

# The Roles of Technology in Primary HIV Prevention for Men Who Have Sex with Men

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**Abstract** Men who have sex with men (MSM) are at disproportionate risk for HIV infection globally. The past 5 years have seen considerable advances in biomedical interventions to reduce the risk of HIV infection. To be impactful in reducing HIV incidence requires the rapid and expansive scale-up of prevention. One mechanism for achieving this is technology-based tools to improve knowledge, acceptability, and coverage of interventions and services. This review provides a summary of the current gap in coverage of primary prevention services, how technology-based interventions and services can address gaps in coverage, and the current trends in the development and availability of technology-based primary prevention tools for use by MSM. Results from agent-based models of HIV epidemics of MSM suggest that 40–50 % coverage of multiple primary HIV prevention interventions and services, including biomedical interventions like preexposure prophylaxis, will be needed to reduce HIV incidence among MSM. In the USA, current levels of coverage for all interventions, except HIV testing and condom distribution, fall well short of this target. Recent findings illustrate how technology-based HIV prevention tools can be used to

provide certain kinds of services at much larger scale, with marginal incremental costs. A review of mobile apps for primary HIV prevention revealed that most are designed by non-academic, nonpublic health developers, and only a small proportion of available mobile apps specifically address MSM populations. We are unlikely to reach the required scale of HIV prevention intervention coverage for MSM unless we can leverage technologies to bring key services to broad coverage for MSM. Despite an exciting pipeline of technology-based prevention tools, there are broader challenges with funding structures and sustainability that need to be addressed to realize the full potential of this emerging public health field.

**Keywords** Men who have sex with men · Technology · HIV prevention

## Introduction

Men who have sex with men (MSM) represent less than 2 % of the US population [1] but account for about two thirds of new HIV diagnoses annually [2]. Primary HIV prevention for MSM is challenging because of the high biological risk of HIV transmission through anal intercourse not protected by condoms [3, 4], stigma, and discrimination [5–7] which can result in decreased willingness to access prevention services, imperfect knowledge of HIV serostatus by MSM living with HIV [8], and a prominent role of transmission “bursts,” in which infections arising from acutely and recently infected men play a key role [9]. Because of these challenges to HIV prevention, there is growing consensus that a comprehensive package of prevention services will be required to meaningfully reduce HIV incidence among MSM [10]. A comprehensive primary prevention package will include access to basic prevention services, such as HIV and STI testing,

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prevention counseling when needed; availability of prevention commodities, such as condoms, condom compatible lubricants, and perhaps home HIV testing kits; meaningful availability of new biomedical prevention modalities, including preexposure prophylaxis (PrEP) and nonoccupational postexposure prophylaxis (nPEP); referrals to culturally competent services for substance use, alcohol abuse, intimate partner violence, and mental health needs; and culturally competent, safe spaces in which to access services without fear of discrimination [10].

Historically, MSM have accessed prevention services in a number of settings. Although most HIV tests in the USA are reported to occur in physician's offices, among MSM only about one in four HIV tests is reported to occur in a private doctor's office, with nearly half occurring in HIV counseling and testing sites, public clinics, STD clinics, and outreach testing programs [11]. Health departments, community-based organizations, and AIDS service organizations provide HIV testing and condom distribution services. Evolving technologies, such as internet-based services, short messaging service capabilities, and mobile apps running on smartphones or tablets, offer new opportunities to directly provide or refer men to certain types of prevention services [12].

Here, we will review the scale of primary prevention services required to meaningfully reduce HIV incidence in MSM in the USA and summarize current levels of coverage. We will then describe the ways in which technologies can support improving scale of primary prevention for MSM and give recent examples of how technology is being used to improve primary HIV prevention.

### How Much Coverage of Prevention Interventions Is Needed to Reduce HIV Incidence?

Several recent modeling studies provide evidence of the levels of coverage of HIV prevention services that will likely be required to reduce HIV incidence among MSM. Agent-based simulation models allow researchers to test counterfactual scenarios and estimate the impact on HIV incidence of implementing different combinations of prevention tools at varying levels of coverage. In a model of the US epidemic based on the PUMA transmission model of Goodreau et al. [13], researchers determined that providing PrEP to 40 % of behaviorally eligible MSM would result in a roughly 25 % reduction in new HIV infections [10]. Brookmeyer et al. found similar results in a model of HIV transmission among South African MSM, noting that a package of 50 % coverage of preexposure prophylaxis among high-risk MSM, 50 % reduction in "never tested" MSM, and a 50 % increase in ART coverage of MSM living with HIV would be required to achieve a one third reduction in new HIV infections [14]. Khanna et al. reported that simply increasing HIV testing frequency among MSM, even to every 3 or 6 months, was

insufficient to reduce new HIV infections, but that personalized testing recommendations for HIV testing frequency were predicted to reduce incidence [15]. The modeling results highlight two important points: HIV testing alone is unlikely to have a meaningful impact on HIV incidence, and 40–50 % coverage of multiple primary preventions will be required to make meaningful reductions in HIV incidence among MSM.

