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Smartphone self-monitoring to support self-management among people living with HIV: Perceived benefits and theory of change from a mixed-methods, randomized pilot study

Dallas Swendeman, PhD, MPH¹, Nithya Ramanathan, PhD², Laura Baetscher, BA¹, Melissa Medich, PhD¹, Aaron Scheffler, BS¹, W. Scott Comulada, DrPH¹, and Deborah Estrin, PhD³

Dallas Swendeman: dswendeman@mednet.ucla.edu; Nithya Ramanathan: nithyaar@gmail.com; Laura Baetscher: laura.baetscher@gmail.com; Melissa Medich: mmedich@ucla.edu; Aaron Scheffler: ascheffler@ucla.edu; W. Scott Comulada: wcomulada@mednet.ucla.edu; Deborah Estrin: destrin@cs.cornell.edu

¹Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, USA

²Department of Computer Sciences, University of California, Los Angeles, USA

³Computer Science, Cornell Tech, New York, NY, USA

Abstract

BACKGROUND—Self-monitoring by mobile phone applications offers new opportunities to engage patients in self-management. Self-monitoring has not been examined thoroughly as a self-directed intervention strategy for self-management of multiple behaviors and states by people living with HIV (PLH).

METHODS—PLH (n=50), primarily African-American and Latino, were recruited from two AIDS services organizations and randomly assigned to daily smartphone (n=34) or bi-weekly web-survey only (n=16) self-monitoring for six weeks. Smartphone self-monitoring included responding to brief surveys on medication adherence, mental health, substance use, and sexual risk behaviors, and brief text diaries on stressful events. Qualitative analyses examine bi-weekly, open-ended user-experience interviews regarding perceived benefits and barriers of self-monitoring, and to elaborate a theoretical model for potential efficacy of self-monitoring to support self-management for multiple domains.

RESULTS—Self-monitoring functions include reflection for self-awareness, cues to action (reminders), reinforcements from self-tracking, and their potential effects on risk perceptions, motivations, skills, and behavioral activation states. Participants also reported therapeutic benefits related to self-expression for catharsis, non-judgmental disclosure, and in-the-moment support. About one-third of participants reported that surveys were too long, frequent, or tedious. Some smartphone group participants suggested that daily self-monitoring was more beneficial than bi-weekly due to frequency and in-the-moment availability. About twice as many daily self-monitoring group participants reported increased awareness and behavior change support from self-monitoring compared to bi-weekly web-survey only participants.

Corresponding author: Dallas Swendeman, UCLA, 10920 Wilshire Blvd., Suite. 350, Los Angeles, California 90024; dswendeman@mednet.ucla.edu; Tel: (310) 794-8128; Fax: (310) 794-8297.

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CONCLUSION—Self-monitoring is a potentially efficacious disruptive innovation for supporting self-management by PLH and for complementing other interventions, but more research is needed to confirm efficacy, adoption and sustainability.

Keywords

Self-monitoring; self-management; HIV/AIDS; chronic conditions; mobile phones; mHealth

Introduction

Self-management is a fundamental component of HIV treatment and prevention as HIV/AIDS has transitioned to a chronic illness with the advent of effective treatments.¹ A major challenge for all chronic conditions is engagement of patients in active self-management during their daily routines and between clinical and behavioral intervention visits.^{2–4} The nearly ubiquitous integration of mobile phones into our daily routines is creating many novel opportunities to enhance engagement in self-management through common functions such as medication reminders,^{5,6} and informational and motivational messaging.^{7,8} Self-monitoring, that is, the active observation and recording of behaviors, states, and their determinants and effects, is a core element of self-regulation and self-management^{9–11} that can be easily implemented and scaled via mobile phones. Self-monitoring is a self-directed intervention activity that does not entail the costs and provider burdens associated with traditional counseling interventions, and may be a massively scalable, disruptive innovation in which even small effects can have significant impacts at scale.¹²

Self-monitoring has been identified as a core element of evidence-based interventions (EBI) for a variety of conditions,^{13,14} although reviews of the self-management literature in general,^{2,3,15} and for HIV specifically,^{1,16} rarely mention self-monitoring. Similarly, the evaluation of multi-component EBI packages has resulted in “black box” barriers to understanding specific intervention components’ efficacy and mechanisms of change.^{12,17} Elaborating causal mechanisms of behavior change and identifying the impacts of specific behavior change tools is a new priority focus for the National Institutes of Health (NIH) through the Science of Behavior Change (SOBC) program.¹⁸ The efficacy and causal mechanisms of *self-monitoring*, in particular, have not been well elaborated to date in general,^{14,19} nor for multiple HIV-related self-management domains of medical adherence, mental health, substance use, and sexual behaviors. This paper aims to help fill this gap in the literature and bring renewed attention to self-monitoring as a behavior change intervention strategy that is made more feasible by the integration of mobile phones into our daily routines.

Early research on self-monitoring suggests that it is integral to self-regulation and self-management through processes involving response to feedback from self-observation, such as reflection in comparison to a criteria (e.g., perceived norms or personal standard), self-correction, and reinforcement via self-reward or critique.^{10,11} There is modest meta-analytic evidence for the efficacy of self-monitoring diet, physical activity, and weight to support self-management of diabetes²⁰ and obesity.²¹ Notably, meta-analytic evidence does not support the efficacy of self-monitoring blood glucose alone for diabetes self-management,²²

which suggests the importance of self-monitoring behaviors, rather than biomarkers alone, for behavior change and maintenance. Evidence also emerges for the potential efficacy of self-monitoring from alcohol, tobacco, and drug (ATOD) abuse intervention research identifying “assessment effects” in which control groups experience improvements in targeted outcomes.^{23,24} There is similar evidence for sexual risk reduction on the order of 15% to up to 30% in control groups in some HIV prevention trials with both HIV-negative^{25,26} and HIV-positive participants.^{27,28} Qualitative process studies of ATOD intervention trials find that participants recognize the impact of assessments on their behaviors and that more frequent monitoring might result in greater effects.²³

There are a number of studies using phone- and web-based diary methods for capturing data with people living with HIV (PLH),^{29–33} however, only a handful of studies have examined *self-monitoring as an intervention tool* for self-management of HIV-related health and risk behaviors. One small randomized controlled trial (RCT) compared self-monitoring by pill diary for two weeks after baseline to a single session behavioral intervention (based on motivational interviewing, cognitive-behavioral, and problem-solving techniques), finding similar improvements in antiretroviral therapy (ART) adherence at 12-week follow-up for both interventions.³⁴ Two other small-scale efficacy studies examining self-monitoring by interactive voice response (IVR) and smartphone application have identified potential enhancements to engagement and efficacy of motivational interviewing for reducing ATOD use among PLH in clinical settings.^{35,36} A larger RCT of computer-based self-monitoring at routine medical visits compared to standard care found some support for reducing sexual risk behaviors by PLH over time.³⁷ The study also found that improvements positively correlated with the number of assessments completed, indicating that self-monitoring frequency and intersecting motivational factors may moderate self-monitoring effects.³⁷ Another recent study of reactivity (i.e., behavior changes) in response to web-based daily diary assessments by gay and bisexual men found a heterogeneity of effects based on motivational factors, suggesting that different mechanisms of self-monitoring function at various stages of activation and motivation.³⁸ While these studies suggest the efficacy of self-monitoring as an intervention strategy and some potential mediating or moderating factors (e.g., motivation), the theoretical and causal pathways of the impacts of self-monitoring on multiple, HIV-related health behaviors and states have not been thoroughly elaborated. The current study aims to begin to fill this gap in the literature.

