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Recent Advances (2011-2012) in Technology-Delivered Interventions for People Living with HIV

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Abstract

Technology is rapidly advancing and becoming a cost effective option for intervention delivery particularly for isolated and hard to reach populations, such as people living with HIV/AIDS. A systematic review was conducted to identify recent technology based interventions for people living with HIV. The review yielded 12 studies that were grouped by the health behavior that it addressed and then the type of technology utilized. The majority of studies reviewed focused on medication adherence and used several different technologies to deliver the intervention including SMS/text messaging, cell phones and computers. This review identified several gaps in the literature particularly the lack of technology-based interventions focusing on engagement and retention to care as well as sexual risk reduction. Suggestions for future research based on these findings are provided.

Keywords

HIV/AIDS; HIV management; technology; technology intervention; technology-based intervention; secondary prevention; systematic review; sexual risk reduction; people living with HIV (PLWH)

Introduction

There are an estimated 33.3 million people in the world living with HIV and 2.6 million new infections every year [1]. The number of AIDS-related deaths worldwide has decreased from 2.1 million in 2004 to 1.8 million in 2009, primarily due to success of and increased access to antiretroviral therapies [1]. However, people living with HIV (PLWH) in developing countries continue to face multiple challenges accessing care. In the United States, the HIV epidemic also continues to expand, with an estimated 1.1 million people infected with HIV and 50,000 new HIV infections each year [2]. It is estimated that 25% of Americans infected with HIV are undiagnosed. In addition, as many as one in three of those diagnosed are not engaged in health care services [3]. Even individuals who are engaged in care do not necessarily benefit from treatment because of non-adherence to antiretroviral medications (ARVs).

For more than a decade researchers have concentrated on developing and evaluating interventions aimed at testing, detecting, engaging, and treating PLWH with many interventions demonstrating positive outcomes. Meta-analyses show that behavioral interventions to improve medication adherence and reduce HIV transmission risk behaviors in those already infected have demonstrated efficacy [4, 5]. Because office and clinic based interventions are limited in reach and scalability, behavioral interventions are utilizing electronic and mobile technologies to improve the health behaviors of people living with HIV. As the world becomes more connected and technology becomes less expensive, novel technological approaches will increase the reach of interventions for primary and secondary HIV prevention. Mobile health technologies are particularly enhancing our ability to reach isolated and hard to access populations. These technologies can range from something as simple as a text message reminder to more complex efforts such as virtual nursing using computer and internet interfaces. Technological solutions can be especially useful tools for improving the long-term use of health behaviors such as medication adherence and sexual risk reduction [6, 7].

As technologies such as cell phones, short message system (SMS) / text messages and the Internet become universally accessible, they are being integrated into behavioral intervention delivery. Several previous reviews concerning technology-delivered interventions for PLWH have shown promising results. In a meta-analytic review of medication adherence interventions utilizing mobile phone text messaging, Horvath et al. [8] found weekly text messaging provided a robust effect on medication adherence for PLWH compared to standard care. A systematic review of text messaging interventions to promote adherence found similar effects [9*]. In addition, information is emerging about the costs and relative benefits of electronic and mobile technology interventions. For example, a recent cost analysis by Page et al. [10*] found that although an internet-based intervention was costly to develop, the monthly maintenance costs after the development period were low. These studies provide encouraging results for the use of technologies in intervention implementation and delivery.

In preparation of this article, we looked at the past 5 years of technology based interventions to determine previous trends in the literature. We found interventions ranging across a wide variety of health behaviors including medication adherence [11-18], sexual risk reduction [14, 19-21], drug use [20], health literacy [22], depression [23-24] and suicidal ideation [25]. However, medication adherence was dominant within the literature. Additionally, the types of technologies utilized also varied. Technologies such as text messaging [13, 15-16], pagers [18], cell phones [12], personal digital assistants (PDAs) [14], videophones [17], the internet [11, 21-22], and computers [19-20, 23-25] were commonly utilized. This literature will be used as a starting point to determine where the field has previously been focused in comparison to where the field is headed.