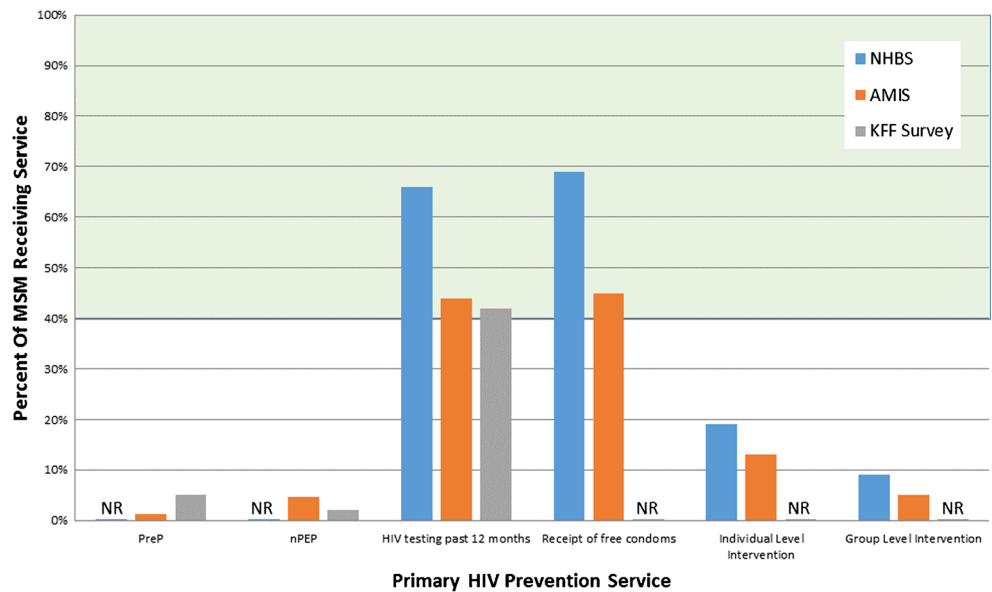
### How Are We Doing with Coverage Levels of HIV Prevention Among MSM in the USA?

Figure 1 depicts the estimated coverage of primary HIV prevention interventions for MSM in the USA, according to three data sources that represent large numbers of diverse MSM or a probability sample of MSM: the National HIV Behavioral Surveillance System for MSM [16, 17], the American Men's Internet Survey [18], and a 2014 Kaiser Family Foundation population-based sample of MSM [19]. The results show that for most primary prevention modalities, coverage is substantially less than the 40–50 % target coverage that is estimated to be needed to result in meaningful reductions in HIV incidence among MSM. Only self-reported HIV testing in the past 12 months and receipt of free condoms reach the 40 % threshold. A web supplement with interactive charts that depict coverage of specific interventions among MSM by age, race, income, education, identity, sexual identity, and rural/urban residence is available ([https://jebjones.shinyapps.io/intervention\\_coverage](https://jebjones.shinyapps.io/intervention_coverage)).

### The Roles of Technology in Increasing Scale of Primary HIV Prevention Interventions

The high levels of coverage of primary HIV prevention interventions required to reduce estimated HIV incidence coupled with low current levels of coverage of services point to the opportunities for technology to make an impact in increasing scale and coverage of prevention interventions for MSM. Technology-based HIV prevention interventions (in this review, those based on browser-based services, SMS services, and mobile-app based services) have been described as being especially strong tools for certain aspects of HIV prevention, including providing information, conducting routine screening or self-assessments according to predetermined algorithms, providing reminders for periodically recommended services, offering prevention commodities, or delivering certain types of HIV prevention interventions [12]. A list of these modalities is included as Table 1, along with examples of recent tools reported in the scientific literature. Of note, there are other areas, such as motivational interviewing or more subjective risk assessments, for which technologies may not be as well suited [12]. Thus, a combination of technology-based and provider-based services will be required for some clients.

