

Reducing HIV risk behavior of men who have sex with men through persuasive computing: results of the Men's INternet Study-II

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Objective: The primary objective of this study was to develop and test a highly interactive Internet-based HIV prevention intervention for men who have sex with men (MSM). MSM remain the group at highest risk for HIV/AIDS in the United States and similar countries. As the Internet becomes popular for seeking sex, online interventions to reduce sexual risk are critical. Given previous studies, a secondary objective was to demonstrate that good retention is possible in online trials.

Design: A randomized controlled trial with 3-month, 6-month, 9-month, and 12-month follow-up design was employed.

Methods: In 2008, 650 participants were randomized to an online, interactive sexual risk reduction intervention or to a waitlist null control.

Results: Retention was 76–89% over 12 months. At 3-month follow-up, results showed a 16% reduction in reported unprotected anal intercourse risk among those in the treatment condition versus control [95% confidence interval (95% CI) of rate ratio: 0.70–1.01]. No meaningful differences were observed at 12-month follow-up.

Conclusion: Internet-based, persuasive computing programs hold promise as an effective new approach to HIV prevention for MSM, at least in the short term. Further, online trials can be conducted with acceptable retention provided strong retention protocols are employed. Four directions for future research are identified.

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Men who have sex with men (MSM) remain the largest population infected with HIV in the United States [1]. Although early (offline) prevention efforts were effective in reducing the spread of HIV [2], there has been a reversal in safer sex practices since the mid-1990s [3], leading researchers to conclude that HIV prevention efforts for MSM in the United States have 'faltered' [4].

Reenergizing HIV prevention for MSM remains an urgent priority in the fight against HIV/AIDS [5].

Increased sexual risk taking and rising HIV rates among MSM have coincided with the broad adoption of the Internet as a way for MSM to meet sexual partners [6]. The Internet is now the largest venue where MSM meet

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sexual partners [7]. A meta-analysis of 14 studies from 1999 to 2005 reported a weighted mean estimate of 40% of MSM meeting their sex partners online [8]. However, the analysis is now dated; the range of estimates was large (23–99%) and highly dependent on the recruitment methods used [8].

Clinic studies have identified men who use the Internet to seek sex with men (MISM) as at higher risk for HIV/STIs (sexually transmitted infections) than other MSM [9]. Internet sex-seeking appears to increase risk through an increased number of partners [10], and therefore increased probability of sexual risk behavior [6,11]. Tracing STI outbreaks [12] and HIV transmission [13] through Internet-mediated liaisons is well documented.

Given the global reach of the World Wide Web, its accessibility, affordability, anonymity, and popularity for sex-seeking among MSM [14], Internet-based interventions hold exceptional promise to address the global pandemic of HIV among MSM if they can be shown to reduce unsafe sexual behavior. The long-term objective of this research is to develop Internet-based interventions strong enough to lower sexual risk behavior among MISM.

To date, three online interventions for adult MISM have been rigorously evaluated. These programs used tailored messaging to MISM entering relationships [15], visual stories to promote HIV testing and to reduce unsafe sex [16], and 'gay' avatars on a virtual cruise [17]. However, two of the trials [15,17] experienced attrition rates of 70–80%, preventing meaningful interpretation of results, whereas the third [16] did not attempt to measure behavior change. Thus, attrition in online interventions appears a major challenge.

Study description

The Men's INternet Study-II (MINTS-II) is a randomized controlled trial (RCT) to test whether an Internet-based sexual health promotion intervention (*Sexpulse*) for MISM can reduce their unprotected anal intercourse. Participants completed the study during a 3-week period from December 2007 to January 2008 with 3-month, 6-month, 9-month, and 12-month follow-up surveys being sent in April, July, October, and January 2009, respectively.

Development of the intervention

Sexpulse was designed by a multidisciplinary team of health professionals, computer scientists, and e-learning specialists and developed by a leading e-learning development company. Extensive formative research was undertaken with 2716 MISM recruited online [11,18]. Key findings were that to be acceptable to the target

population, online HIV prevention must be comprehensive, highly visual, and more sexually explicit than conventional prevention programs [18].

Our theoretical approach was grounded in the Sexual Health Model approach to HIV prevention [19] and principles from e-learning [20]. The Sexual Health Model posits that sexually healthy persons are more likely to make sexually healthy decisions, while e-learning stresses that to be effective, online interventions should be user-oriented, engaging, informative, and fun. For our starting point, we adapted a seminar-based sexual health curriculum for MSM into an online intervention [21].