The purpose of this paper is to review recent advances and current trends in the use of electronic and mobile health technologies for people living with HIV/AIDS. Access to technology is rapidly expanding and has the potential to significantly alter the delivery of health behavior interventions. We therefore consider intervention trials that have been completed in no more than two years prior to the time this paper went to press. Specifically, we concentrated on intervention trials published in 2011 and 2012. We also examine other evidence for emerging trends in the research literature regarding electronically based behavioral interventions for people living with HIV/AIDS.

Literature Search Method and Criteria for Inclusion

A systematic literature review was conducted in Pubmed/Medline and PsycInfo databases to identify studies published since 2011 that address health promotion or secondary prevention for PLWH using electronic or mobile technology as a delivery platform. Combinations of the following search terms were used to ascertain relevant articles: behavioral intervention, secondary prevention, intervention, HIV, AIDS, technology, text message, SMS, short message service, telehealth, telemedicine, internet, computer, phone. Articles were included if they met three a priori criteria: (a) the target population for the study was PLWH, (b) the study consisted of an intervention that was evaluated for efficacy, and (c) a specific technology was the method of intervention delivery. Studies were not included if the technology (i.e. computer, internet, interactive voice response) was solely used for data collection. The type of efficacy evaluation was not limited solely to randomized control trials (RCTs); pre-post experimental designs were included.

Results

Results of our systematic literature search are shown in Figure 1. We identified 18,318 articles meeting our search criteria, of which 117 were published since 2011 and were deemed relevant to interventions for people living with HIV. In addition, we excluded 44 on the basis of not being specific to secondary HIV prevention, 43 because they were not intervention trials, and 18 because electronic or mobile technologies were not the method of intervention delivery. Our final set of studies included in the review consists of 12 studies, 9 of which employ technology to improve medication adherence, and single studies focused on drug use, stress management, and smoking cessation. Table 1 provides a description of the study designs, methods and findings.

Medication Adherence

Current trends are showing several different electronic and mobile technologies are being used to increase medication adherence for people living with HIV. With an increasing number of the world's population having cell phones, phone and SMS/text message technology have become promising modes of intervention delivery particularly for medication adherence because individuals can be reached wherever they are and at any time.

Cell Phone Based Interventions

Three intervention studies have come out in the last two years that focus on delivering medication adherence interventions over cell phones. One study [26] with promising results was conducted in Atlanta, Georgia with 40 men and women living with HIV who were 95% or less adherent to their HIV medications in the past month as measured by self-report via the Visual-Analog Scale. The intervention consisted of an in-office counseling session and four one-on-one behavioral self-regulation adherence counseling sessions over the phone. Participants also completed 3 unannounced pill counts and a 4-month computerized behavioral assessment to measure adherence and relevant theoretical constructs. Results showed significant increases in medication adherence for those in the intervention condition compared to contact-matched controls based on the unannounced pill counts. Effect sizes ranged from $d=.45$ to $d=.80$. Additionally, participants in the intervention condition also showed greater medication self-efficacy and used significantly more behavioral strategies, such as using pillboxes and alarms, than those in the control condition.

Another cell phone [27] intervention examined the efficacy of using cell phone reminders for ART adherence in Pakistan. This controlled trial was conducted with 76 men and women randomized to receive either the intervention condition which consisted of participant

involved counseling and weekly cell phone reminders over the course of a month or the control condition which received routine counseling. Results showed that those in the experimental intervention condition had significantly higher adherence as measured by self-report. Additionally, compared to the control condition, those who received cell phone reminders had significantly lower viral loads, as measured by clinical records with HIV viral loads <50 copies. This intervention was efficacious for HIV positive adults on first line ART.