This paper presents qualitative results from a pilot study of daily self-monitoring via smartphone and bi-weekly web-surveys by PLH for multiple HIV-related domains over six weeks. The primary aim of this paper is to elaborate a theoretical model for the potential benefits of self-monitoring in supporting self-management of medication adherence, mental health, substance use, and sexual risk behaviors by PLH, through analysis of open-ended user-experience interview responses. Secondary aims explore potential differences in efficacy of daily versus bi-weekly self-monitoring as well as barriers and challenges reported, in order to inform application of self-monitoring for future research, intervention, and practice.

Methods

Recruitment, Eligibility, Screening, & Randomization

Details on study design were published previously.³⁹ Briefly, in accordance with the UCLA Institutional Review Board requirements, fliers listing eligibility criteria, study purpose (i.e., “to help develop a mobile phone application for PLH”), and a contact phone number were posted at two AIDS service organizations in Los Angeles. Clients interested in participation called the contact phone number and completed an eligibility screening, which included: taking any medicine daily (antiretroviral or other drugs); ATOD use at least once a week; sexually active at least once a week; daily mobile phone and internet use; and English speaking. If eligible, participants completed informed consent, baseline interviews, and a review of study instructions at an on-site appointment.

Participants were randomized into one of three study groups using randomization lists balanced across self-reported ethnic (African-American, Latino, Caucasian, Asian/Other) and gender categories (male, female, transgender). Two mobile phone groups with daily self-monitoring had minor variations in framing the study purpose, with two paragraphs in consent forms framing the study as either developing a new research tool (Group A “Assessment,” n=14) or behavior change tool (Group B, “Behavior Change,” n=20). This framing reflects two of the study aims, in addition to examining the reliability and validity of smartphone surveys reported previously.³⁹ The variation in framing was designed to preliminarily assess potential impacts on participation and self-monitoring efficacy, as suggested by a review of reactivity and behavior change in diary and ecological momentary assessment studies.⁴⁰

The bi-weekly web-survey only condition (Group C, “Comparison,” n=16) was included to preliminarily assess efficacy of daily versus bi-weekly self-monitoring. Due to the small sample size and short duration of this pilot study, and variability in risk levels (i.e., many participants were adherent, not engaging in risk), preliminary statistical analyses did not detect statistically significant differences between daily smartphone and bi-weekly web-survey conditions on any single self-report outcome in the bi-weekly web-surveys. Therefore, this paper also explores potential differences in efficacy of daily versus bi-weekly self-monitoring based on qualitative reports.

Procedures

Eligible participants met with a research assistant (RA) and completed a baseline retrospective computer-assisted self-interview (CASI) on Survey Monkey (i.e., the web-survey) at their first in-person appointment. The RA trained participants in using the web-survey and smartphone applications by reviewing surveys together and providing written instructions with screen shots of the smartphone application (*Ohmage*, www.ohmage.org). Training included customizing time-based alarms for surveys at schedules convenient to participants’ daily routines (e.g., during breaks, meals, or before bed). Participants could receive additional training by calling the RA and during follow-up interviews. Participants were scheduled to complete web-surveys with 14-day recall assessments at baseline, and end of weeks 2, 4, and 6. Email reminders were sent with personalized survey links. If web-

surveys were not completed within 3 days of due date, the RA made follow up phone calls. Brief, qualitative, user-experience interviews were conducted by phone at the end of Weeks 2 and 4, and in-person at the final 6-week meeting.

Mobile phone group participants (Groups A and B) received a study-assigned mobile phone (a first-generation Android G1 smartphone, valued at \$50). Participants were instructed to complete mobile phone surveys once daily on alcohol, tobacco, and other drug (ATOD) use, sexual behaviors, and medication adherence; four times-per-day on physical and mental health-related quality-of-life (HRQOL) to capture and reflect high variability in symptom experiences throughout a day; and, to self-initiate stressful event reports or a text diary entry at any time. Participants were instructed to complete phone surveys at times they programmed the application alarm to trigger (i.e., time-based reporting) as well as at any time when relevant experiences occurred (event-based reporting). A web-based visualization portal was also available to mobile phone group participants capable of displaying their personal phone survey responses over-time, by location (using a google map of phone survey geo-location stamps), and associations between variables. This prototype visualization tool was difficult to use and interpret, and was rarely accessed by participants.⁴¹

Participants were compensated \$25 for in-person meetings at baseline and 6-weeks, \$10 for each of the three follow-up web surveys, and \$10 for each of the two phone interviews. Phone surveys were compensated on a cumulative scale as follows: \$5 for completing 25%, \$15 for 50%, \$20 for 75%, and \$30 for 100%, for a grand total of up to \$170 maximum per participant for all surveys and interviews. Incentives were provided based on seven total phone assessments per day. Many participants opted to complete stressful event and text diary surveys to meet their daily survey quotas in lieu of daily ATOD or sexual behavior surveys.³⁹

A prior paper from this study specifically examines the validity and reliability of daily versus bi-weekly recall reports, and provides more extensive details on survey question content.³⁹ A brief overview is provided below along with details of the open-ended qualitative questions that are the focus of the current analysis.

Bi-Weekly Web-Surveys and Daily Smartphone Surveys

Demographics assessed at baseline included age, gender, sexual orientation, race/ethnicity, and education. Smartphone surveys were adapted from web-survey questions to assess daily (or in the moment) periods. Smartphone surveys were organized in the smartphone app by the four categories outlined below.

Medication adherence was reported using the AIDS Clinical Trial Group (ACTG) adherence questionnaire,⁴² which was modified to also assess the prior 14 days for web-surveys. Participants were instructed to report on medications in general, and ART specifically if they were being treated. Phone surveys included 8 items (prompted 1×/day) on whether a medication was missed or taken, the timeliness, and reasons for late or missed medications. The final item instructed participants to repeat the survey for each medication taken.

Mental health and physical health symptoms were reported using the brief Health-Related Quality of Life (HRQOL) measure.⁴³ Web-survey questions were adapted to assess number of days felt depressed, anxious, fatigued, energetic and activity limitations in the past 14 days. Phone surveys were prompted four times-a-day, adapted to cover the past several hours, and rated on a 0–3 scale as follows: ‘Not at all’, ‘A little’, ‘Somewhat’, or ‘Extremely. The four times-per-day schedule was used to capture expected variability in symptom experiences throughout a day. Phone surveys also included separate Stressful Event and Photo Diary surveys. The stress survey (4 items; participant-initiated), included a question on the stress level (on a 1–10 scale), and optionally, to provide a text annotation, take a photo related to the event, and/or edit the day/time of the event. A Photo Diary (2 items; participant-initiated) provided the option to report non-stressful events by taking a photo and providing a brief text annotation.

