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Opportunities and Challenges of Digital Technology for HIV Treatment and Prevention

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Abstract

Novel eHealth interventions are creating exciting opportunities for health promotion along the continuum of HIV care and prevention. Reviews of recent work indicate the use of multiple platforms (e.g., smartphones, social media), with trends toward individualized approaches and real-time assessments. However, the field needs more rigorous investigations to provide evidence of long-term impact on clinical indicators and should expand its targets beyond men who have sex with men and medication adherence. Challenges to the field include working within restricted funding timelines and disseminating eHealth interventions to those most in need.

Keywords

HIV/AIDS; prevention; treatment; mhealth; digital technology

Introduction

Novel digital technologies are creating exciting opportunities for health promotion along the continuum of HIV care and prevention, especially in light of rapidly expanding access to this technology. Indeed, 90% of adults in the United States own a cell phone and 67% own a smartphone [1]. Globally, mobile cellular subscriptions have reached 7 billion and mobile broadband has grown 12-fold since 2007 to reach 47% of the world's population [2].

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Compliance with Ethics Guidelines

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

Conflict of Interest

Drs. Simoni, Kutner, and Horvath declare that they have no conflict of interest.

Increasing technological sophistication and widening Internet access means technology-based interventions may be cost effective and rapidly scalable after initial production costs [3]. They also offer considerable improvements over clinic-based strategies that are of limited generalizability and fail to extend beyond individuals in care. Other advantages of technology include its ability to impact hard-to-reach populations (including those who practice behaviors typically stigmatized within healthcare settings, such as injection drug users and men who have sex with men). Interventions operating through digital platforms can enhance consistency of content delivery and facilitate intervention by minimally trained personnel. By leveraging technologies familiar to people, especially mobile technology, interventions can be delivered at the most relevant times and places.

Varying terminology has been applied to these interventions, including computer-based interventions, information or digital technology, mHealth (for mobile health), and eHealth (for electronic health) technologies. Often, these terms are used interchangeably or without definition or specification. However, there does seem to be some consensus that electronic or eHealth interventions subsume Internet-based and mHealth technologies. Web 2.0 is a newer concept referring to technologies that allow for greater interactions between users and user-generated content. Examples of Web 2.0 technologies include Facebook and Twitter, which are increasingly leveraged for health intervention [4]. Consensus for a definition of Health 2.0 and Medicine 2.0 (i.e., Web 2.0 technologies used for healthcare purposes) remains elusive [5].

Technology-based interventions range from simple text-based reminders [6] to complex interactive computer-based counseling interfaces [7], to smartphones with GPS and biomedical sensors [8]. The earlier platforms (i.e., telephones, videophones, pagers, CD-ROM, personal digital assistants) have been generally supplanted with computers, tablets, Internet or Web-based programs, cell phones (including Short Message Service/text messaging), mobile web/smartphone applications or “apps”, and interactive voice-response technology. The most recent technologies for delivery include devices with the capability to do real-time monitoring or ecological momentary assessment (e.g., Wisepill); Web 2.0/social media, networking; programs involving gaming and gamification; and virtual reality (e.g., Secondlife).

These various technologies can be thought of simultaneously as user environment (that can diminish or induce risk), an intervention delivery tool, and a research tool, although our understanding of how to best leverage these functions is still unclear. In any of these capacities, technology-based interventions might involve a range of activities and can target individuals or populations at risk, PLWHA, or even the general public. Specifically, prevention efforts may involve outreach and education activities advocating condom use and other risk reduction strategies or monitoring risk behavior [9]. Along the continuum of HIV care, technologies can target HIV voluntary testing and counseling (including partner notification); linkage to care; retention in care; as well as ART initiation, adherence, and persistence. Targets among PLWHA include reductions in substance use (alcohol, tobacco, and other drugs) and improvement in mental health outcomes (depression, suicidal ideation, stress management). To reach a wider audience, technology might be used to disseminate general anti-stigma messages.

Review of reviews of technology

Multiple reviews have summarized recent research on technology-based interventions for HIV prevention and care. Pellowski and Kalichman [10] found 12 intervention studies published in 2011–2012 on technology-based approaches for PLWHA, with most (9 of 12) focused on adherence and with 1 each on substance use, stress management, and smoking. For their systematic review of recent (2013–2014) eHealth, mHealth and "Web 2.0" social media strategies in HIV prevention and care, Muessig et al. [3] identified 23 published intervention studies and 32 funded projects underway. Catalani et al. [11] located 62 articles on the use of mobile technology for HIV/AIDS in 2001–2011. Heterogeneity in methods, samples, targeted outcomes, and reporting preclude meta-analytic summaries but several conclusions consistently emerge.