Gray et al. [28] conducted a very small (N=4) intervention pilot study that adapted Behavioral Family Systems Therapy (BFST) to address medication adherence in adolescents living with HIV. In a case study type design, the intervention was administered to adolescents and their families in mixed method sessions including home sessions and telephone conference call sessions. The researchers found an estimated higher adherence during the intervention period as determined by in-clinic pill counts and MEMS (Medication Event Monitoring System) caps. Additionally, all participants reported decreased barriers to adherence and there appeared to be a decreasing trend in viral load for some of the participants.

In general, cell phones seem to be an effective means of intervention delivery for medication adherence interventions. Kalichman et al. [26] and Uzma et al. [27] found positive effects on adherence for both objective measures (i.e. unannounced pill count and viral load) as well as subjective measures (i.e. self-reported adherence). Although, the Gray et al. [28] intervention shows some promising results with adolescents, concrete conclusions cannot be drawn because of its very small sample size.

SMS/Text Messaging Interventions

In addition to using cell phones as a means for 'talk' intervention delivery, text messaging has also been commonly used in recent years. Text messaging can be used for dose-time centered reminders as well as more general motivation for a patient to continue taking their medications. Additionally, text messaging provides a relatively discrete platform for intervention delivery and has been used with multiple populations with varying effects.

In a small-scale randomized controlled trial, Hardy et al. [29] assessed the efficacy of a personalized daily text message intervention compared to a control condition that consisted of a dose-centered reminder beep. Twenty-three HIV positive men and women in Boston, were randomized to one of the two conditions. Results showed that adherence based on MEMS cap data was significantly higher for participants who received the personalized daily text messages. Pill count and self-reported adherence measures, however, were not significantly different between the intervention and control conditions.

SMS and text messaging technologies applied to medication adherence have also been utilized with specific sub-populations. One such study [30] examined the feasibility, acceptability and efficacy of an SMS intervention among HIV positive youth (ages 14-29) who had poor adherence to their antiretroviral medications. The intervention used daily SMS reminders in conjunction with interactive follow-up messages to increase medication adherence. The intervention was found to be feasible and acceptable to HIV positive youth in the United States. Utilizing a pre-post design for this pilot study, Downshen and colleagues [30] found significant increases in medication adherence as measured by Visual-Analog Scale and self-reported recall of the past 4 days. However, they did not find supporting biological data, although CD4 T cell counts and viral load were trending to improvement.

Another study showing trending improvement on medication adherence focused on HIV positive Brazilian women. da Costa and colleagues [31] conducted a small scale randomized trial comparing daily dose-centered text message reminders to a control group that did not receive text messages. Overall, the majority of participants in the SMS condition believed that the messages helped them with their medication adherence and said that they would like to continue receiving the messages, providing evidence for the acceptability of the intervention. However, researchers only found a trend toward higher adherence among those in the intervention condition on measures of self-report, pill count and MEMS data.

Working with another key population, Lewis et al. [32] developed an intervention for men who have sex with men (MSM) utilizing tailored text messages to improve medication adherence. The study was found to be feasible and acceptable to this population. Researchers also found promising results in this proof-of-concept study including significant increases in medication adherence, as measured by self-report, for those who were non-adherent at the start of the study. Results also showed significant increases in CD4 count and significant decreases in viral load as obtained through medical records.

On the whole, these four intervention studies provide some support for the efficacy of text messaging as a method of intervention to increase medication adherence for several sub-populations. However, because these studies are all pilot or test-of-concept studies, they often suffered from too little power to detect even modest sized effects. The trends of increased medication adherence are encouraging but larger trials of these interventions are necessary to determine the actuality of the results.

A moderately sized randomized control trial by Pop-Eleches et al. [33] however, provides convincing evidence for the modality of intervention delivery for medication adherence. Pop-Eleches and colleagues [33**] conducted a five-arm intervention trial not only looking at the efficacy of a text message intervention but also evaluating the length of the messages delivered and when they were delivered. Adherence was measured via MEMS caps using a 90% adherent cut-off to compare adherent versus non-adherent participants. The number of treatment interruptions, greater than 48 hours, was also calculated. When conditions were combined by length, neither the long reminders nor the short reminders yielded significantly higher adherence compared to the control. However, in an additional analysis researchers found adherence to be significantly higher among those in the weekly reminders conditions compared to the control. Those receiving weekly reminder also had significantly lower rates of treatment interruptions when compared to the control. This study provides good evidence for weekly text message medication reminders to improve medication adherence.