ATOD use was reported using measures from prior studies with PLH.⁴⁴ Web-surveys assessed the number of days participants used alcohol, tobacco, marijuana, cocaine, crack, methamphetamine/stimulants, hallucinogens, and heroine/opiates over the prior two weeks. Phone surveys included 12 items (including skip options; prompted 1×/day). A single stem question asked participants to check all applicable alcohol, tobacco, marijuana, cocaine, methamphetamine, or “other drug” use “since last report” (i.e., prior day ideally). This framing was used to anticipate missed daily reports and event-based reporting trends for some ATOD use that may not occur daily, and which was observed in the data.³⁹

Sexual behaviors were reported using a slightly modified version of the NIMH Multisite Prevention Trial Protocol.²⁵ Web-surveys included questions regarding total number of sex partners and partner-level reports for up to five recent sex partners on numbers of sex acts, unprotected sex acts, and unprotected sex acts with HIV-negative or unknown status partners, also over the prior two weeks. Phone surveys included 17 items (including skip options; prompted 1×/day) on partner type (e.g., one-time or regular), gender, HIV and STD status, and nickname for repeat reports; time since encounter ended; anal, vaginal or oral intercourse; active or receptive partner; condom use; safe sex discussions; and ATOD use during the encounter. The final item instructed participants to repeat the survey for each sexual encounter.

Web-surveys also assessed goals and supports with a series of yes/no and open-ended follow-up questions for each of the four domains: medication use (adherence), mental health, ATOD use, and sexual risk behaviors. The first question asked, “Are you currently trying to make any changes related to your...” and if yes, “Is anyone helping you with this?” Open-ended follow-up questions asked for details on the goals, sources of support, and frequency of support (not examined in this analysis).

Qualitative User-Experience Interviews

Brief, semi-structured, open-ended qualitative interviews were conducted by telephone at 2- and 4-weeks, and in-person at 6-weeks after baseline, to gather user-experience feedback on the web and mobile phone tools. The opening question was non-directive, “Please tell me about your experiences and thoughts on using the web survey (and cell phone surveys, for groups A and B) over the past two weeks.” Three follow-up questions (or probes) were then

asked for each of the three technology tools (web-surveys, cell phone surveys, and web-based visualizations): 1) concerns about sensitive information; 2) what was “helpful or useful”; and 3) what was “annoying, tedious, or not useful.” No additional probes were used to elicit further responses or detailed elaborations.

Analytic Methods

Qualitative user-experience interview responses were coded in iterative rounds using a grounded approach, which involves working from the data to identify key themes or descriptive codes and subthemes within the data.⁴⁵ The lead author and RA initially reviewed the data and generated three primary codes: 1) benefits related to increased awareness of behaviors, states, or their associations; 2) benefits related to supporting behavior change, broadly categorized to include initiating, maintaining, or adhering to healthy behaviors;¹⁸ and 3) barriers or concerns around smartphone and web-based self-monitoring. Two other RAs then coded the data independently, with the lead author reviewing results, clarifying constructs, and developing code trees for subsequent rounds of coding. After each round of coding, grounded themes were compared with common and complementary behavior change theory constructs from an integrative framework.⁴⁶ Theories include Social Cognitive Theory,⁹ the Health Belief Model,⁴⁷ the Theory of Planned Behavior and Reasoned Action,⁴⁸ the Trans-theoretical Model⁴⁹ and the related Precaution Adoption Process Model,⁵⁰ and the Information, Motivation, Behavioral Skills meta-theory.⁴⁸ In addition, an independent pathway of benefits emerged from the data regarding self-expressive functions of self-monitoring as having a therapeutic benefit, which was referenced by participants in relation to journaling, diary keeping, and their cathartic effects (e.g., “venting”) through functions such as expressive writing⁵¹ and non-judgmental disclosure.⁵² These theories guided coding in subsequent rounds to elaborate the theoretical model on the mechanisms, mediators, and potential impacts of self-monitoring. Figure 1 shows the theoretical model, which is further discussed in reference to participants’ responses in the results below.

The two higher order outcome codes of perceived self-monitoring benefits for improving awareness and supporting behavior change were confirmed via comparison with the behavioral activation sub-codes of pre-contemplation and contemplation for *awareness*, and maintenance, action, and preparing/decided to act for *change*. Inter-rater reliability between the two independent RA coders on these outcome codes were calculated using Cohen’s kappa and range from 0.41 to 0.79, corresponding to agreement rates of 82% to 100%, indicating moderate to good agreement.⁴⁵ The lowest agreement rates were for middle categories of contemplation and preparing/deciding to act, while the rest of the categories were at 90% or higher agreement. Exploratory aims around hypothesized variability in perceived benefits across study arms were assessed by examining proportions of participants reporting awareness and change benefits for each domain of medication adherence, mental health, ATOD use and sexual behavior, and for general, non-specific references. This data was also integrated⁵³ with the corresponding goal and support response data to explore their potential associations in cross-tabulations.

Results

Over a nine-month recruitment period, 126 calls were received and 118 individuals screened, with 53 eligible and 50 consented and enrolled into the study. Table 1 presents baseline information on key demographic variables, medication adherence, mental health symptoms, substance use, sexual risk behaviors, and assessment retention. The majority of participants were male, gay or bisexual, with an average age in the mid-forties. The sample was diverse in ethnicity (about 50% African-American and 25% Latino) and education level. Most participants (about 80%) taking ART reported >90% adherence rates. About 58% of participants reported 5+ days experiencing anxiety symptoms in the 14 days prior to baseline, and 44% reported 5+ days of depressive symptoms. Past 14-day use of alcohol, marijuana, and tobacco were common, while use of other drugs was modest. About one quarter of participants reported unprotected sexual intercourse with HIV-negative or unknown status partners in the prior 14 days.

The three study groups were fairly well balanced across demographic and risk factors, although the randomization was not perfectly balanced due to small sample size and balancing points in randomization lists. Web-survey completion rates were high, around 90% except for the final follow-up (76%). Group B (Behavior change framed, mobile phone) had lowest follow-up rates, but this is also the result of three participants being lost to follow up during the first week of the study (and phones not returned); excluding these participants makes follow-up rates more similar to other groups. Qualitative follow-up interview participation rates were lower, particularly for Group C (web-survey only, control). Completion rates for mobile phone surveys in Groups A and B are reported in a prior publication,³⁹ but in general, were modest with an average of 7 to 10 days of reporting per two-week reporting periods for each domain, and about 90% completing two weeks, 74% four weeks, and 50% completing six weeks of smartphone self-monitoring.

Figure 1 presents the theoretical framework that emerged from the data in conjunction with iterative comparisons to an integrative theoretical model for behavior change.⁴⁶ The model specifically focuses on elaborating theoretical constructs related to *self-monitoring* mechanisms, their mediators, and outcomes of activation states and wellbeing embedded in participants' responses. The arrows in Figure 1 suggest potential relationships between the specific theoretical constructs as elaborated below, although not every construct in the model is directly referenced in participant responses. Representative responses on the general functioning and benefits of self-monitoring are presented in the following narrative. More specific responses referring to medication adherence, mental health, ATOD use, and sexual risk behaviors are presented in Tables 2 and 3, and discussed below in terms of potential variability across domains for self-monitoring functions, mechanisms, and outcomes.

The primary outcomes outlined in Figure 1 are *Activation states*, which refer to the "stages of change" in the Trans-Theoretical Model (TTM) and Precaution Adoption Process Model (PAPM), but reframed here to refer to behavioral activation rather than stages, in acknowledgement of the lack of evidence for impacts of stage-tailored interventions^{54,55} and that people may move through multiple activation states with each behavior change

challenge.^{55,56} Self-monitoring mechanisms include processes of reflection, cues to action, reinforcement, and self-expression. Self-monitoring is posited to impact activation states indirectly through multiple theory-based mediators, and directly through cues or reminder functions, as elaborated below.

