Recent mobile health interventions to support medication adherence among HIV-positive MSM

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Purpose of review
We describe recent mobile health (mHealth) interventions supporting antiretroviral therapy (ART) medication adherence among HIV-positive MSM.

Recent findings
Keyword searches (1 January 2016–13 May 2017) identified 721 citations. Seven publications reporting on six studies met inclusion criteria. Five studies focused on MSM. Interventions primarily employed text messaging (n=4), whereas two focused on smartphone apps and one on social media. Three studies measured intervention impact on adherence and found increased ART use intentions (n=1), self-reported adherence (n=1), and viral suppression (n=1, no control group). Other mHealth interventions for HIV-positive MSM focused on status disclosure and reducing sexual risk.

Summary
mHealth interventions to support ART adherence among MSM show acceptability, feasibility, and preliminary efficacy. No recent mHealth interventions for MSM measured impact on viral suppression compared with a control condition despite earlier (pre-2015) evidence for efficacy. Studies are underway that include multiple features designed to improve adherence within complex smartphone or internet-based platforms. Areas for future growth include overcoming measurement and engagement challenges, developing tools for coordinating patient and provider adherence data, testing combination interventions, and adapting efficacious interventions for new languages and geographic settings.

Keywords
adherence, intervention, mobile health, MSM, technology

INTRODUCTION
Globally, gay, bisexual, and other MSM are disproportionately impacted by HIV [1,2*,3]. MSM are estimated to account for 18–49% of all new HIV infections worldwide [4], with larger proportions in high-income countries such as the United States (67% of all new diagnoses in 2014) [5]. Treatment with antiretroviral therapy (ART) to achieve viral suppression improves individual health [6] and prevents onward transmission [7,8**,9**,10]. Sustained adherence to ART is critical for long-term viral suppression but remains suboptimal among MSM, ranging from 16 to 74% across 12 countries [11]. In the United States, only half of all HIV-diagnosed MSM are estimated to achieve viral suppression [12], with significantly lower rates documented among young MSM (6–7%) [13,14].

Societal stigma and discrimination within healthcare systems impede access to quality HIV care for MSM and influence adherence and viral suppression [15–17]. Many MSM manage multiple adherence barriers (e.g., mental health and unstable housing) [16,18,19], with each factor increasing the chances of having a detectable viral load [16,20**]. Despite clear need, few ART adherence interventions have focused explicitly on MSM [21*,22].

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Among 117 US-based ART adherence interventions published between 2007 and 2015, only two focused on MSM [21].

Mobile health (mHealth) interventions – including text message (SMS)-based and multi-component smartphone apps, mobile-optimized websites, and social media interventions – offer highly accessible and adaptable platforms to support medication adherence [23,24,25]. The flexibility of mHealth interventions allows the delivery of tailored content for each user’s needs [23] and accessibility helps reduce some societal and structural barriers [26]. mHealth also offers strong capability for scalability and diffusion across geographic locations, including within resource-limited settings [27].

mHealth tools have not yet been fully explored in support of ART adherence for MSM. A 2016 review of social-media-based interventions found no interventions focused on supporting ART adherence among HIV-positive MSM [28]. Similarly, a 2017 systematic review and meta-analysis of the impact of SMS reminders on HIV care compliance [29] found only one HIV-positive MSM-focused intervention [30]. Given the rapid pace of technology development, this review aims to focus on HIV-positive MSM to identify recent interventions and highlight new contributions in the use of mHealth to support ART adherence.

KEY POINTS

- Recent mHealth intervention tools to support HIV medication adherence among MSM show acceptability, feasibility, and preliminary efficacy at increasing ART use intentions, self-reported adherence, and viral suppression.
- Additional research is needed in the form of rigorous large-scale trials, evaluation of commercially available medication adherence apps, and development of new methods to accurately measure adherence and assess which clinically relevant barriers can be addressed using technology-based tools.
- Further development needs for technology-based adherence interventions include end-user engagement features, tools for coordinating patient and provider adherence data (e.g., dashboards), and adaptation of efficacious interventions for new languages and geographic settings.

METHODS

We searched PubMed from 1 January 2016 to 13 May 2017 for English language publications, using combinations of keywords and MeSH terms: HIV, AIDS, antiretroviral, ART, therapy, medication, adherence, compliance, nonadherence, technology, technology-based, SMS, text message, texting, online, internet, web, Web 2.0, social media, social networking, app, application, smartphone, cell phone, cellular phone, mobile phone, eHealth, mHealth, video conferencing, videocall, Twitter, Grindr, Jack’d, Facebook, computer, internet, computer-based, virtual reality, VR, MSM, men who have sex with men, gay, homosexual, bisexual, LGBT, sexual minority. Publications were excluded that did not include: an intervention description, an mHealth intervention component, an ART adherence behavioral (e.g., self-reported medication taking, device recorded medication taking) or biomedical (e.g., viral load, viral suppression, and drug levels) outcome, or a focus on MSM populations or report including MSM subpopulations. Three authors reviewed citations and full texts were pulled for all citations noted as relevant by at least one reviewer. Of the 721 articles extracted, seven articles reporting on six interventions met inclusion criteria (Table 1).