Overall, recent text messaging interventions targeting medication adherence for people living with HIV have shown promising results, however, more research is needed that focuses on multiple measures of adherence in addition to self-report. In addition, larger trials are needed to determine the efficacy of interventions tested with adequate statistical power and generalizability.

Computerized Interventions

Another method of intervention delivery tested in the recent literature targeting medication adherence for people living with HIV is the use of computer interfaces. In a large-scale randomized control trial of a fully automated intervention, Fisher et al. [34] tested an Information-Motivation-Behavior theory based computer intervention. Nearly six hundred HIV positive men and women recruited from HIV clinics in Connecticut were randomized to receive one of two conditions. The intervention condition received an interactive computer based intervention aimed at adherence promotion. Those in the control received the standard of care as well as the introductory portions of the computer program but did not

receive the interactive components. In an intent-to-treat analysis, the intervention condition did not have a significant impact of medication adherence as compared to the standard-of-care control as measured by self-report and abstracted viral load. However, in a sub-analysis, looking at participants who completed 6 sessions and who were continuously prescribed medications, Fisher and colleagues did report a significant increase in perfect 3-day self-reported adherence.

In general, this computer intervention is promising but it is lacking in objective measures to show efficacy in increasing medication adherence. More research is needed to identify key elements of this intervention to capitalize on the positive results. Computerized interventions may still be a promising modality of intervention for medication adherence, however, more studies must be conducted for this to be determined.

Other Health Behaviors

Our review of recent and current research on technology used to improve the health of people living with HIV only identified three non-adherence studies. Aharonovich et al. [35] tested an intervention utilizing innovative interactive voice response technology to deliver brief motivational interviewing to reduce substance use behaviors in people living with HIV. The intervention was named “HealthCall” and consisted of 1-3 minute daily calls during which patients reported substance use and other health behaviors to a telephone interactive voice response system. These data were subsequently used as feedback to patients during motivational interviewing-based counseling. The study found the adaptation of the technology feasible and also reported positive effects on reducing substance use behavior.

Another health behavior of concern is the high prevalence of smoking among people living with HIV. Vidrine et al. [36] utilized cell phone based counseling in order to aid in smoking cessation efforts. The intervention condition received a series of 11 counseling phone calls over the course of three months that emphasized problem solving and skills training. When compared to a usual care control condition, those in the intervention had significantly higher quit-abstinence rates. Those who received the cell phone counseling were 4.33 times more likely to be abstinent from smoking at day 7.

Finally, Brown et al. [37] delivered a behavioral stress management intervention to 60 HIV positive women using a computerized counseling program. The intervention condition was a 90-minute computer session focusing on basic information about stress, cognitive appraisal, coping strategies and relaxation training. The control group received the same intervention but delayed. Results of this small trial showed improved knowledge regarding stress management techniques, but no significant differences in depressive symptoms, psychological distress, perceived stress or coping self-efficacy compared to a control condition.

On the whole, these interventions show that there have been several successes in utilizing electronic and mobile technologies to improve the health of people living with HIV in recent years. The types of technologies utilized seem to be consistent with past research and technology interventions focused on medication adherence are still dominant. However, it should be noted that technology-based interventions focused on sexual risk reduction for people living with HIV are lacking in these recent advances, which differs from previous work in this field. It is possible that the field is moving away from using technology to address sexual risk issues. Also notable is the lack of technology-based interventions to increase engagement and retention to HIV-related care. Thus, recent technologically based interventions are not addressing some pressing aspects of health behavior interventions for people with HIV.