Reflection is a core element of MI and the linked TTM, which describe how reflective processes build self-awareness, concern or inspiration, re-evaluation, and awareness of effects on social relationships. Observational learning from SCT is applied here to self-observation. These reflective processes are theorized to shift multiple theory-based mediator constructs, such as attitudes or perceived risks, benefits, and norms from the Health Belief Model (HBM); outcome expectancies from SCT; and self-efficacy or behavioral control beliefs from multiple theories. These perceptions and cognitions are posited to primarily influence pre-contemplation and contemplation of action, as well as intentions or motivations more closely linked to behaviors. For example, several participants mentioned self-reflective benefits of self-monitoring that indicated moving from an unengaged to engaged state of pre-contemplation of change:

“Helps me check in with my behavior and think about it.” (Grp B, Age 59, Female, Latino);

“Makes you think about how you are living your life.” (Grp B, Age 38, Male, White);

“It made me think about what I’m doing. My behaviors.” (Grp C, Age 44, Female, Black).

Other participants’ responses suggested benefits related to risk perceptions:

“Made me more aware of my bad habits.” (Grp C, Age 46, Transgender, White);

“It’s not often a person is forced to think about what they do and the possible consequences.” (Grp C, Age 58, Male, Black).

Self-monitoring also was reported to support contemplation for action:

“Shows me what I need to work on in my life” (Grp A, Age 51, Female, Black);

“Helped me realize what I need to work on” (Grp B, Age 31, Male, Latino).

For some participants, self-monitoring was credited with supporting behavioral changes:

“I started changing my behavior once I started taking the surveys- I have been thinking about it for a while but the surveys make me concentrate on certain areas of my life that I wasn’t focusing on.” (Grp A, Age 52, Male, Black);

“It’s good for anyone to have as many opportunities as they can to self-reflect. It’s beneficial. It can help you make better decisions.” (Grp C, Age 58, Male, Black).

Reinforcement or rewards from self-tracking is another self-monitoring function, which is posited to enhance motivations or intentions and skill mastery for action and maintenance. As one participant stated,

“It’s a reality check a couple times a day- it makes you look at the things you do and then makes you learn and change your behavior for next time. It’s like a learning tool.” (Grp B, Age 38, Male, White).

Cues to action (i.e., reminders) in the HBM, and the related “stimulus control” construct in TTM, are posited to have direct impacts on behaviors, but are also dependent on having intentions and skills for the behavior. Some participants recognized benefits of these functions for the mobile phone surveys in particular, for example,

“Surveys helped me be more in control and responsible in doing what I need to be doing- it gave me something to do every day.... Cell phone is more helpful than the web survey at keeping me on track because it’s always there.” (Grp B, Age 39, Male, Native American);

“Taking the surveys makes me more focused. Helps me concentrate on my health and stay aware.” (Grp A, Age 52, Male, Black).

Self-expression through journaling and non-judgmental disclosure is another set of related self-monitoring functions noted by participants, and supported by theory and research.^{51, 52} Self-expression functions are theorized to provide opportunities for catharsis and to mimic elements of social support and therapeutic relationships, such as non-judgment and confidentiality, as outlined at bottom of Figure 1 and discussed in more detail below. For example, in regards to journaling, one participant noted succinctly,

“Writing about my habits keeps me from doing the bad habits.” (Grp C, Age 33, Male, Latino).

Others noted non-judgment and aspects of social support,

“Makes a difference feeling like I have someone to talk to- I feel like I can tell the researchers anything and they won’t shun me.” (Grp B; Age 41, Female, White);

“Don’t feel judged on cell phone....More truthful because you are talking to a machine rather than speaking to a live person” (Grp A, Age 38, Male, Latino).

The majority of responses on these self-expressive functions and benefits are noted in reference to mental health-related therapeutic benefits for general well-being, detailed in Table 2 and discussed below.

Domain Specific Results: Adherence, Mental Health, ATOD Use, & Sexual Behaviors

Representative responses referring to specific domains of behavior change are shown in Tables 2 and 3, including codes for functions, mediators, and outcomes of activation states and well-being. Table 2 presents results for health-related domains, medication adherence and mental health. Table 3 presents results for risk behaviors of ATOD use and sexual behaviors. Results are discussed below in terms of potential variability in functions, mediators, and outcomes for each domain.

Results presented in Table 2 suggest that trends in responses for benefits of self-monitoring specific to medication adherence are primarily linked to the reminder functions of the surveys and their alarms (i.e., cues to action) as well as reinforcement of habits or routines.

Reflective processes also supported a few participants in recognizing the extent of missed doses and lack of routines for adherence, although the majority of responses refer to maintenance of adherence due to the large proportion of adherent participants in the sample.

Responses regarding mental health (i.e., mood, stress) are further illustrated in Table 2. Responses suggest impacts on pre-contemplation and contemplation states based on reflective processes, similar to other outcome domains. In addition, general well-being was reported to be supported by self-expression for catharsis (e.g., “venting”) and other aspects of therapeutic relationship processes, such as non-judgmental disclosure (e.g., “something to talk to”). One participant also referred to self-monitoring being beneficial in reinforcing progress made from recent initiation of treatment with a psychiatrist (see Table 2).

Results presented in Table 3 illustrate self-monitoring benefits noted by participants in reference to risk behaviors. Themes regarding perceived benefits of self-monitoring for ATOD use tended to focus either on reflective processes for risk perceptions and contemplation of change, or on reinforcement and cue functions for maintenance (e.g., “keeping in check”). A few participants also noted how self-monitoring multiple domains increased their awareness of the relationships between their substance use, sexual behaviors and other triggers (e.g., boredom, thinking about illness).

Themes regarding sexual behavior illustrated in Table 3 also centered on impacts of self-monitoring on condom use, reducing numbers of partners, and disclosure and discussions of STI status. Self-monitoring functions included reflective processes for altering risk perceptions, intentions, and contemplating decisions for action. Participants also noted that self-monitoring functioned as a reminder cue for taking action to reduce risks and as reinforcement through self-reward by tracking progress after initiating change (see Table 3).

Benefits of Daily Smartphone Self-Monitoring Versus Bi-Weekly Web-Surveys

Participants’ responses also suggested potential for greater benefits from daily smartphone self-monitoring compared to bi-weekly web-surveys alone. In general, participants in Group C (bi-weekly, web-only) reported fewer benefits when queried about useful aspects of completing surveys, and those reports tended to be less elaborate and centered around reflective processes, as shown in responses in Tables 2 and 3. In addition, a few participants noted benefits specific to daily mobile self-monitoring related to in-the-moment availability and daily routines,

“Cell phone is more helpful than the web survey at keeping me on track because it’s always there.” (Grp B, Age 39, Male, Native American);

“The surveys are time sensitive so I can say how I feel in a particular moment of the day.” (Grp A, Age 51, Female, Black);

“Helps me keep a ‘log’, like therapy—but can do it every day instead of waiting for a week to see your therapist...Nice to do it throughout the day, multiple times a day, on a daily basis. Life happens daily- not weekly like when you see a therapist.” (Grp A, Age 38, Male, Latino).

The proportions of mobile phone groups' (A and B) participants reporting awareness and change benefits was about twice that of bi-weekly only group (C) for all domains except sexual behaviors. Among mobile phone group participants, about two-thirds reported awareness benefits and roughly a quarter reported change benefits compared to the bi-weekly group, with about one quarter reporting awareness benefits and only a few participants reporting change for ATOD use only and none for adherence or mental health. General proportion estimates are used here due to limitations of the data related to small sample sizes, variable retention rates and numbers of repeat assessment, as well as variability in proportion calculations depending on different assumptions around missing data (i.e., represents participants disengagement so can be included in denominator, or was not probed extensively in open-ended interviews).