RECENT ANTIRETROVIRAL THERAPY MOBILE HEALTH ADHERENCE INTERVENTIONS TAILORED FOR OR INCLUSIVE OF MSM

For core mHealth components, most interventions used text messaging, including three pilot studies, one randomized controlled trial (RCT) [31,32,33,34], and one planned intervention that will use social media and SMS [36]. One article reported on the development and usability testing of a stand-alone smartphone app [25]. Studies were based in the United States (n = 5) and China (n = 1) [33]. Three US-based studies focused on Black or Black and Latino MSM [31,34,36], and one on general MSM (96% Black) [25]. The average participant age across four studies was over 35 years old, whereas two studies explicitly focused on adolescents and young adults [25,36]. Three interventions reported being informed by the Information, Motivation, and Behavioral Skills (IMB) model [25,33,34], whereas one utilized social cognitive theory (SCT) in conjunction with the Theory of Empowerment Education [36]. Studies that measured outcomes related to ART or viral suppression found moderate increase in intentions to use ART (albeit among individuals already on ART) [31], increase in viral suppression [32], and higher self-reported adherence (intervention vs. control at 6-month follow-up, 98.72 vs. 93.11%, P = 0.006) [33]. Below we highlight a few findings and novel features from these interventions.
| Citation | Study name | Population sample | Technology | Study type | Intervention (I) | Control (C) | Results |
|----------|------------|-------------------|------------|------------|-----------------|-------------|---------|
| Herbst et al. [31*] | Messages4Men | Black & Latino MSM diagnosed >6 months; n=320 (age: 28% 18–29, 23% 30–39, 50% 40+); US | One-way SMS | Pilot study | I: Single session, 3 brief messages to increase intentions for behavior change: 1 each focused on ART self-benefit and partner-benefit, 1 on condoms C: none | Some increased intentions for ART use and condom use. Detectable VL associated with reporting message content was new information. Of note: SMS content was tested on web platform, not actually sent to phones. 91% already on ART |
| Rana et al. [32**] | New-to-care or care/ART challenges PLHIV n=13/32 MSM (full sample mean age: 36 years); US | Two-way SMS + monthly phone call | Pilot study | I: 6 months of standard or user created SMS on daily ART, appointments, barriers to staying in care. User queries answered by SMS or call within 24 (weekdays) or 48 h (weekend). Monthly call to adjust frequency of SMS based on user choice C: none | BL to 6-month FU: VS increased 56–78% (P=0.002). A total of 79.1% of scheduled HIV care visits kept (range 0–100%). Qualitative exit interviews (n=20): high SMS acceptability, satisfaction with frequency, content, and helpfulness. Users appreciated combined SMS/human support. Of note: 2 participants ineligible due to no cell phone. No participants changed frequency of SMS during study, 3 changed SMS content. No subanalyses reported for MSM |
| Ruan et al. [33*] | ART within past 3-month PLHIV n=4/100 MSM (full sample mean age: 40.3 years); Hunan, China | Two-way SMS | RCT | I: 6 months of two-way SMS using an IMB-based 3-step adherence model. A total of 124 SMS in 6 ‘modules’ (e.g., greetings, ART reminders, HIV knowledge, humor, and motivation). Months 1–3: 5 SMS/week, months 4–6: 3 SMS/week. ART SMS sent 30 min prior to scheduled dose, other SMS sent at 8PM C: SOC | I vs. C, BL to 6-month FU: no difference in CD4; self-report ART adherence by VAS was 98.72 vs. 93.11% (P=0.006); 96% satisfied/highly satisfied with I; 74% wanted to continue receiving SMS. Desired frequency of SMS: 1–2/week. Of note: All SMS <70 Chinese characters, HIV-related terminology avoided. No subanalyses reported for MSM. Only 1 MSM participant was randomized to the intervention arm |
| Senn et al. [34**,35*] | Black MSM, missed appointment, break in care, <95% ART n=3 mentors; n=8 mentees (mean age: 40 years); US | Two-way SMS app (for Android) + peer support | Design, develop, and pilot study | I: For 1-month mentors provide via SMS informational and motivational support about HIV; help mentees build skills to stay in care and take ART (based on IMB). Mentors’ protocol: respond to texts within 12 h; contact at least every 3 days C: None | Intervention was feasible and acceptable: 5/7 were satisfied/very satisfied. Mentees wanted more frequent contact; mentors and mentees wanted more personalized contact (e.g., introductory phone call). Social media was recommended as additional contact. No care outcomes reported. Of note: study cell phones were purchased for both mentors and mentees. A total of 4 participants experienced technical/logistical problems with phone or app |
| Citation study name | Population sample size location | Technology Study type | Intervention (I) Control (C) | Results |
|---------------------|---------------------------------|-----------------------|-----------------------------|---------|
| Tanner et al. [36**] | racially and ethnically diverse MSM, age 13–34 years US | Health Educator + social media (Facebook), SMS, in-app IM | I: CBPR-developed, based on SCT and Theory of Empowerment Education. Health Educator interacts in-person and via SMS, Facebook, and in-app IM based on participant preferences to provide: ART refill and daily med reminders, problem solve ART prescription and adherence barriers, applaud positive behaviors | weCare scheduled to start late 2016. Dose will be measured by Health Educator recording participant interactions through a secure REDCap log. Of note: weCare covers full Continuum of Care – here we focus only on ART and VS. Health Educator will maintain profiles on Facebook, A4A/Radar, badoo, Grindr, Jack'd, & SCRUFF; will use BlueStacks App Player and Fake GPS software to operate apps from desktop to “appear” in catchment cities where participants live |
| LeGrand et al. [25**] | MSM, age 20–28 years n = 3 focus groups (20 MSM); 7 MSM one-on-one usability sessions US | App for iPhone, Android Design, develop, and usability testing | I: IMB theory-informed ART adherence app utilizes game mechanics, social networking features, and personalization (e.g., editable profile and avatar), tailored feedback messages, functional ART support (e.g., editable medication alarm, daily medication tracker), and privacy features | 26/27 participants identified as Black/African American. Participants preferred an adherence app that was informational, interactive, social, and customizable. In usability testing, app was easy to understand and navigate, and was rated highly. Of note: Multifeature app where each feature is linked to components of IMB model. Epic Allies is currently completing a 5-site RCT implemented within the US ATN |