From the perspective of persuasive computing [22], we consider the role of computers as tools (persuasion through customization and tunneling), media (simulation and experience), and social actors (roles). We paid specific attention to human-computer interaction [23] and user experience, using testing to remove distractions that would lessen participant engagement with the intervention. The intervention was modular with extensive user flexibility to maintain the feeling of control typical in both graphical user interfaces and Web interaction. The modules borrowed most directly from computer games, which have a long history of presenting persuasion opportunities [24], but also incorporated video segments, interactive text, and animations.

Module prototypes were developed using a multi-iteration design and development process. Prototypes were reviewed internally by experts, tested with MISM in a usability laboratory, and refined as needed.

Intervention description

In translating the curriculum into an online experience, the didactic approach was dropped in favor of active learning. From the participant's perspective, the overall goal of the intervention was presented as building a personal 'portrait of sexual health,' with each module yielding a portrait piece. Module examples include a 'hot sex' calculator, which calculates the odds of great sex while demonstrating decision making in dating; a virtual gym where men can explore body image concerns common in this population; an online chat simulation where users can explore ambiguity and evasion; and a reflective journey where participants can identify and graph the effects of past successes and disappointments, identify long-term goals, shed secrets, and deepen spirituality. These modules were supplemented by virtual peers who contributed their experiences from diverse perspectives, reinforcements in the form of 15-s cartoons, polls where participants could compare their answers with those of other participants, and FAQs where learners could seek specific information. Two modules employed personal video vignettes of three MSM living with HIV and three HIV-negative MSM discussing ways they avoid transmitting/acquiring HIV. Other modules covered

mental and emotional health, physical health, intimacy, relationships, sexuality, and spirituality aspects of the Sexual Health Model, with each module addressing implications for safer sex, commitment to reducing risk, and long-term sexual health.

Methods

Participant recruitment procedures

Banner advertisements placed on two of the nation's largest gay Web sites and e-mails to participants from previous research connected MISM to the study Web page (see Fig. 1). Eligibility criteria included being male, 18 years or older, and a US resident, with a recent history of engaging in unprotected anal intercourse with at least one other man. In addition, potential participants were informed that they would need to be comfortable viewing sexually explicit materials online, be prepared to complete all online activities within 7 days, and be willing to provide an e-mail address and phone number to maintain contact. All study protocols were approved by our institution's review board.

Strategies to improve retention

High attrition in prior Internet-based HIV prevention trials was a concern [15–17]; hence, we focused on strategies to improve participant retention. Prior research identified time constraints and inadequate compensation as reasons MISM drop out of online studies. Therefore, compensation was set at \$80 for completing the pretest, intervention, and posttest, with an additional \$20–25 for completing each follow-up survey. This amount was deemed sufficient, but not coercive, for retention. Second, we employed a quarterly e-affle with a monetary first prize of \$150 to maintain study contact. Third, we developed a retention protocol where failure to return a survey triggered automated reminders, followed by personalized human contact by e-mail and then telephone.

Experimental conditions

All participants were invited to complete baseline, immediate postintervention, and 3-month, 6-month, 9-month, and 12-month follow-up surveys. A computer algorithm was used to randomly assign participants to one of two experimental conditions. Participants assigned to the null control condition completed an additional sexual health survey between baseline and postintervention assessments. Participants assigned to the intervention arm completed *Sexpulse*. Seven days after enrollment, participants who had not completed the null control survey or *Sexpulse* were sent two automated e-mail reminders 1 week apart, and were then contacted by telephone. At each follow-up, reminder e-mails were sent asking participants to return to the Web site to complete follow-up surveys.

Measures

The primary end point for the trial was the self-reported number of male partners with whom a participant engaged in unprotected anal intercourse with male partner (UAIMP) during the prior 90 days. In addition, the pretest survey assessed other dimensions of sexual health and collected demographic and Internet-use information. Immediate postintervention surveys assessed participants' ratings of the intervention and qualitative comments on strengths and weaknesses of the intervention.

Results

Figure 1 presents the enrollment, allocation, and retention results. A total of 650 MISM completed the baseline survey and were randomized to one of the experimental conditions. Retention over the 12-month study ranged between 76 and 99%.

Table 1 presents baseline characteristics and displays the covariate balance achieved through randomization. Except for a greater proportion of white men and modest differences in the distributions of age and educational attainment, randomization procedures appear to have balanced background characteristics across treatment conditions.