Study groups were similar in sexual behavior awareness benefits reported, at about 40% of participants but behavior change benefits were reported by about half as many mobile group participants as bi-weekly group participants (about 15% compared to 30%). The groups had similar proportions of participants reporting sexual risk reduction goals (about 60%) and about one-third reporting supports. These results should be interpreted with caution but suggest the possibility that sexual risk self-management does not benefit more from daily compared to bi-weekly self-monitoring, and possibly that the lack of benefits in other domains for bi-weekly web-survey only participants (Group C) made the perceived benefits around sexual behaviors more salient for reporting. Again, there were no statistically significant impacts on standardized self-report outcome measures so these results only suggest hypotheses for further testing.

Proportions of participants reporting goals and supports did not vary across groups for mental health, ATOD use, or medication adherence. Almost all, about 90% of participants, reported goals for mental health and ATOD use, with about two-thirds reporting support for mental health and just under half for ATOD use. Less than half, about 40%, reported goals for medication adherence and about one quarter reported support. Exploratory examination of associations between reports of having goals and reports of benefits from self-monitoring had some trends for higher proportions of reports of self-monitoring benefits when goals were reported, but none were statistically significant, except for sexual behavior change benefits reported by 28% with goals vs. 0% without (fisher's exact test $p = 0.037$). Again, results should be interpreted as exploratory due to the many limitations of this data. Participants reporting having support for goals (professional or social) tended to report benefits from self-monitoring less frequently than those without support, although none of the associations were statistically significant and so results only suggest hypotheses for future research.

Negative Feedback on Self-Monitoring

Participants identified a number of negative qualities of the surveys, such as being repetitive, too long, confusing, and intrusive. About one-third of participants described the surveys as "repetitive," "redundant", "monotonous," or "tedious," including participants in the bi-weekly web-survey only group. About one quarter of participants reported that surveys were

too long or too frequent, with all but one participant being from the mobile phone groups. Some participants suggested improvements, for example,

“I like it, but I wish it was more than the same questions every day” (Grp A, Age 61, Male, Black).

About 20 percent of participants across the three study groups reported that the surveys were intrusive or were concerned about privacy, primarily around the sexual behavior surveys and the detailed partner-level reports. In one extreme example, likely in reference to geo-location tagging of phone survey responses, one participant responded,

“I felt like a wild animal being tracked.” (Grp A, Age 47, Male, Latino / Native American).

This response emphasizes the importance of privacy protections around mobile technologies (participants were trained to use the application settings to turn off geo-location if they wished). Only five participants (about 10 percent) stated that the self-monitoring questions were confusing or reported technical challenges, and none were in the web-survey only group. Four participants requested more in-depth questions to better reflect their experiences.

Discussion

This paper makes a modest but novel contribution to elaborating the potential efficacy and causal mechanisms of self-monitoring to support self-management generally, and specifically for multiple domains for PLH. The results of this pilot study illustrate how the multiple self-monitoring functions of reflection, reinforcement, and cues to action can influence risk perceptions, motivations, and skills to support behavioral activation states ranging from contemplation to action and maintenance. Participants also described how self-monitoring functioned for self-expression to provide opportunities for catharsis through journaling, aspects of social support from non-judgmental disclosure, and in-the-moment availability, to improve their sense of well-being. The latter result was surprising given the brief text responses supported by the smartphone application, as opposed to longer narrative writing processes identified in prior research.⁵¹ Participants' feedback suggests that the frequency and in-the-moment nature of the brief text-based responses may account for their potential impacts. Results also suggest that perceived benefits from self-monitoring were greater for daily mobile phone monitoring compared to bi-weekly self-monitoring alone, which is consistent with some prior process research on assessment effects in ATOD abuse intervention studies.²³ The exploratory results of this pilot study also suggest moderating effects of having goals or supports on impacts of self-monitoring, similar to prior studies' findings on motivations and risk perceptions;^{37,38} however, this result could also be explained by those with goals simply being more aware of self-monitoring benefits. Much more rigorous research is needed to test the hypotheses suggested by the results of this study around self-monitoring frequency, intensity, duration and sustainability, and efficacy as both an independent intervention and as an adjunct to other interventions.

The results of this pilot study should be interpreted with caution given the many limitations of this data. The small sample size made statistical analyses for group comparisons

infeasible. The specificity of quantitative estimates across study groups was also limited by small sample sizes, varying and low retention rates for the qualitative interviews, uncertain assumptions about missing data, and some degree of uneven randomization. Open-ended reports were brief and participants were not prompted to elaborate their responses, which suggests the salience of the perceived benefits reported but also likely under-identified the frequency of themes reported and more specific details of self-monitoring functions and mediators on outcomes. In addition, some of the specific constructs and pathways suggested in the theoretical model may not be fully represented in participants' brief responses with limited prompting for elaboration. Only about one-third of participants completed the qualitative interview at 6-week follow-up compared to about three quarters completing the web-survey. This limitation presents further bias in the qualitative data, and so more detailed analyses of longitudinal trends were not viable. Similarly, only half of the mobile phone groups' participants completed 6-weeks of daily self-monitoring, indicating the burden and burnout suggested by negative feedback in this study about long, detailed, and frequent self-monitoring. Follow-up periods longer than six-weeks are warranted for many real-world applications such as between clinical visits yet prior research has found that even two-weeks of daily self-monitoring results in improved ART adherence at three months post-assessment, similar to a single session intervention comparison.³⁴ Future research and application of self-monitoring for self-management support should anticipate patients engaging in several weeks of daily self-monitoring interspersed with longer periods of weekly self-monitoring, for example. Patients engaged in more intensive behavioral interventions with weekly visits might be more open to, or better served by, daily self-monitoring, particularly when first initiating behavior changes.

Although self-monitoring has long been noted as a key self-management strategy,¹⁰ it is rarely highlighted in reviews of the self-management literature generally^{2,3,15,57} nor for HIV specifically.¹ Similarly, Social Cognitive Theory⁹ notes self-monitoring as a primary self-regulation strategy, in addition to self-efficacy, and yet it seems that most interventions emphasize targeting self-efficacy and perhaps assume that self-monitoring functions sufficiently as a passive and internal process. This trend also runs parallel to the emphasis on the *stages of change* in the TTM while there is relatively little attention paid to the TTM's ten *processes of change*,⁴⁹ which are primarily self-reflexive and are incorporated into the theoretical model in this paper. Despite longstanding theoretical emphasis, self-monitoring as a more actively engaged self-management tool has not been consistently incorporated into interventions for PLH. For example, the Los Angeles County Department of Public Health, Division of HIV/STD Programs recently funded medical care coordination (MCC) programs (i.e., patient-centered medical homes) in HIV treatment settings, based on a model arising from work in San Francisco.⁵⁸ The primary goal of MCC is supporting patients to achieve a "self-managed" state for medical adherence, sexual risks, mental health and substance abuse by incorporating brief behavioral interventions into clinical care teams.⁵⁸ While MCC emphasizes monitoring by care providers at quarterly or semi-annual visits, and the use of assessments for brief motivational interviewing, patient *self-monitoring* is not noted in the MCC protocol, consistent with much of the literature on self-management.^{3,15} Research in progress with MCC providers in Los Angeles has identified that a key challenge is patients'

lack of participation in self-management activities between clinical and behavioral intervention visits.