ART, antiretroviral therapy; ATN, U.S. Adolescent Medicine Trials Network for HIV Interventions; B, baseline; C, control; CBPR, community-based participatory research; FU, follow-up; I, intervention; IM, instant messages; IMB, information–motivation–behavioral skills; PLHIV, people living with HIV; RCT, randomized controlled trial; SMS, text messages; SOC, standard of care; US, United States; VAS, visual analog scale; VL, viral load; VS, viral suppression.
Messages4Men tested brief, one-way messages in a single-session pilot study that aimed to increase intentions for behavior change among HIV-positive and HIV-negative Black and Latino MSM in three US cities [31]. Eligible HIV-positive men were: 18 and older, diagnosed for at least six months, and not currently in another HIV-related study. Messages for HIV-positive MSM focused on the benefits of ART adherence to oneself and one’s partner and condom use. No overall association between viewing the messages and increased intention for ART use was found. Among participants with detectable viral load, exposure to messages about benefits of ART to oneself was associated with reporting messages provided new information [adjusted odds ratio (AOR) = 2.32; 95% confidence interval (CI) = 1.04–5.26] and exposure to messages about ART benefit to one’s partner was associated with intentions for ART use (AOR = 7.69; 95% CI = 1.01–50.0). These findings highlight the importance of message tailoring and targeting for achieving specific desired impact among different subpopulations of MSM – in particular continuing to emphasize the benefits of adherence for both individual health as well as its importance for reducing transmission.

Two interventions combined two-way – or bidirectional – text messaging with another intervention component. The first, by Rana et al. [32], included 32 people living with HIV in the United States who were either new to care, had experienced a break in care of a year or more, or who were considered by their provider to be at-risk for ART or appointment nonadherence (14/32 had detectable viral load at baseline, 13/32 identified as MSM). Participants received 6 months of SMS about adherence and HIV care. At enrollment, participants were prompted to identify their own barriers and facilitators to care or choose from preselected barriers and facilitators adapted from the US CDC’s Medical Monitoring Project. Study staff called once per month to discuss and adjust (if needed) frequency and content of SMS. Comparing baseline to follow-up, the proportion of virally suppressed participants increased from 56 to 78% (P = 0.002).

The second intervention, by Senn et al., described formative work [35], development, and pilot testing [34] of a text messaging and peer-support intervention to improve retention in care and adherence for Black MSM in the United States. Peer mentors – themselves HIV-positive Black MSM – received a 2-h training on information and skills related to ART and HIV care and how to respond to participants (‘mentees’) in nonjudgmental, motivational ways. Participants were assisted in sending their first message to peer mentors at study enrollment. For 1 month, mentors communicated with mentees via SMS. Mentors were asked to respond to texts within 12 h and to make contact with mentees at least every 3 days. Five out of seven participants were satisfied/very satisfied with the intervention. Mentees wanted more frequent contact, whereas both mentors and mentees wanted more personalized contact (e.g., an introductory phone call). Social media was recommended as additional form of contact that could be used. No ART outcomes were reported [34].

Two articles reported on the development and/or usability testing of two adherence interventions for young MSM [25,36]. Epic Allies is a theory-informed smartphone app designed to support engagement in care, ART initiation and adherence, and viral suppression [25]. The app utilizes game mechanics, social networking features, personalization (e.g., editable profile and avatar), weekly tailored feedback messages, and functional ART support (e.g., medication adherence tracker and reminders). Epic Allies was developed in three phases, including initial conceptualization, theory-based design, and prototype development; three focus groups with 20 MSM (age 20–28 years); and usability testing with seven MSM (age 20–28 years) [25]. Based on feedback through development and usability testing, the app was further refined and is currently undergoing a five-site RCT through the US Adolescent Medicine Trials Network for HIV/AIDS Interventions [37].