Table 2 presents the 3-month and 12-month change in HIV risk (UAIMP) in the last 3 months. We note the observed distribution of UAIMP was highly skewed – most men reported unprotected anal intercourse (UAI) with a few male partners, and a small number of men reported many such partners. Accordingly, it can be seen that 20% of participants in both experimental conditions did not report any risk change at the 3-month follow-up. Unfortunately, 12% in the control arm, compared to 10% in the treatment arm, reported more than one additional UAIMP at follow-up.

Another way to examine change is displayed in Fig. 2, which presents the adjusted mean UAIMP (and 95% confidence bands) by measurement period and experimental condition. Clearly, the point estimates within condition diverge after treatment, although confidence bands overlap. It is also important to note that self-reported risk declined in both the treatment and control conditions.

Table 3 presents results from negative binomial regression models, which estimate the treatment effect as a rate ratio. The upper panel presents treatment effects at 3 months, and the lower panel presents results at 12-month follow-up. Table 3 also presents results for all participants (i.e., full sample) and only those with some risk at baseline (i.e., nonzero risk), which could have been reduced by the

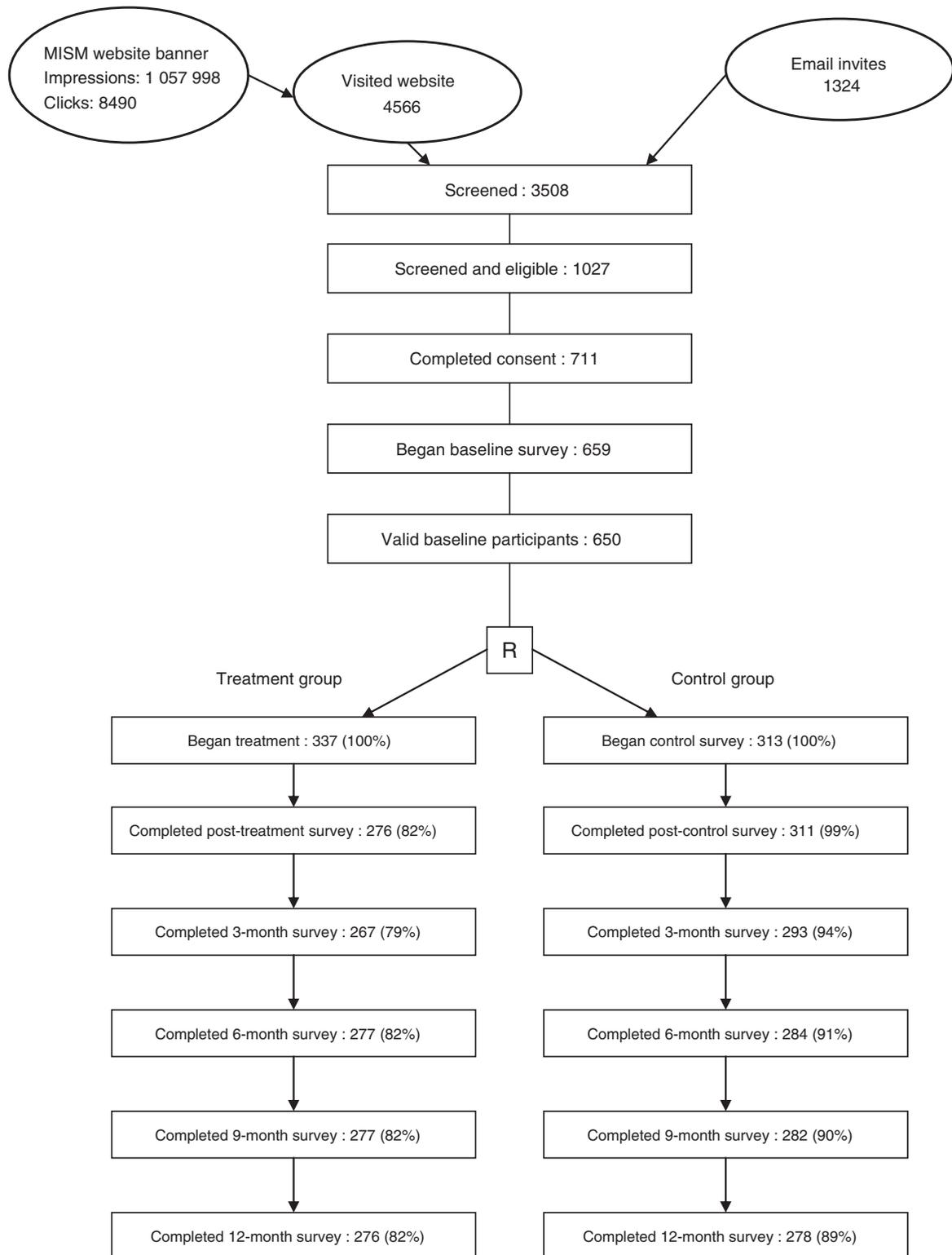


Fig. 1. Men's INternet Study-II randomized controlled trial data collection.

