we expected? How do we know that some community healthcare workers did not develop some new utility for the mobile phone which may have improved their personal workflow, but is different from the intended use? Did the patient adopt the behavior as expected? Was the model appropriate for the community health workers and/or the community? Were there some characteristics of the actual mobile phone intervention that made people more or less likely to interact with the technology? Was there adequate support in place to assist CHWs with the transition to incorporating the new technology in their existing workflow? Does the expected change in behavior actually lead to improved health outcomes? Was the follow-up period long enough to observe the expected improvement in health outcomes? Are there intermediate changes on the pathway to improved health outcomes that should have been considered?

Scenario 3: Population-level mHealth Intervention

A mass text messaging campaign is targeted toward a specific segment of the population to encourage them to adopt safe sexual practices. We expect that we send messages to a target audience, they are influenced by content of messages, they change behavior and this behavior leads to improved health outcomes at the population level. *If we find there is no change in health outcomes related to sexual practices, how do we know what part of the intervention does not work?* Did the messages actually reach the target population? Did the target population get the message but never read them? Did each member of target population read the same number of message? Did they all need the same number of message to initiate change? Did the content of the messages utilize the proper behavior

Table 3.1. Example scenarios and aspects of change model often missed during evaluation if pathways of change are not conceptualized beforehand.

Scenario	What we expect	What we normally measure	Technology Engagement (Dosage/ intended use vs. actual use)
1. Individuals receive a phone with a behavioral intervention to help manage diabetes care.	We expect that each individual will engage with the phone and receive the behavior change content, which will encourage them to change their health behaviors, and eventually lead to improved health outcomes.	Improved diabetes outcomes	Did each individual utilize the features available on the phone in the same way and at the same frequency?
2. Community health workers in rural villages receive mobile phones equipped with tools to improve efficiency of health delivery, and ultimately health outcomes.	We expect the community health worker to make the behavior change necessary to incorporate the mobile phone into his or her work, which leads the patient changing his or her behavior as instructed by the community health worker (take medication, visit health clinic, etc.), we expect these changes to lead to improved health outcomes for the entire village.	Village level health outcomes	Did each community healthcare worker use all the features of the mobile phone in the way we expected? How do we know that some community healthcare workers did not develop some new utility for the mobile phone which may have improved their personal workflow, but is different from the intended use?

What we may miss (Other possible measures)

Mechanism of Change (Behavior Change Theory)	Appropriateness of Intervention Design	Outcomes Measured	Length of Follow-up
Did the behavior change content provide the theoretical techniques necessary to influence behavior?	Was this behavior change content appropriate to everyone utilizing the intervention, or should it have been tailored to address participants based on some predetermined characteristics? Was the user interface aesthetically pleasing?	Were the health outcomes chosen for measurement the most appropriate, or are there intermediate psychosocial or behavioral characteristics that should have been monitored as well?	Was the follow up period long enough to observe the expected improvement in health outcomes?
Did the patient adopt the behavior as expected?	Was model appropriate for the CHWs and/or the community? Was there some characteristics of the actual mobile phone intervention that made people more or less likely to interact with the technology? Was there adequate support in place to assist CHWs with the transition to incorporating the new technology in their existing work flow?	Does the expected change in behavior actually lead to improved health outcomes? Are there intermediate changes on the pathway to improved health outcomes that should have been considered?	Was the follow up period long enough to observe the expected improvement in health outcomes?

Continued

Table 3.1. Continued

Scenario	What we expect	What we normally measure	Technology Engagement (Dosage/ intended use vs. actual use)
3. A mass text messaging campaign is targeted towards a specific segment of the population to encourage them to adopt safe sexual practices.	We expect that we send messages to a target audience, they are influenced by content of messages, they change behavior, and this behavior leads to improved health outcomes on the population level.	Health outcomes of the target population related to sexual practices	Did the messages actually reach the target population? Did the target population get the messages but never read them? Did each member of target population read the same number of message? Did they all need the same number of message to initiate change?

change theories or techniques most effective with this population? Was this mode of delivery appropriate for the target population? Are there some participants who would have benefitted better from an actual downloadable application? Would some have preferred messages delivered more or less frequently? Were messages the appropriate length? Does this behavior actually lead to the expected health outcome? Was the follow-up time long enough to recognize a change in health outcomes? Were there some intermediate outcome measures that could indicate that health outcomes would eventually improve?