Lastly, Tanner et al. [36] describe the design and development of weCare – an intervention for racially and ethnically diverse US MSM, age 13–34 years. weCare was developed using processes of community-based participatory research (CBPR) and is based on SCT and the Theory of Empowerment Education. Although weCare covers the full HIV Continuum of Care, here we focus only on ART and virologic outcomes. A Health Educator interacts in-person and via SMS, Facebook (Facebook, Inc., Menlo Park, California, USA), and in-app instant messaging to provide participants with reminders, information, and problem solving regarding ART prescriptions and refills and adherence. Implementation and evaluation of weCare was scheduled to start in late 2016 [36].

**WHAT CORE FEATURES SHOULD BE INCLUDED IN AN ANTIRETROVIRAL THERAPY ADHERENCE MOBILE HEALTH INTERVENTION FOR MSM?**

Above we described recently published mHealth interventions identified through systematic searches. We now turn toward synthesizing key features from these interventions in the context of previous and future mHealth adherence interventions for MSM.
SMS are generally shown to be effective at improving medication adherence across a variety of populations and settings [29**,38**] (with some exceptions [39]). Further, short weekly SMS have been shown to perform better than daily messages in reducing nonadherence [30,40,41]. All interventions identified in this review included at least some component of SMS reminders, reflecting this as a current core feature in adherence support interventions. A 2017 meta-analysis of ART adherence interventions found multiple interventions achieved better results than single interventions [38**]. As suggested by the studies reviewed above, interventions testing SMS in combination with other features (e.g., social media contact, app-based self-monitoring) show promise for increasing the effectiveness of messages alone.

Indeed, MSM participants request [34**] and appreciate [32**] enhancements beyond SMS that focus on social support and connection with others. In focus groups about HIV-related app preferences with stimulant-using adult MSM, participants requested social networking features, information about local resources, connection to their medical chart, and HIV-related news [42**]. These requests for information and connection are echoed in focus groups with young MSM along with preferences for information that is presented succinctly [43], customizable app features [25**], personalized reminders and accountability for medication taking behaviors [44*], and information on both HIV and general health and wellness [43,44*]. Anonymity and privacy are also consistently stressed features – though not inherent barriers to using mHealth HIV interventions [35*,43,44*].

Thus, there is interest, public health need, and scientific rationale for multicomponent, complex mHealth interventions to support ART adherence among MSM. Interventions should be responsive to current best practices for mHealth-supported ART adherence and tailored to men’s expressed needs and preferences. Intervention developers may want to consider incorporating gamification to improve engagement [45,46] and dynamic tailoring based on frequent assessments – features that effectively promote ART adherence [30,47]. Several interventions are underway that do this for MSM. Thrive with Me is a theoretically based (IMB model), multicomponent ART adherence intervention for MSM age 18 years and older (majority substance users) that includes asynchronous peer communication (similar to Facebook), tailored adherence information, and SMS dose reminders, and SMS adherence, mood, and substance use self-monitoring. An 8-week pilot study showed high feasibility (90%), acceptability, and significant improvement in self-reported ART adherence [48], and the intervention is currently undergoing an RCT in New York City [49]. AllyQuest is an HIV medication adherence and social support app [for Android and iPhone (Apple Inc., Foxconn, Pegatron, Cupertino, California, USA)] designed for MSM age 18–29 years. The app components were informed by SCT and the Fogg Behavioral Model [50] of persuasive technology. In a 4-week pilot study, greater app use was associated with significant increases in knowledge about HIV and confidence in ability to reliably take ART [51]. A third example is the Youth mHealth Adherence Intervention for HIV+ YMSM (Dowshen, personal communication May 2, 2017). This tailored intervention app for Android phone will support ART adherence and engagement in care for MSM age 14–24 years and includes a customizable avatar, medication reminders and tracking, and social support features (anonymous chat, ability to send ‘kudos’). Gamification features include a point system, leader board, and ability to unlock new accessories. A feasibility study (n = 10) anticipated beginning enrollment in 2017 (Dowshen, personal communication May 2, 2017).

Alongside ART adherence, mHealth interventions can be used to support sexual risk reduction among HIV-positive MSM. This is a critical need for curtailing the epidemic among MSM given suboptimal adherence and viral suppression in the context of high rates of condomless anal sex [52*]. Two recent mHealth interventions explicitly designed for HIV-positive MSM focus on sexual risk reduction [53**,54*]. One study reported on Sex Positive! – an intervention comprised 10 video vignettes (optimized for mobile viewing) that utilize SCT and social learning theory to increase critical thinking about HIV transmission and status disclosure [53**].

**CHALLENGES TO DEVELOPING, DELIVERING AND EVALUATING MOBILE HEALTH ADHERENCE INTERVENTIONS**

Several gaps and challenges offer opportunities for significant advances to the field of mHealth interventions for ART adherence. First, there is interest and acceptability to use mHealth technologies to coordinate care between patients and providers (e.g., dashboards) [42**]. Dashboards can provide an easily interpretable, real-time overview of a patient’s ART tracking, and other health indicators or behaviors (e.g., side-effects, alcohol consumption). This information can be used to provide tailored feedback to patients both at and between in-office appointments. Barriers to dashboard use include physician concerns about the privacy of patient information, ease of access/use, lack of
coordination between dashboards and electronic medical records, and time restrictions both during and between patient visits [55].