**Fig. 1** Estimated coverage of primary HIV prevention interventions among men who have sex with men in the USA and estimated levels of coverage required to reduce HIV incidence, 2010–2015. *NHBS* National HIV Behavioral Surveillance, *AMIS* American Men’s Internet Survey, *KFF* Kaiser Family Foundation, *NR* not reported, *PrEP* preexposure prophylaxis, *nPEP* nonoccupational postexposure prophylaxis. *Shaded area* represents the coverage of multiple primary HIV prevention interventions estimated by models to result in meaningful (i.e., 25–30 %) reductions in HIV incidence among MSM



**What Technology-Based Services, Interventions, and Apps Are Being Developed and Are Available to MSM?**

A recent review of web-based, web 2.0, and mobile app interventions [33••] identified some key observations about the types of technology-based applications in testing and development. For example, there has been an evolution of technology-based interventions from largely web-based to web 2.0-based or mobile app based. There is a notable paucity of interventions that address HIV prevention across the continuum from primary HIV prevention to support through the treatment continuum for people living with HIV.

From a consumer-facing perspective, academically developed technology resources are not the sole sources available to MSM. To further understand this issue, we conducted a systematic inventory of Android and iOS mobile apps relevant to HIV prevention. A crawler<sup>1</sup> was used to examine the data dump of all apps in the Google Play and Apple stores as of May 2015. Applications that had any mention of “HIV” or “AIDS” in their name or description lines were further filtered using pattern recognition in R and then reviewed manually for relevance to HIV or AIDS. The final dataset contained 147 apps from the Google Play Store and 138 apps from the Apple App Store. Apps were classified as having been developed by professional or academic institutions versus commercial entities. Each app was also evaluated to determine cost and availability of content focused on prevention approaches (nPEP, PrEP, condom use, HIV testing), and whether the app was geared toward MSM populations. A complete listing of the apps and their characteristics is available as a [web appendix](#). Most apps (71 %) were developed by a nonacademic or public

health institution, were free (83 %), and reported information about one or more HIV prevention modalities (53 %). Apps were nearly evenly split between Android (52 %) and iOS (48 %) operating systems. Only 7 % of the apps focused specifically on the MSM population; none dealt with nPEP or PrEP. Two included information on treatment as prevention, three provided information on condoms, and eight provided information on regular HIV testing.

**Novel Approaches to Technology-Based Prevention**

One area of recent substantial scientific output is that of understanding the preferences of men for prevention apps in an attempt to build apps that address the stated needs and desires of the target population. Some have explored the acceptability of providing HIV prevention information through social/sexual networking apps and found that most users of those apps who participated in online surveys were open to the idea of HIV prevention through a mobile phone [34•] and found the social/sexual networking apps to be an appropriate platform for disseminating health information [35•]. Ramallo et al. have noted that there are some barriers to using social networking sites for HIV prevention activities, including concerns about privacy and stigma [36]. Goldenberg et al. conducted focus groups with MSM and key informant interviews with health department and community-based organization managers, and found that there was broad acceptance of the idea of app-based services and substantial buy-in from other prevention stakeholders to support the prevention services offered through an app [23•]. Although these focus group participants in Seattle and Atlanta initially expressed concerns about sharing private data, they responded favorably to the app having credible sponsors/developers (e.g., university or health department) and were therefore willing

<sup>1</sup> Credit: Marcelo Lins

**Table 1** Possible functions of technology-based primary HIV prevention tools for MSM, rationale for their uses, examples of their uses, and references