Taking advantage of technology utilization information to form usage metrics can help form the intermediate variables needed in order to measure mediators and moderators of the expected outcome, and answer many of the questions identified by the scenarios presented in the text and in Table 3.1. MHealth and other ICTs allow unique opportunities for analysis because so much information is captured that is not available in traditional behavior change interventions. There are many opportunities to utilize data that is not traditionally collected for the purposes of research.

What we may miss (Other possible measures)			
Mechanism of Change (Behavior Change Theory)	Appropriateness of Intervention Design	Outcomes Measured	Length of Follow-up
Did the content of the messages utilize the proper behavior change theories or techniques most effective with this population?	Was this mode of delivery appropriate for the target population? Are there some who would have benefitted better from an actual downloadable application? Would some have preferred messages delivered more or less frequently? Were messages the appropriate length?	Does this behavior actually lead to the expected health outcome? Were there some intermediate outcome measures that could indicate that health outcomes would eventually improve?	Was the follow-up time long enough to recognize a change in health outcomes?

For example, in the case of the mHealth intervention mentioned in Scenario 2, data collected for the purpose of improved service delivery could also be utilized to create aggregate reports for epidemiologic surveillance (Table 3.1). With creativity, we are able to utilize data that ordinarily would not be considered research worthy. For instance, in Scenario 1 system usage metrics such as how long or how often a person accessed a particular feature of the mHealth intervention would allow you to understand how much that person used the system and develop metrics that allow the measurement of what aspects of the intervention are most likely to bring about change (Table 3.1).

As observed in my systematic review, interaction within many mHealth programs is voluntary, meaning participants can decide what aspect of the intervention to utilize and at what frequency. The result is that different people will use it in different ways. In effect, people begin to self-tailor because they use the parts that are most convenient or relevant to them. For example, in Scenario 3, one user may only pay attention to text messages that offer interactive questions with the opportunity to

respond, while another may only read text messages that provide knowledge and suggest an action for overcoming a related barrier (Table 3.1). It can be viewed as an organic tailoring process. It is therefore important for us to parse out the details of this usage behavior to determine how and why different types of users utilize different aspects of an intervention, and if it ultimately leads to change.

Conclusion

In order to understand why an mHealth intervention does or does not have an impact, we must first conceptualize the mechanisms by which we expect change to happen for each specific aspect of the intervention. Using an overall model of change during the design, implementation, and evaluation stages of an mHealth intervention can prevent throwing the proverbial baby out with the bath water; meaning that when an intervention does not reach expected outcomes, instead of dismissing it as an unsuccessful intervention altogether, researchers are able to tease apart the various aspects of the intervention to determine where the breakdown in the expected model of change occurred and also ensure that the proper intermediate outcomes are being measured.

For example, Ritterband and colleagues have suggested an overall model of behavior change for internet interventions that can also be applied to mHealth interventions. The model proposes that behavior change occurs through nine nonlinear steps (Ritterband, Thorndike, Cox, Kovatchev, and Gonder-Frederick, 2009). Each person approaches the intervention with a certain set of *user characteristics* that influence their *website use*. Website use is also influenced by *website characteristics* and *support*. Engagement with the website leads to *behavior change*, *symptom improvement*, and *treatment maintenance* through various *mechanisms of change*. Every step of the model can be influenced by *environmental factors* (Ritterband *et al.* 2009). While this model is specific to internet interventions, it is applicable to mHealth interventions and underscores the importance of drawing from the related fields of eHealth and other ICTs for social change initiatives.

There is an ecosystem of health that already exists; the overlay of mobile phones has only made this ecosystem more fluid and is allowing it to progress rapidly. Each mHealth intervention will take a different approach depending on circumstances and the resources available. At the end of the day, no one project will answer all the questions of mHealth, but if we are able to make strategic partnerships, build upon lessons learned from other ICT-related research, develop sound and systematic documentation of methods, and apply rigor in evaluations, we will eventually be able to piece it all together. In the future, there will be more information available to create a comprehensive picture of where each project stands in the mHealth ecosystem and allow us to move forward swiftly and bring about change.

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