Most published interventions focus on medication adherence. While there has been increasing attention to use of technology to address the full care continuum, gaps remain around linkage to care, retention in care, and initiation of antiretroviral therapy [3]. Despite examples of early successful sexual risk reduction interventions [7,12], few are underway currently [3].

The preponderance of interventions target men who have sex with men, with Catalani et al. [11] noting a lack of mHealth tools targeting other key populations such as injection drug users, sex workers, and pregnant mothers. Enthusiasm to address the prevention and treatment needs of these groups using technologies may be undermined by the perception that members have low rates of technology adoption. In contrast, the increasing number of mHealth interventions targeting youth [13] suggest an awareness that this group may be particularly able to benefit from these platforms given the great uptake of cellular/smart phones among teens and emerging adults versus older individuals [1].

Optimism about the promise of technology-based approaches must be tempered by a lack of methodological rigor in many studies, with most published reports describing pilot work, proof-of-concept designs, or examination of acceptability and feasibility but not efficacy. Evaluations rely predominantly on short-term and self-reported outcomes. Generally positive findings regarding the acceptability and feasibility across diverse groups and settings suggest in at least some arenas that the field is ready to move to more rigorous, fully powered randomized controlled trials, with more objective measures of clinical outcomes and long-term efficacy. Note there is a small number of more rigorously conducted studies showing efficacy for technology-delivered interventions, including significant effects on biomarker outcomes [6,7,14], encouraging further development in these areas.

Few technology-based HIV intervention studies reference theoretical or conceptual models, limiting our understanding of mechanisms of effect and key elements of successful interventions. For example, it is not clear whether the significant effects in Lester et al.'s study [6] are the direct result of the reminder function of text reminders to take medication or patients' increased sense of feeling supported. Multi-component interventions [12,15] typically do not "unpack" intervention effects, which limits the identification of the key technology-based components that drive change. There is some movement in this direction

with at least two studies examining the varying impact of number of messages, their length, and frequency [16,17].

Although technology has expanded globally, most reported HIV prevention and treatment interventions were conducted in North America and Africa [11]. There is concern that these interventions may not generalize to other settings with fewer resources, varying access to technology and the Internet, and persons with different cultural and social perspectives or lower eHealth literacy. In such contexts, emphasis should be placed on first understanding technology experiences, access, and use prior to deploying technology-based interventions [3]. Trends apparent in the literature on HIV prevention and treatment intervention suggest more mobile and personalized technologies, such as social networking sites [18]; provision of real-time assessment and feedback; gamification; and virtual reality.

Current Challenges to the Field

Challenges for the field remain with respect to the process of research as well as dissemination and implementation.

With respect to the research enterprise, there is a lack of resources for the high costs of design and programming. Moreover, United States federal funding timelines lag behind the accelerated pace of technological advances [3]; 5-year R01s practically guarantee any initial innovations are outdated by completion of the trial, giving new meaning to the term “planned obsolescence.” In addition, researchers often deplete resources in formative stages of the work, as there is no common platform to design interventions, and the proprietary nature of many interventions prohibits their revision or replication. Resources spent developing programs would be better spent on design, evaluation, and roll-out.

With more methodologically sophisticated outcome studies, we will soon be poised to explore the best options for dissemination and implementation. This future work should examine cost-effectiveness and the challenge of deciding who can sustain interventions after they demonstrate effectiveness [19]. Scale-up may be particularly challenging in low-income countries, where the health infrastructure and resources are limited. eHealth literacy issues need to be considered in dissemination and implementation efforts, as those most in need of assistance and those unlikely to access traditional prevention or care delivery options may be the least literate. Cultural tailoring may be needed, perhaps with each implementation (e.g., for African American women as described in Tufts et al.) [20]. Wide-scale implementation will likely involve integrating eHealth interventions into a patient’s healthcare in a highly individualized manner – a very different process from how most research studies are conducted, with their strict eligibility criteria and a one-size-fits-all approach. Implementation efforts must ensure privacy for vulnerable populations [21]. This is a concern where government monitoring and restrictions pose significant barriers to trust, such as in settings where homosexuality is punishable by death [3].

Conclusion

Technological advances and expanding access to eHealth tools and high-speed Internet are creating opportunities across the globe for innovation in how we approach HIV prevention

and care. Reviews of recent eHealth intervention research suggest a range of platforms have been investigated, with trends toward more individualized approaches and real-time assessments. Targets need to expand beyond MSM and medication adherence to include key populations and other points along the care continuum such as care initiation and retention. More rigorous evaluations are necessary, to provide evidence of impact on long-term clinical indicators. The field faces challenges around research funding and timelines as well how to expedite implementation and fund wide-scale dissemination for the most at-risk groups.

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