Function	Rationale	Examples	References
Provision of information	Providing basic information on HIV risks and prevention practices. May be static information, interactive bulletin boards, FAQ formats, or infographics.	<ul style="list-style-type: none"> <li>• <a href="http://www.healthmpowerment.org">www.healthmpowerment.org</a>, an HIV prevention community delivered in a browser-based format, offers “Ask Dr. W.”, where men can ask questions on a bulletin board format of an infectious disease physician.</li> <li>• <a href="http://www.AIDSVu.org">www.AIDSVu.org</a> provides browser-based and mobile-optimized information on the impact of HIV in localized geographic areas.</li> </ul>	[20, 21]
Self-assessment	Men are asked a series of questions to determine whether a certain prevention service might be right for them.	<p>Sex Pro is a browser-based service that provides personalized risk assessments based on self-reported behaviors.</p> <ul style="list-style-type: none"> <li>• <a href="http://www.findyourfrequency.com">www.findyourfrequency.com</a> is a browser-based utility to determine recommended HIV testing frequency.</li> <li>• HealthMindr is an app-based utility that allows MSM to screen themselves for PrEP or nPEP eligibility.</li> </ul>	[22•]
Reminders of recurring services	Provide SMS-based, email-based, reminder calls, or native mobile OS notifications to promote recurring services (e.g., HIV testing on a certain regular interval, self-assessment for PrEP eligibility).	HealthMindr allows men to schedule a regular HIV testing interval and then select how they will receive reminders when a followup test is due.	[23•]
Offering prevention commodities	Websites or mobile apps can offer prevention commodities (e.g., condoms, lubricants, HIV self-test kits, STI self-test kits) by mail.	HealthMindr offers distribution of free condoms and HIV self-test kits by mail.	[23•]
Adherence reminders	Provide SMS-based, email-based, reminder calls, or native mobile OS notifications to promote medication adherence. Although most technology-based adherence services and interventions have focused on promoting adherence to antiretroviral therapy among those living with HIV, such systems also have applicability to PrEP adherence.	<ul style="list-style-type: none"> <li>• The Sibanye Health Project in South Africa provides weekly SMS adherence reminders to MSM on PrEP.</li> <li>• PrEP demonstration projects have utilized texting, mobile apps, and websites to provide adherence education or counseling.</li> </ul>	[24, 25]
Delivering prevention interventions	Behavioral interventions can be delivered through web-based or app-based activities, typically through theory-based activities to strengthen self-efficacy, change attitudes or norms, provide information, or model prevention skills.	<ul style="list-style-type: none"> <li>• <a href="http://www.healthmpowerment.org">www.healthmpowerment.org</a> is a browser and mobile-phone based intervention to increase self-efficacy, skills and abilities and change attitudes and norms about HIV prevention behaviors.</li> <li>• Keep it Up! is a browser-based HIV prevention intervention for young MSM who have just tested negative for HIV.</li> </ul>	[26••, 27, 28, 29••]
Referrals to services	Providing information about where men can access specific prevention services; may be simple referral directories, provide transit directions, or provide tailored referrals	GetConnected is a HIV/STI education site and testing locator. Users are directed to testing locations based on reviews and user values and priorities.	[30••]
Provide services from live providers directly through web communication channels	Counseling services or individualized education can be provided through secure web channels; this is similar to the secure transmission of provider-patient communications in telemedicine or through chat interactions on social media.	Nexus is a couples HIV testing and counseling service provided by a trained counselor through a HIPPA-compliant telemedicine portal. Male couples receive HIV self-testing kits by mail and test themselves and	[31, 32]

**Table 1** (continued)

Function	Rationale	Examples	References
		receive counseling through a browser-based video chat. Motivational interviewing through Facebook (MiCHAT) was associated with decreased CAI among young MSM.	

*FAQ* frequently asked questions, *SMS* short message service (text messaging), *PrEP* preexposure prophylaxis, *STI* sexually transmitted infections

to share their data with credible partners to evaluate and improve programs.

Several specific technology-based tools for primary HIV prevention deserve individual discussion. For example, there is a growing body of scientific output around the healthpowerment.org website and mobile-optimized service [26••]. This website, based on the integrated model of behavior change, supports community discussions, dialogue with medical providers, quizzes, journaling spaces, and interactive decision-making tools to help assess sexual risks [20]. The results of a pilot trial suggest that participants experienced improvements in social support, social isolation, and depressive symptoms after engagement with the site [26••].

Another promising technology-based primary prevention approach is Get Connected, a website which provides tailored recommendations for HIV and STI testing to young MSM [30••]. The site allows men to set their own priorities and preferences for characteristics of a testing location and matches them with testing providers that have been surveyed by “secret shoppers” who rated providers on preestablished criteria [37]. This concept extends the current focus on “personalized medicine” to the public health world and is an example of a technology-based prevention approach that aims to create a sense of ownership within the user by tailoring prevention messages around their self-reported priorities.

A third intervention that has been systematically developed and rigorously evaluated is Keep It Up, an online, multi-modal HIV prevention intervention targeted to young MSM who have recently received a negative HIV test [29••]. The period following receipt of a negative HIV test result can be a period of opportunity to promote positive behavioral changes or a period of vulnerability for HIV acquisition [38]. The initial randomized study of the Keep It Up intervention demonstrated a 44 % reduction in HIV risk behaviors over a 12-week follow-up period; a larger, multicity randomized controlled trial of the intervention with a longer follow-up period is currently enrolling participants [28].