Second, as with most adherence interventions, the accurate measurement of adherence barriers and adherence, and connection to clinical outcomes remains a challenge. The development of mHealth interventions typically follows the pattern of formative work to identify barriers to adherence and desired mHealth intervention features, followed by usability or pilot testing, and eventually an RCT. Yet common self-report adherence barriers (e.g., ‘I forgot’) that arise in formative work may not correlate with clinical outcomes [56]. Furthermore, memory devices and reminders alone are likely to be insufficient for overcoming the significant individual and structural-level barriers to adherence that many MSM face [57]. These considerations should affect the way formative work and intervention design are conducted. Innovative intervention development strategies (e.g., community-engaged research, crowdsourcing [36–58]) may offer new venues in this regard. Furthermore, whereas mHealth may facilitate more frequent recording of adherence, at least one study to date found discordance between app-measured adherence and self-report and pharmacy refill, with app-measured adherence being lower [61]. This will be the case if participants do not use the app every day, emphasizing the importance of creating highly engaging apps, considering whether users should be able to back-fill app-based adherence data, including biological outcome measures (viral load), and identifying parameter estimates for adjusting app-reported data. At least two studies in the field are currently gathering these metrics [25–49].

Third, as mHealth interventions become more complex, individually tailored, and multifaceted, the complexity of measuring meaningful or standardized intervention exposure/dose also becomes more complicated. Extremely limited work has been done in this area for HIV interventions (Bauermeister et al., current issue), hampering the ability to identify which intervention components and features are associated with desired outcomes.

Relatedly, the chronicity of HIV raises questions about the use of mHealth to maintain longer term ART adherence beyond a typical 3–12-month intervention period. Extended utility would require resources and innovation to create content and features that are continually new, relevant, and aligned with the evolving evidence base. Further challenges stem from the need to keep up with software and hardware upgrades. The use of open-source software and existing platforms that also evolve over time and the adaptation of existing platforms for new populations can mitigate some of these resource demands. Effective, open-source interventions could also be embedded into commercial platforms (e.g., Apple Health) to maximize uptake. On the side of scientific rigor, there are unanswered questions about whether people actually need to use mHealth tools for long periods of time – or whether the tools can establish self-sustaining skills and patterned behaviors. Furthermore, in trials, participants are asked to use (or be exposed to) mHealth interventions continuously over a set amount of time. However, in real-world settings, some of these interventions may be better employed in an ‘as needed’ fashion. Implementation studies and dynamic intervention designs (e.g., Sequential Multiple Assignment Randomized Trials) may offer insight by providing data about long-term mHealth use and effectiveness and testing combinations of mHealth intervention approaches.

Perhaps the greatest area for growth in mHealth interventions for MSM is the exchange of evidence-based mHealth interventions or intervention components across settings and populations. This includes the tailoring and testing of effective general population mHealth interventions for use with MSM, as well as the cultural adaptation and translation to other languages of successful MSM-focused apps, SMS-based interventions, and social media approaches.

CONCLUSION

Several recent mHealth interventions developed specifically for MSM show promise for supporting ART adherence and viral suppression. However, none of the reviewed interventions for supporting ART adherence to achieve viral suppression among ART adherence and viral suppression. However, none of the reviewed interventions for MSM measured the impact of an mHealth intervention on viral suppression compared with a control condition. Several studies are planned or underway that will assess multiple features within complex smartphone or internet-based platforms providing the opportunity to advance the evidence base for mHealth supported ART adherence as well as expand the science in mHealth measurement and engagement challenges. Combination interventions that use multiple delivery modalities are a future important area for growth alongside adapting efficacious interventions for new languages and geographic settings. Global saturation of basic phones – and increasingly smartphones – has laid the groundwork for widely scalable mHealth interventions to support ART adherence to achieve viral suppression among significantly more HIV-positive MSM.

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Conflicts of interest
There are no conflicts of interest.

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21. Risher KA, Kapoor S, Daramola AM, et al. Challenges in the evaluation of interventions to improve engagement along the HIV care continuum in the United States: a systematic review. AIDS Behav 2017; doi: 10.1007/s10461-017-1687-8. [Epub ahead of print]

This systematic review of US-based studies published between 2007 and 2015 focused on interventions along the HIV-positive Continuum of Care. The review identified 152 studies including 117 medication adherence interventions; only two focused on MSM.

22. Chayachati KH, Ogbojo O, Price M, et al. Interventions to improve adherence to antiretroviral therapy: a rapid systematic review. AIDS 2014; 28(Suppl 2):S187–204.

23. Hightow-Weidman LB, Muessig KE, Bauermeister J, et al. Youth, technology, and HIV: recent advances and future directions. Curr HIV/AIDS Rep 2015; 12:500–515.

24. Muessig KE, Nkanki M, Bauermeister J, et al. A systematic review of recent smartphone, Internet and Web 2.0 interventions to address the HIV Continuum of Care. Curr HIV/AIDS Rep 2015; 12:173–190.

25. LeGrand S, Muessig KE, McIlvay T, et al. Epic Allies: development of a gaming app to improve antiretroviral therapy adherence among young HIV-positive men who have sex with men. MJRS Serious Games 2016; 4:e6.