Emerging Technologies

Our review identified evidence for emerging technologies that will likely propel the field forward in the near future. Studies using cell phones were most common, including SMS/text as well as voice technologies. There is also a trend emerging toward adapting technologies for interventions that had originally been used as data collection and assessment modalities, in particular, interactive voice response technology and cell-phone assessments are both being used to frame counseling around patient self-monitoring and self-assessment. We also identified new technologies that are being used in HIV-related health behavior research but have not yet been tested in randomized trials. Cellular communications can signal when patients open a pill container, and failure to receive a signal can trigger a provider-based intervention [38]. In addition, researchers are harnessing the power of the internet to deliver behavioral interventions using video-conferencing for people living with HIV in remote and rural areas [39]. In addition, we identified use of technology for HIV prevention that may have equal appeal for interventions targeting people living with HIV including video-streaming behavior change themes in digital stories [40]. Social media and networking are being used to build support for risk reduction behavior change that could provide similar applications in interventions for people living with HIV [41].

The next generation of health behavior technology is just coming of age and offers new opportunities for AIDS-behavioral interventions. These technologies exploit high-speed processing, wireless mobility, and global connectivity to allow for real-time dynamic and active assistance. A recent review by Kennedy et al. [42**] examined such technology that allows (a) dynamic adaptive tailoring of messages depending on context, (b) interactive education, (c) support for client self-monitoring of behavior change, and (d) novel adaptations of behavior change theories using active technology. For example, health interventions are using ecological momentary assessment to capture patient in-the-moment experiences to extract goals, beliefs, mood, and emotions in clinical sessions. Action-based telehealth-behavior models are being used to increase awareness, set goals, remind, and reward health behaviors. There are also PDA coaching applications that contextually tailor health messages based on current experience. These rapidly emerging technologies should be capitalized on to impact health behavior interventions for HIV positive persons and will require careful monitoring in future systematic literature reviews.

Conclusions

Our review of current and emerging technologies for enhancing health behavior interventions for PLWH demonstrates that medication adherence is exploiting these advances, while far fewer applications of technology are being applied to other health-related behaviors. Thus, despite the well-recognized need of one-third of HIV positive individuals not in treatment, we did not find evidence for using technology to improve engagement and retention in care, at least not in the research literature. We see great possibilities for future interventions that use these technologies to achieve key public health objectives in the care of PLWH. For example, behavioral interventions are being developed and tested to enhance the impact of using antiretroviral treatments as prevention (TasP). While the evidence is clear that HIV treatments can reduce HIV infectiousness including multiple observation studies [43] and a randomized controlled trial [44], the success of this new wave in HIV prevention is dependent on retaining in care, medication adherence and controlling co-occurring sexually transmitted infections. Additionally, the majority of the studies reviewed were very small scale and may have suffered from lack of statistical power due to small sample sizes. More adequately powered studies are needed to determine the true efficacy and usability of these technology based interventions. These gaps in the current

and emerging literature should be the priority in the next wave of electronic and mobile technology-based behavioral interventions for HIV infected populations.

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The findings in this article will most likely be influential in the development and implementation of future medication adherence text messaging interventions for people living with HIV.]

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Figure 1.

Flow diagram of systematic literature review for technology based interventions for people living with HIV.

Table 1
Study characteristics for technology based-interventions for people living with HIV included in the systematic review