A final innovative area falls outside of the domain of prevention services delivered to individual men but represents an area of opportunity for improving targeting of public

education programs and public health responses. Young et al. have reported an important proof of concept study in which they associated the content of “tweets” (postings on the Twitter social network) with HIV prevalence in US counties, obtained through [www.AIDSVU.org](http://www.AIDSVU.org) [39••]. The results were a proof of concept for using trends in keywords or phrases posted on Twitter to identify areas where new HIV diagnoses are likely to occur. This could be used in the future as a kind of “crowd sourcing” to direct prevention providers and public health officials to areas of current risk, in an attempt to intervene with HIV prevention interventions at the time risks are occurring. This effort is part of a larger move toward using “big data” to improve our HIV prevention efforts [40].

## Conclusion

Realizing the potential of technology-based primary HIV prevention is critical, and there are several areas in which there exist substantial opportunities to advance the structures that support the technology research enterprise. First, it is important that we distinguish between particular technology applications and the theoretically based content and delivery which they embody. The cost of developing a proprietary intervention platform can be high, and technology platforms are in constant evolution. Rather than repeatedly testing broad technology-based platforms for delivering prevention efforts, it is critical that we design studies that help identify the particular elements of a technology-based prevention service that are effective, so those elements may be reproduced in future technology frameworks. Understanding the crucial impactful elements of technology-based interventions should be a priority for research. For example, gaming interventions that were developed in the era of web 1.0 would be able to be updated to a mobile phone environment if the particular game elements that conferred efficacy were elucidated in the original efficacy study. This might mean considering factorial designs so that experiments demonstrating which components of apps are effective are possible.



Second, there is a need for better structures for resource sharing, so that some common elements of technology-based interventions—e.g., informational resources, testing locators, survey utilities for study measures, and administrative components—do not have to be redeveloped each time a new app or web concept is proposed and a new project funded. The redundant development of technology pieces that are not part of the novel science has a substantial cost both in terms of time and money. There may be roles for both governmental funders and private companies in developing platforms into which novel ideas for content can be channeled and which can be cosmetically tailored (or branded) to suit different subpopulations.

Third, if our goal is to ultimately use technology-based interventions to increase the coverage of prevention services—and this should be our goal—we must prioritize other kinds of studies of technology products to document and iterate their effectiveness. As the science of technology-based prevention progresses, the ultimate goal is to develop technology tools that have high acceptability, are highly utilized by those at risk for HIV infection, and are effective in increasing certain behaviors and effective at decreasing other behaviors. Close integration with existing stakeholders, such as health departments and CBOs, is necessary, because the ultimate path to sustainability of technology-based tools runs to the door of our public health partners charged with delivering services. Implementation science approaches will need to be undertaken to demonstrate how the behaviors of MSM, health departments, CBOs, and clinicians can be shaped to maximize the opportunities of these tools. Studies will need to be done where the outcome is uptake, where the implementation of tools is examined across different public health settings, and where community-based measures of impact are evaluated.

The landscape of HIV prevention has changed radically in the past decade, both because of biomedical advances such as PrEP, because of the evolution of the risk environment for MSM through new web- and app-based venues for meeting sex partners, and because of the advances in processing speed and data speed that have allowed the transformation of the mobile phone. These factors create a moment of opportunity to revolutionize the scale at which we deliver HIV prevention services and interventions, and the tools through which we deliver them.

#### Key Points:

- Although high levels of coverage of multiple HIV prevention interventions will be required to reduce HIV incidence among MSM, currently most interventions have low coverage in the MSM population.
- Technology-based interventions offer significant promise to allow cost-effective scaling of prevention interventions for MSM.

- Technology-based interventions have applicability for a broad range of prevention intervention activities, including health screenings, reminders for health services, adherence support, and providing information. Some prevention services, like counseling and motivational interviewing, will likely always require personally delivered services.
- There are a number of challenges to realizing the full public health potential of technology-based interventions, and funders of research and programs should work with intervention developers to reduce development time and promote efficient shared platforms for intervention.

#### Compliance with Ethics Guidelines

**Conflict of Interest** Dr. Sullivan reports grants from NIH, grants and personal fees from CDC, grants from MAC AIDS Fund, and grants from Gilead Sciences outside the submitted work. Mr. Jones, Mr. Kishore, and Dr. Stephenson declare that they have no conflict of interest.

**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.

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