Presents the design, development, and usability testing of Epic Allies – an MSM-tailored app based on information motivation and behavioral skills (IMB) theory and utilizing game mechanics, social networking features, personalization, tailored feedback messages, functional ART support (e.g., editable medication alarm, daily medication tracker), and privacy features. Participants preferred an adherence app that was informative, interactive, social, and customizable. In usability testing, the app was easy to understand and navigate, and was rated highly. This intervention is currently being tested in a US-based five-site randomized controlled trial (RCT).

26. Amico KR, Evidence for technology interventions to promote ART adherence in adult populations: a review of the literature 2012–2015. Curr HIV/AIDS Rep 2015; 12:441–450.

27. Haberer JE, Sabin L, Amico KR, et al. Improving antiretroviral therapy adherence in resource-limited settings at scale: a discussion of interventions and recommendations. J Int AIDS Soc 2017; 20:1–15.

This review came out of a 2015 meeting held by the Bill and Melinda Gates Foundation focused on ART adherence interventions that show promise for scalability to resource limited settings. The review draws on published literature, other reviews, WHO Consolidated Guidelines for HIV, and practical considerations for implementation. The intervention options discussed are grouped into: ‘education and counselling; information and communication technology-enhanced solutions; healthcare delivery restructurings; and economic incentives and social protection interventions’. Within the communication section, the review highlights the important role of SMS reminders as a scalable HIV intervention in resource-limited settings.

28. Garrett R, Smith J, Young SD. A review of social media technologies across the global HIV care continuum. Curr Opin Psychol 2016; 9:55–66.

This review of social media-based interventions along the HIV Continuum of Care (published July 2005 to July 2015) found 44 relevant article including 17 interventional studies and 19 observational studies. Social media is increasingly being used with moderately equal distribution across the areas of: outreach and recruitment, surveillance and observation, and prevention and treatment. One intervention for HIV-positive youth included adherence support and one intervention for HIV-positive MSM focused on sexual risk reduction. No interventions focused on supporting ART adherence among HIV-positive MSM.
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29. Mayer JE, Fontelo P. Meta-analysis on the effect of text message reminders for sexual risk behavior among Black men who have sex with men. JAIDS 2017; 74(Suppl 2):S121–S127.

30. Lewis MA, Uhrig JD, Bann CM, et al. Tailored text messaging intervention for HIV adherence: a proof-of-concept study. Health Psychol 2013; 32:248–254.

31. Herbst JH, Mansergh G, Pitsn N, et al. Effects of brief messages about antiretroviral therapy and condom use benefits among Black and Latino MSM in three US cities. J Homosex 2017. [Epub ahead of print]

32. Rana AI, van den Borg J, Lamy E, Bechwick CG. Using a mobile health intervention to support HIV treatment adherence and retention among patients at risk for disengaging with care. AIDS Patient Care STDS 2016; 30:178–184.

Reports on a pilot study conducted among 32 people living with HIV (including 13 MSM). Participants received daily two-way SMS for 6 months on topics like ART adherence, care appointments, and barriers to staying in care. User queries were answered by SMS or call within 24–48 h. Monthly calls were used to adjust frequency and content of SMS based on user preference. Viral suppression increased baseline to 6-month follow-up from 56% to 78% (P = 0.002, no control group).

33. Ruan Y, Xiao C, Chen J, et al. Acceptability and efficacy of interactive short message service intervention in improving HIV medication adherence in Chinese antiretroviral treatment-naïve individuals. Patient Prefer Adherence 2017; 11:221–228.

Reports on an RCT of a two-way SMS-based intervention for people living with HIV (4/100 participants identified as MSM) conducted in Hunan, China. Intervention participants received 6 months of two-way SMS using an IMB-based theoretical model. A total of 124 SMS were delivered in 6 ‘modules’. Message frequency was intentionally reduced over time from 5 SMS/week during the first 3 months to 3 SMS/week during the second 3 months. The intervention found no difference in CD4 count; although self-report ART adherence was 98.72% (intervention) vs. 93.11% (control), P = 0.006.

34. Senn TE, Braksmaer A, Couy-Dongier P, et al. Development and preliminary pilot testing of a peer support text message intervention for HIV-infected Black men who have sex with men. JADS 2017; 74(Suppl 2):S121–S127.

Reports on the design, development, and pilot testing of a two-way SMS app (for Android phones) and peer support for HIV-positive Black MSM who have missed an HIV appointment, experienced a break in care or report being less than 95% ART adherent. For 1 month, mentors provide via SMS informational and motivational support about ART, help mentees build skills to stay in care and take ART (based on IMB). Mentors’ protocol: respond to texts within 12 h; contact at least every 3 days. The pilot was conducted with three mentors and eight mentees. The intervention was feasible and acceptable; 5/7 were satisfied very satisfied. Mentees wanted more frequent contact; mentors and mentees wanted more personalized contact (e.g., introductory phone call). Social media was recommended as additional contact. No HIV care outcomes are reported.

35. Senn TE, Braksmaer A, Couy-Dongier P, et al. Mobile technology use and desired technology-based intervention characteristics among HIV–Black MSM who have sex with men. AIDS Care 2017; 29:433–443.