Author, Year	Journal	Location	Health Behavior	Technology Intervention	Sample	Results
Aharonovich et al., 2012	In press, AIDS Care		Drug Use	I: Motivational Interviewing with daily brief patient calls C: Motivational Interviewing Only	Non-injection drug users, HIV+	HealthCall was found to be feasible and acceptable. Between groups effect size of .062 favoring HealthCall arm
Brown et al., 2011	AIDS Care	New York, USA	Stress management	I: Computer administered stress management intervention C: Delayed treatment	HIV+ women; Intervention N=30; Control N=30	Improved stress management knowledge ($p<.01$); No significant differences in depressive symptoms, psychological distress, perceived stress and coping self-efficacy compared to control
da Costa et al., 2012	International Journal of Medical Informatics	Brazil	Medication adherence	I: SMS text messages on alternating days 30 minutes before dose time C: Received no text messages	HIV+ women; Intervention N=8; Control N=13	Adherence for the intervention condition was higher for self-report, pill counting and MEMS though not significantly
Dowshen et al., 2012	Journal of Medical Internet Research	United States	Medication adherence	Pre-post design; Daily SMS reminders and interactive follow-up messages	HIV+ youth (ages 14-29) N= 25	Daily SMS reminders for HIV+ youth were found to be feasible and acceptable. Adherence based on the Visual-Analog Scale was significant ($d= 1.13$, $p<.001$) as was self-reported recall ($d=.73$, $p=.005$). Viral load and CD4 cell count changes were not significant.
Fisher et al., 2011	AIDS and Behavior	Connecticut, USA	Medication adherence	I: Interactive computer-based adherence intervention C: Standard of Care and general assessment	HIV+ adults recruited from clinics; Intervention N= 290; Control N= 204	The intervention condition was significantly higher on perfect 3-day adherence measures. Significant differences were not found for decreases in viral load.
Gray et al., 2011	Journal of Health Psychology	Southeastern United States	Medication adherence	Pre-post design; 7 alternating home and telephone sessions	HIV+ adolescents N= 4	Estimated higher adherence during intervention; Positive and neutral trends in adherence across treatment; Decreased barriers to adherence for all participants.
Hardy et al., 2011	AIDS Patient Care and STDs	Boston, Massachusetts, USA	Medication adherence	I: Personalized daily text messages C: Reminder beep at time of dosing	HIV+ adults recruited from HIV clinic; Intervention N= 10 Control N= 9	Adherence based on MEMS caps was significantly higher for the personalized text message condition ($p=.002$). Pill count and self-reported adherence measures were not significantly different.

Author, Year	Journal	Location	Health Behavior	Technology Intervention	Sample	Results
Kalichman et al., 2011	AIDS Patient Care and STDS	Atlanta, Georgia, USA	Medication adherence	I: 4 self-regulation counseling sessions over the phone C: Contact matched phone calls	HIV + adults; Intervention N=21; Control N=19	Adherence based on unannounced pill counts was significantly higher for the intervention condition (effect sizes ranging from $d=.45$ to $d=.80$). Participants in the intervention condition also showed greater medication self-efficacy (effect sizes ranging from $d=.33$ to $d=.65$)
Lewis et al., 2012	In press, Health Psychology		Medication adherence	Text Message		Self reported adherence significantly improved, viral load significantly decreased, CD4 count significantly increased
Pop-Eleches et al., 2011	AIDS	Kenya	Medication adherence	C: No messages I1: Short daily text messages I2: Long daily text messages I3: short weekly text messages I4: long weekly text messages	HIV + adults initiating cART; Control N= 139; I1 N= 70; I2 N=72; I3 N=73; I4 N=74	Those receiving weekly text messages had significantly higher adherence averaged across all time points compared to the control. Weekly reminders also significantly reduced the frequency of treatment interruptions.
Uzma et al., 2011	Journal of the International Association of Physicians in AIDS Care (JIAPAC)	Pakistan	Medication adherence	I: weekly phone reminders C: routine counseling	HIV + adults on first-line ART; Intervention N=38; Control N= 38	Those in the intervention condition had significantly better self-reported adherence ($p<.001$) and significantly lower viral load ($p=.012$).
Vidrine et al., 2011	Nicotine & Tobacco Research	Houston, Texas, USA	Smoking Cessation	I: cell phone intervention C: usual care	HIV + adults who smoke more than 5 cigarettes a day; Intervention N= 236; Control N= 238	Those in the intervention condition had significantly higher smoking abstinence rates than those in the control condition (continuous abstinence $p=.001$).