Most self-management interventions for PLH focus on increasing patients' knowledge, self-efficacy, and self-management skills by providing feedback, problem-solving support, and achievable goal setting.¹ Self-monitoring potentially complements these strategies by accelerating and reinforcing their effects. Mobile phone applications offer novel opportunities to engage patients in self-monitoring and self-management between clinical visits, in real-time and during daily routines. A key challenge will be making self-monitoring applications engaging for patients and making data useful for providers, to maximize benefits of the data provided by patients. Although self-monitoring is not a new concept, mobile phones are enabling self-monitoring at a scale and level of engagement that warrants further investigation as both an independent intervention and an intervention adjunct.

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References

1. ElZarrad MK, Eckstein ET, Glasgow RE. Applying chronic illness care, implementation science, and self-management support to HIV. *Am J Prev Med*. 2013; 44 Suppl. 2(1):S99–S107. [PubMed: 23253770]
2. Barlow J, Wright C, Sheasby J, et al. Self-management approaches for people with chronic conditions: a review. *Patient Edu Couns*. 2002; 48:177–187.
3. Bodenheimer T, Lorig K, Holman H, et al. Patient self-management of chronic disease in primary care. *JAMA*. 2002; 288:2469–2475. [PubMed: 12435261]
4. Rotheram-Borus MJ, Ingram BL, Swendeman D, et al. Adoption of self-management interventions for prevention and care. *Prim Care*. 2012; 39:649–660. [PubMed: 23148958]
5. Finitsis DJ, Pellowski JA, Johnson BT. Text message intervention designs to promote adherence to antiretroviral therapy (ART): a meta-analysis of randomized controlled trials. *PloS One*. 2014; 9:e88166. [PubMed: 24505411]
6. Mbuagbaw L, van der Kop ML, Lester RT, et al. Mobile phone text messages for improving adherence to antiretroviral therapy (ART): an individual patient data meta-analysis of randomised trials. *BMJ Open*. 2013; 3:e003950.
7. Fjeldsoe BS, Marshall AL, Miller YD. Behavior change interventions delivered by mobile telephone short-message service. *Am J Prev Med*. 2009; 36:165–173. [PubMed: 19135907]
8. Reback CJ, Grant DL, Fletcher JB, et al. Text messaging reduces HIV risk behaviors among methamphetamine-using men who have sex with men. *AIDS Behav*. 2012; 16:1993–2002. [PubMed: 22610370]
9. Bandura A. Social cognitive theory of self-regulation. *Organ Behav Hum Dec*. 1991; 50:248–287.
10. Kanfer FH. Self-monitoring: Methodological limitations and clinical applications. *J Consult Clin Psychol*. 1970; 35:148–152.

11. Kanfer, FH.; Gaelick-Buys, L. Self-Management Methods. In: Kanfer, FH.; Goldstein, AP., editors. *Helping People Change: a Textbook of Methods*. 4th ed.. Elmsford: Pergamon Press; 1991. p. 305-360.
12. Rotheram-Borus MJ, Swendeman D, Chorpita BF. Disruptive innovations for designing and diffusing evidence-based interventions. *Am Psychol*. 2012; 67:463–476. [PubMed: 22545596]
13. Chorpita BF, Daleiden EL, Weisz JR. Identifying and selecting the common elements of evidence based interventions: A distillation and matching model. *Ment Health Serv Res*. 2005; 7:5–20. [PubMed: 15832690]
14. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. 2013; 46:81–95. [PubMed: 23512568]
15. Lorig KR, Holman HR. Self-management education: history, definition, outcomes, and mechanisms. *Ann of Behav Med*. 2003; 26:1–7. [PubMed: 12867348]
16. Saberi P, Johnson MO. Technology-based self-care methods of improving antiretroviral adherence: a systematic review. *PloS One*. 2011; 6:e27533. [PubMed: 22140446]
17. National Institute of Mental Health Multisite HIV Prevention Trial Group. The NIMH Multisite HIV Prevention Trial: Reducing HIV sexual risk behavior. *Science*. 1998; 280:1889–94. [PubMed: 9632382]
18. Science of Behavior Change. National Institutes of Health; 2015 Jan 12. Available at: <https://commonfund.nih.gov/behaviorchange/index>
19. Lyons EJ, Lewis ZH, Mayrhoon BG, et al. Behavior change techniques implemented in electronic lifestyle activity monitors: a systematic content analysis. *J Med Internet Res*. 2014; 16:e192–e202. [PubMed: 25131661]
20. Norris SL, Engelgau MM, Narayan KV. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. *Diabetes Care*. 2001; 24:561–587. [PubMed: 11289485]
21. Burke LE, Wang J, Sevick MA. Self-monitoring in weight loss: a systematic review of the literature. *J Am Diet Assoc*. 2011; 111:92–102. [PubMed: 21185970]
22. Coster S, Gulliford MC, Seed PT, et al. Self-monitoring in type 2 diabetes mellitus: a meta-analysis. *Diabet Med*. 2000; 17:755–761. [PubMed: 11131099]
23. McCambridge J. [Commentary] Research assessments: instruments of bias and brief interventions of the future? *Addiction*. 2009; 104:1311–1312. [PubMed: 19624324]
24. Jenkins RJ, McAlaney J, McCambridge J. Change over time in alcohol consumption in control groups in brief intervention studies: systematic review and meta-regression study. *Drug Alcohol Depend*. 2009; 100:107–14. [PubMed: 19041196]
25. NIMH Multisite HIV Prevention Trial. Conceptual basis and procedures for the intervention in a multisite HIV prevention trial. *AIDS*. 1997; 11:S29–S35. [PubMed: 9475709]
26. Kamb ML, Fishbein M, Douglas JM Jr, et al. Efficacy of risk-reduction counseling to prevent human immunodeficiency virus and sexually transmitted diseases: a randomized controlled trial. Project RESPECT Study Group. *JAMA*. 1998; 280:1161–1167. [PubMed: 9777816]
27. The National Institute of Mental Health (NIMH) Multisite HIV Prevention Trial Group. (Rotheram-Borus, M. J., PI, Los Angeles site). The NIMH Multisite HIV Prevention Trial: Reducing HIV sexual risk behavior. *Science*. 1998; 280(5371):1889–1894. PMID: 9632382. [PubMed: 9632382]
28. Healthy Living Project Team. Effects of a behavioral intervention to reduce risk of transmission among people living with HIV: the healthy living project randomized controlled study. *J Acquir Immune Defic Syndr*. 2007; 44:213–221. [PubMed: 17146375]
29. Barta WD, Portnoy DB, Kiene SM, et al. A daily process investigation of alcohol-involved sexual risk behavior among economically disadvantaged problem drinkers living with HIV/AIDS. *AIDS Behav*. 2008; 12:729–740. [PubMed: 18071894]
30. Barta WD, Tennen H, Kiene SM. Alcohol-involved sexual risk behavior among heavy drinkers living with HIV/AIDS: negative affect, self-efficacy, and sexual craving.”. *Psychol Addict Behav*. 2010; 24:563–570. [PubMed: 21198219]