This study reports on formative research (surveys and qualitative interviews) with 22 US-based HIV-positive Black MSM regarding current technology use and requests for aspects of technology that would improve their HIV use. Findings were used to develop the text-based message intervention described in Senn et al. [34].

36. Tanner AE, Malm L, Song E, et al. weCare: a social media-based intervention designed to increase HIV care linkage, retention, and outcomes for racially and ethnically diverse young MSM. AIDS Educ Prev 2016; 28:216–230.

Describes the design and development of weCare – a health educator guided intervention for racially and ethnically diverse young MSM age 13–34 years that will utilize participants’ existing social media preferences (Facebook, in-app instant messenger) and SMS to support the full HIV Continuum of Care from prevention to treatment. weCare was developed using CBPR methods, based on social cognitive theory (SCT) and theory of empowerment education. The adherence-focused components include ART refill and daily medication reminders, problem solving for ART prescription and adherence barriers, and positive reinforcement of desired behaviors. An implementation and evaluation trial was planned to start in late 2016.

37. Allies HIV ART Adherence Intervention. ClinicalTrials.gov identifier: NCT02782130. Primary Investigator: Hightow-Weidman, L. Sponsor: University of North Carolina at Chapel Hill, Funder; National Institute on Drug Abuse and National Institute of Mental Health. Last updated 14 March 2017. Available at: https://clinicaltrials.gov/show/NCT02782130?term=HIV+and+EpiscopalHealth+network1. [Accessed online 22 May 2017].

38. Kanters S, Park JJ, Chan K, et al. Interventions to improve adherence to antiretroviral therapy: a systematic review and network meta-analysis. Lancet HIV 2017; 4:e31–e40.

This comprehensive systematic review and meta-analysis searched the Cochrane Central Register of Controlled Trials, Embase, and MEDLINE as well as major conference databases (2013–2015) for studies published up through July 2015 that tested RCTs of interventions to improve ART adherence. A major strength of this study is its inclusivity of interventions outside of the United States. A total of 85 eligible trials were identified. Key findings of effective interventions include – for ART adherence: the superiority of text messages over standard of care overall, as well as specifically in low-income and middle-income settings, and the benefit of multiple interventions over single interventions; for viral suppression: cognitive behavioral therapy and supporter interventions were significantly better than standard of care overall but not in low-income and middle-income settings. Results/interventions are not reported by risk group.

39. Kalichman SC, Kalichman MO, Cherry C, et al. Randomized factorial trial of phone-delivered support for ART use and condom use. The use of detectable viral load was associated with reporting message content was new information and increased intentions to use ART.

40. Horvath TJ, Alemu D, Darth T, et al. Creating effective mobile phone apps to optimize antiretroviral therapy adherence: perspectives from stimulant-using HIV-positive men who have sex with men. JMIR Mhealth Uhealth 2016; 4:e48.

Five focus groups were conducted in San Francisco and Minneapolis with 26 stimulant-using HIV-positive men on ART. Discussion topics included technology access, use and preferences, and needs and preferences for apps that would support HIV-related care. Almost half of participants reported weekly or more stimulant use. Participants requested social networking features, information about local resources, connection to their medical chart, and HIV-related news.

41. Muesing KE, Pike EC, Fowler B, et al. Putting prevention in their pockets: developing mobile phone-based HIV interventions for black men who have sex with men. AIDS Patient Care STDS 2013; 27:211–222.

42. Saberi P, Siede-Khan R, Sheon N, Lightfoot M. The use of mobile health applications among youth and young adults living with HIV: focus group findings. AIDS Patient Care STDS 2016; 30:254–260.

Four focus groups were conducted in San Francisco with 17 (n = 14 MSM) youth living with HIV, age 18–29 years. A total of 11 participants reported ever being homeless, nine reported having only enough money to get by or having less than enough to get by. Desirable characteristics for a health-related app included: connectivity to other HIV-positive youth, facilitating access to healthcare providers, recording health data and information, and health news and knowledge. The importance of privacy was emphasized by all.

43. Prestage G, Zablotska I, Bavinton B, et al. Previous and future use of HIV self-testing: a survey of Australian gay and bisexual men. Sex Health 2016; 13:55–62.

44. Cugelman B. Gamification: what it is and why it matters to digital health behavior change developers. JMIR Serious Games 2013; 1:e3.

45. Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print behavior change interventions. Psychol Bull 2007; 133:673–693.

46. Horvath KJ, Oakes JM, Rosser BR, et al. Feasibility, acceptability and preliminary efficacy of an online peer-to-peer social support ART adherence intervention. AIDS Behav 2013; 17:2031–2044.

47. A Technology-Delivered Peer-to-Peer Support ART Adherence Intervention for Substance-using HIV+ Adults (TWM). ClinicalTrials.gov identifier: NCT02704208. Primary Investigator: Horvath, K. Sponsor: Institute University of Minnesota - Clinical and Translational Science Institute, Funder: National Institute on Drug Abuse. 2016. Last updated 25 October 2016. Available at: [https://clinicaltrials.gov/show/NCT02704208].

48. Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print behavior change interventions. Psychol Bull 2007; 133:673–693.