31. Cook PF, McElwain CJ, Bradley-Springer LA. Feasibility of a daily electronic survey to study prevention behavior with HIV-infected individuals. *Res Nurs Health*. 2010; 33:221–234. [PubMed: 20499392]
32. Kiene SM, Simbayi LC, Abrams A, et al. High rates of unprotected sex occurring among HIV-positive individuals in a daily diary study in South Africa: the role of alcohol use. *J Acquir Immune Defic Syndr*. 2008; 49:219–226. [PubMed: 18769345]
33. Tucker JA, Blum ER, Xie L, et al. Interactive voice response self-monitoring to assess risk behaviors in rural substance users living with HIV/AIDS. *AIDS Behav*. 2012; 16:432–440. [PubMed: 21311964]
34. Safren SA, Otto MW, Worth JL, et al. Two strategies to increase adherence to HIV antiretroviral medication: life-steps and medication monitoring. *Behav Res Ther*. 2001; 39:1151–1162. [PubMed: 11579986]
35. Aharonovich E, Greenstein E, O'Leary A, et al. HealthCall: technology-based extension of motivational interviewing to reduce non-injection drug use in HIV primary care patients - a pilot study. *AIDS Care*. 2012; 24:1461–1469. [PubMed: 22428809]
36. Hasin DS, Aharonovich E, O'Leary A, et al. Reducing heavy drinking in HIV primary care: a randomized trial of brief intervention, with and without technological enhancement. *Addiction*. 2013; 108:1230–1240. [PubMed: 23432593]
37. Lightfoot M, Rotheram-Borus MJ, Comulada S, et al. Self-monitoring of behaviour as a risk reduction strategy for persons living with HIV. *AIDS Care*. 2007; 19:757–763. [PubMed: 17573595]
38. Newcomb ME, Mustanski B. Diaries for observation or intervention of health behaviors: factors that predict reactivity in a sexual diary study of men who have sex with men. *Ann Behav Med*. 2013; 47:325–334. [PubMed: 24081918]
39. Swendeman D, Comulada WS, Ramanathan N, et al. Reliability and validity of daily self-monitoring by smartphone application for health-related quality-of-life, antiretroviral adherence, substance use, and sexual behaviors among people living with HIV. *AIDS Behav*. 2014 epub ahead of print.
40. Heron KE, Smyth JM. Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. *Br J Health Psychol*. 2010; 15:1–39. [PubMed: 19646331]
41. Swendeman D, Ingram BL, Rotheram-Borus MJ. Common elements in self-management of HIV and other chronic illnesses: an integrative framework. *AIDS Care*. 2009; 21:1321–1334. [PubMed: 20024709]
42. Chesney MA, Ickovics JR, Chambers DB, et al. Self-reported adherence to antiretroviral medications among participants in HIV clinical trials: the AACTG Adherence Instruments. *AIDS Care*. 2000; 12:255–266. [PubMed: 10928201]
43. Health-Related Quality of Life (HRQOL). Centers for Disease Control and Prevention; 2012 Nov 1. Available at: <http://www.cdc.gov/hrqol/>.
44. Comulada SW, Weiss RE, Cumberland W, et al. Reductions in drug use among young people living with HIV. *Am J Drug Alcohol Abuse*. 2007; 33:493–501. [PubMed: 17613977]
45. Miles, MB.; Huberman, AM. *Qualitative Data Analysis: An Expanded Sourcebook*. 2nd ed. Thousand Oaks: Sage Publications; 1994.
46. Rimer, BK.; Glanz, K. *Theory at a Glance: A Guide for Health Promotion Practice*. 2nd ed. Washington, D.C.: U.S. Department of Health and Human Services, National Institutes of Health; 2005.
47. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. *Health Educ Q*. 1988; 15:175–183. [PubMed: 3378902]
48. Ajzen I, Fishbein M. Attitude-behavior relations: a theoretical analysis and review of empirical research. *Psychol Bull*. 1977; 84:888–918.
49. Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. *Am J Health Promot*. 1997; 12:38–48. [PubMed: 10170434]
50. Weinstein ND, Sandman PM. A model of the precaution adoption process: evidence from home radon testing. *Health Psychol*. 1992; 11:170–180. [PubMed: 1618171]

51. Pennebaker JW. Writing about emotional experiences as a therapeutic process. *Psychol Sci.* 1997; 8:162–166.
52. Frattaroli J. Experimental disclosure and its moderators: a meta-analysis. *Psychol Bull.* 2006; 132:823–65. [PubMed: 17073523]
53. Creswell, JW.; Klassen, AC.; Plano Clark, VL.; Smith, KC. Best Practices for Mixed Methods Research in the Health Sciences. National Institutes of Health; 2011 Aug. Available at: http://obssr.od.nih.gov/mixed_methods_research/
54. Littell JH, Girvin H. Stages of change. A critique. *Behav Modif.* 2002; 26:223–273. [PubMed: 11961914]
55. Cahill K, Lancaster T, Green N. Stage-based interventions for smoking cessation. *Cochrane Database Syst Rev.* 2010; 11:CD004492. [PubMed: 21069681]
56. Noël Y. Recovering unimodal latent patterns of change by unfolding analysis: application to smoking cessation. *Psychol Methods.* 1999; 4:173–191.
57. Warsi A, Wang PS, LaValley MP, et al. Self-management education programs in chronic disease. *Arch Intern Med.* 2004; 164:1641–1649. [PubMed: 15302634]
58. Medical Care Coordination Guidelines. Los Angeles County Department of Public Health, Division of HIV and STD Programs; 2013 Mar 1. Available at: http://publichealth.lacounty.gov/aids/Contractors/MCC_Protocol%203_1_2013.pdf Miller, WR.; Rollnick, S. Motivational Interviewing: Helping People Change. 3rd ed. New York: Guilford Press; 2012. (in Figure 1 only)

Figure 1.
Self-Monitoring Theory of Action

Table 1

Demographic characteristics and assessment completion rates, by study arm

	Daily Mobile A "Assessment"		Daily Mobile B "Behavior Change"		Bi-weekly Web Only C		Total	
	N = 14		N = 20		N = 16		N = 50	
	n	%	n	%	n	%	n	%
Gender^b								
Female	1	7.1	4	20.0	1	6.7	6	12.2
Male	11	78.6	15	75.0	14	93.3	40	81.6
Transgender	2	14.3	1	5.0	0	0.0	3	6.1
Race								
Black	7	50.0	8	40.0	9	56.3	24	48.0
Latino	1	7.1	3	15.0	4	25.0	8	16.0
Native American	0	0.0	1	5.0	0	0.0	1	2.0
White	4	28.6	6	30.0	3	18.8	13	26.0
Mixed ^a	2	14.3	2	10.0	0	0.0	4	8.0
Sexual orientation^b								
Bisexual	3	23.1	3	15.0	0	0.0	6	12.2
Gay	8	61.5	13	65.0	13	81.3	34	69.4
Heterosexual	2	15.4	4	20.0	3	18.8	9	18.4
Medication Adherence *								
ART (miss <3 of 14 days)	8	80.0	13	81.3	10	83.3	31	81.6
ART (miss 0 in last 3 days)	7	77.8	11	73.3	11	91.7	29	80.6
Mental Health								
Anxious (5+ days / 14 days)	6	75.0	5	62.5	4	40.0	15	57.7
Sad (5+ days / 14 days)	3	37.5	4	44.4	5	50.0	12	44.4
Substance Use (>0/14 days)								
Alcohol	13	92.9	18	90.0	15	93.8	46	92.0
Cocaine	4	28.6	5	25.0	5	31.3	14	28.0
Crack	8	57.1	8	40.0	4	25.0	20	40.0