49. Fogg BJ. Persuasive technology: using computers to change what we think and do. San Francisco, CA: Kaufmann Publishers; 2003.

50. Hightow-Weidman L, Knudson K, Muesing K, et al. AllyQuest: engaging HIV+ young men in care and improving adherence through a social networking and gamified smartphone app. Accepted Abstract #A48-0522-01252. 9th International AIDS Society Conference on HIV Science (IAS 2017), Paris, France; 23–26 July 2017.

51. Wilson PA, Kahana SY, Fernandez MI, et al. Sexual risk behavior among viremically detectable human immunodeficiency virus-infected young men who have sex with men. JAMA Pediatr 2016; 170:125–131.

This cross-sectional study among 991 HIV-positive MSM, age 15–26 years old across 20 HIV clinics in the United States found high rates of detectable viral load (69%) and condomless anal intercourse (46.2%) – in contrast to recent serodiscordant condomless anal intercourse (31.3%). These findings emphasize the critical need for continued efforts to support viral suppression among HIV-positive MSM as well as focus on particular subgroups such as those who may be at risk for acquiring other sexually transmitted infections and onward HIV transmission.
53. Hirshfield S, Downing MJ Jr, Parsons JT, et al. Developing a video-based eHealth intervention for HIV-positive gay, bisexual, and other men who have sex with men: study protocol for a randomized controlled trial. JMIR Res Protoc 2016; 5:e125.

This RCT protocol article describes the Sex Positive! Study – an intervention for HIV-positive MSM that focuses on sexual risk reduction. The intervention is comprised of 10 video vignettes (optimized for mobile viewing) that utilize SCT and social learning theory to increase critical thinking about HIV transmission and status disclosure. Sex Positive! has completed enrollment but main trial results are not yet published.

54. Milam J, Morris S, Jain S, et al. Randomized controlled trial of an internet application to reduce HIV transmission behavior among HIV infected men who have sex with men. AIDS Behav 2016; 20:1173–1181.

This internet-based and phone-based RCT aims to reduce sexually transmitted infections and condomless anal intercourse among HIV-positive MSM in the United States. The intervention also includes a focus on HIV-status disclosure. For 12 months, participants received either a monthly internet-based sexual behavior survey, or the same monthly survey and tailored SMS focused on personalized (algorithm-based) risk-reduction. Increase in disclosure and decrease in sexual risk was found in both study arms without significant differences.

55. Swendeman D, Farmer S, Mindry D, et al. HIV care providers’ attitudes regarding mobile phone applications and web-based dashboards to support patient self-management and care coordination: results from a qualitative feasibility study. J HIV AIDS 2016; 2: doi: 10.16966/2380-5536.127.

This study reports on in-depth qualitative interviews that were conducted with healthcare providers regarding acceptability and barriers to use of healthcare apps and patient dashboards as a tool of patient self-management and care. Physician concerns focused on the privacy of patient information, ease of access/use, lack of coordination between dashboards and electronic medical records, and time restrictions both during and between patient visits.

56. Sauceda JA, Neilands TB, Johnson MG, Saberi P. An update on the barriers to adherence and a definition of self-report nonadherence given advancements in antiretroviral therapy (ART). AIDS Behav 2017; doi: 10.1007/s10461-017-1759-9. [Epub ahead of print]

57. Kalichman SC, Kalichman MO, Cherry C. Forget about forgetting: structural barriers and severe nonadherence to antiretroviral therapy. AIDS Care 2017; 29:418–422.

This study analyzes data from 556 people living with HIV with lower than 95% ART adherence. Analysis then classified participants as ‘severely nonadherent’ (less than 75% ART) and ‘moderately nonadherent’ (75–95% ART) and compared reasons for nonadherence. Severe nonadherence was significantly associated with substance use and other structural barriers (e.g., cost of medication). The authors conclude that reminders/memory aids alone will not be enough to overcome severe nonadherence in similar populations as that studied.

58. Liu C, Mao J, Wong T, et al. Comparing the effectiveness of a crowdsourced video and a social marketing video in promoting condom use among Chinese men who have sex with men: a study protocol. BMJ Open 2016; 6:e010755.

Describes the innovative study protocol for the intervention presented in Tang et al. (59).

59. Tang W, Han L, Best J, et al. Crowdsourcing HIV test promotion videos: a noninferiority randomized controlled trial in China. Clin Infect Dis 2016; 62:1436–1442.

Presents the results of an innovative RCT conducted in China aiming to increase HIV testing comparing a promotional video developed via a crowdsourcing contest approach with an evidence-based health marketing video. Just over a third of participants exposed to the videos completed HIV testing with no significant difference between the crowdsourced video and the professional video. A costing analysis estimated that the crowdsourced intervention cost $384 less per person for each new HIV diagnosis made.

60. Carrico AW, Jain J, Discepola MV, et al. A community-engaged randomized controlled trial of an integrative intervention with HIV-positive, methamphetamine-using men who have sex with men. BMC Public Health 2016; 16:873.

61. Anglada-Martinez H, Martín-Conde M, Rovira-Illamola M, et al. Feasibility and preliminary outcomes of a web and smartphone-based medication self-management platform for chronically ill patients. J Med Syst 2016; 40:99.