	Daily Mobile A "Assessment"		Daily Mobile B "Behavior Change"		Bi-weekly Web Only C		Total	
	N = 14		N = 20		N = 16		N = 50	
	n	%	n	%	n	%	n	%
Marijuana	10	71.4	14	70.0	12	75.0	36	72.0
Tobacco	9	64.3	11	55.0	10	62.5	30	60.0
Methamphetamine	6	42.9	9	45.0	7	43.8	22	44.0
Sexual Behaviors								
Casual or One-Time Sex Partner (past 14 days)	6	42.9	8	40.0	9	56.3	23	46.0
Unprotected sex with HIV-negative/unknown (14 days)	4	28.6	5	25.0	2	12.5	11	22.0
Web-Survey Retention								
2 week	13	92.9	17	85.0	16	100	46	92.0
4 week	13	92.9	16	80.0	15	93.8	44	88.0
6 week	11	78.6	13	65.0	14	87.5	38	76.0
Qual. Interview Retention								
2 week	13	92.9	17	85.0	11	68.8	41	82.0
4 week	12	85.7	12	60.0	9	56.3	33	66.0
6 week	6	42.9	6	30.0	4	25.0	16	32.0

* Denominator only includes those who responded to the question.

^a Group A (Latin / Nat. Amer., Latin / Sfaric); Group B (Latin / Nat. Amer., French / Spanish-Indian)

^b Overall N = 49 due to missing information for one participant

Table 2
Perceived Benefits of Self-Monitoring for Health: Medication Adherence and Mental Health

Medication Adherence	Self-Monitoring Mechanism	Mediators	Outcomes
I realized that I don't actually have a set schedule for my meds. (31, Male, Latino, B)	Reflection - Self-awareness		Contemplation
Helped me think about how many times I actually miss my medication- I never thought about it before. (50, Male, White, C)	Reflection - Self-awareness	Perceptions - Susceptibility	Precontemplation
Reminds me to take my meds. (39, Male, Native American, B)	Cues to Action		Maintenance
Reminds me to take my meds, and helps me keep my medicines in order. (56, Male, White, A)	Cues to Action, Reinforcement		Maintenance
The alarm reminded me to take my medication on time- I am now accustomed to taking it at that time every day. (40, Male, Black, B)	Cues to Action, Reinforcement		Maintenance
Got me into a better routine with my medicine. (34, Male, Latino, B)	Reinforcement		Maintenance
Helped me not miss my medicine. (61, Male, Black, C)	Cues to Action		Maintenance
Made me more adherent to my medications. (46, Not Reported, White, C)	Reinforcement		Maintenance
Mental Health			
Helped me realize my emotional state and my sleep patterns. (23, Male, Black, B)	Reflection - Self-awareness		Precontemplation
The survey questions aren't questions that you would ask yourself or even talk about with friends- so it really makes you think about things (i.e. mood, sexual behavior). (52, Male, Black, A)	Reflection - Self-awareness		Precontemplation
Mood questions got me to reflect on my various moods throughout the past two weeks. (60, Male, White, C)	Reflection - Self-awareness		Precontemplation
Helped me realize exactly what I am stressing about and what I need to work on. (31, Male, Latino, B)	Reflection - Inspiration	Intentions	Contemplation
Liked General Feeling Surveys- recently started seeing a psychiatrist and started taking medication so it was helpful to keep track of my mood (depression, energy levels). The surveys helped me keep track of how I was getting better each day. (40, Male, Latino, A)	Reinforcement - Self-reward		Maintenance
Acts like a diary - can express myself when I'm are feeling down, can express myself, and write down my emotions which helps calms me down. (38, Male, Latino, A)	Self-expression	Catharsis	Well-being
Sometimes you don't say everything to your therapist and it helps to write down how you are feeling- not to get feedback, but it just feels good to let it out. (38, Male, Latino, A)	Self-expression	Non-judgmental, Catharsis	Well-being
Helpful to get things off my chest when I'm stressed- something to talk to. (47, Transgender, Black, A)	Self-expression	Catharsis	Well-being
Therapeutic- I can express how I feel at that moment. (49, Male, Latino, B)	Self-expression, In-the-moment	Catharsis	Well-being

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Medication Adherence	Self-Monitoring Mechanism	Mediators	Outcomes
Felt like I could talk freely- like having a therapist. (41, Female, White, B)	Self-expression	Non-judgmental	Well-being
I feel free to vent to the phone about things that I can't talk to my partner about- I can really express how I feel. (30, Male, Black, B)	Self-expression	Catharsis, Non-judgmental	Well-being

Table 3
Perceived Benefits of Self-Monitoring for Risk Behaviors: Alcohol, Tobacco, Drugs, & Sexual Behaviors

	Self-Monitoring Mechanism	Mediators	Outcomes
Alcohol, Tobacco & Other Drug Use (ATOD)			
I saw that when I got bored, wasn't feeling healthy, or when I think about my illness, it triggers me to do drugs. (49, Male, Black, A)	Reflection - Self-awareness	Perceptions - Susceptibility	Contemplation
Made me start thinking about my actions- cutting down on drinking and smoking weed. (44, Female, Black, C)	Reflection - Concern	Intentions	Contemplation
Made me take a closer look at my drug usage and my desire to stop. (50, Male, Black, C)	Reflection - Concern	Intentions	Contemplation
I realized how much I was smoking and that I need to quit. (31, Male, Latino, B)	Reflection - Inspiration	Intentions	Contemplation
Helps me look at my behavior and think about what I should keep doing to stay clean. (33, Male, Latino, C)	Reinforcement, Reflection	Intentions	Maintenance
Helps me stay on track with not smoking. (52, Male, Black, A)	Reinforcement	Intentions	Maintenance
Keeps me in check- and helps me think about not drinking alcohol. (61, Male, Black, A)	Reinforcement, Cues to Action	Intentions	Maintenance
Keeps me in check, monitoring sexual encounters and drug activities. (38, Male, Latino, A)	Reinforcement		Maintenance
Made me think about not drinking and taking my medicine at the same time. (44, Female, Black, C)	Reflection - Reevaluation	Intentions	Contemplation
Helped me realize that we usually smoke weed to get intimate. (31, Male, Latino, B)	Environmental reevaluation	Intentions	Precontemplation
Sexual Behaviors			
Make me think about my actions with my partner- to be safe or not. (61, Male, Black, C)	Reflection	Intentions	Contemplation
Now I have to reflect on my behavior and possibly make better decisions- specifically about being conscious about being safe with protection. (58, Male, Black, C)	Reflection - Self-awareness, Concern/Inspiration	Perceptions, Intentions	Contemplation
Opened my eyes in terms of speaking up about STD status. (31, Male, Latino, B)	Reflection - Reevaluation	Intentions	Preparation
More open with partner about my STD status. (31, Male, Latino, B)			Action
Reminds me to ask the questions about safe sex and find out the status of my partner. (61, Male, Black, C)	Cues to Action		Action
Useful for helping me stop my sexual activity- I want to be single for now. (44, Female, Black, C)	Reinforcement	Intentions	Action
I talked to my boyfriend about safe sex after taking the survey. (26, Male, Black, C)			Action

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Self-Monitoring Mechanism	Mediators	Outcomes
I saw my own track record. I didn't realize how many people I was sleeping with until I saw the numbers in from of me. By the end of the study, my number was down. (40, Male, Black, B)	Reflection - Concern Reinforcement - Self-reward Perceptions - Severity	Action