intervention. Finally, both crude (i.e., unadjusted) and adjusted estimates are presented. The modeled results suggest that the *Sexpulse* program reduced short-term risk by an estimated 16.8% [95% confidence interval (95%

CI): 0.69, 1.00; $P=0.05$] in the unadjusted and by 15.6% (95% CI: 0.704, 1.013; $P=0.068$) in the adjusted full sample models. Similar effects are observed in those who reported some baseline risk. By 12-month follow-up, no

Table 1. Demographic and health characteristics of participants at baseline (n = 650).

	Total, n (%)	Treatment arm, column (%)	Control arm, column (%)	Percentage difference between arms
Age (years)				
18–25	153 (23.5)	24.0	23.0	1.0
26–35	224 (34.5)	33.5	35.5	2.0
36–45	180 (27.7)	27.3	28.1	0.8
Older than 45	93 (14.3)	15.1	13.4	1.7
Race/ethnicity				
White	443 (68.2)	71.2	64.9	6.3
Black or African American	41 (6.3)	5.3	7.4	2.1
Latino/Spanish/other	98 (15.1)	13.1	17.3	4.2
Asian	23 (3.5)	2.7	4.5	1.8
Other	45 (6.9)	7.7	6.1	1.6
Educational attainment				
Less than high school or high school graduate	51 (7.9)	8.6	7.0	1.6
Some college education	223 (34.3)	34.7	33.9	0.8
College degree	147 (22.6)	22.0	23.3	1.3
Graduate/professional school	229 (35.2)	34.7	35.8	1.1
Annual income				
Less than \$20 000	121 (18.6)	19.3	17.9	1.4
\$20 000–31 999	127 (19.5)	18.1	21.1	3.0
\$32 000–44 999	117 (18.0)	17.8	18.2	0.4
\$45 000–64 999	124 (19.1)	20.2	17.9	2.3
Greater than \$65 000	133 (20.5)	20.5	20.5	0.0
Refuse to answer	28 (4.3)	4.2	4.5	0.3
Employment status				
Technical profession	76 (11.7)	8.9	14.7	5.8
Business profession	188 (29.0)	28.9	29.2	0.3
Human services profession	117 (18.1)	18.8	17.3	1.5
Sales/clerical	59 (9.1)	9.8	8.3	1.5
Student	115 (17.8)	17.6	18.0	0.4
Skilled worker	43 (6.6)	8.6	4.5	4.1
Unskilled worker	6 (0.9)	0.9	1.0	0.1
Unemployed	27 (4.2)	3.9	4.5	0.6
Retired	17 (2.6)	2.7	2.6	0.1
Residence				
Rural or small town	104 (16.1)	17.1	15.1	2.0
Medium-sized city	106 (16.4)	18.0	14.7	3.3
Suburb of a large-sized city	155 (24.0)	24.0	24.0	0.0
Downtown or central district of a large-sized city	281 (43.5)	41.0	46.2	5.2
Number of children				
0	600 (92.6)	92.9	92.3	0.6
1–2	38 (5.9)	5.4	6.4	1.0
3 or more	10 (1.5)	1.8	1.3	0.5
Sexual orientation				
Homosexual/gay/same gender loving	594 (91.4)	90.8	92.0	1.2
Bisexual/straight/other	56 (8.6)	9.2	8.0	1.2
HIV status				
HIV-positive	140 (21.6)	20.8	22.4	1.6
HIV-negative	508 (78.4)	79.2	77.6	1.6
Long-term partner				
Yes	159 (24.5)	24.0	24.9	0.9
No	491 (75.5)	76.0	75.1	0.9
Current/ever member of gay organization				
Yes	340 (52.4)	53.7	51.0	2.7
No	309 (47.6)	46.3	49.0	2.7

meaningful differences between treatment and control conditions are observed.

Analyses not presented show no evident impacts of 'dose,' operationalized as time spent completing *Sexpulse*. Further, the modeled estimates of Table 3 are robust to specification, such that adding or subtracting other potential confounders (e.g., HIV status) has no meaningful impact.

Discussion

There were three major findings in this study. First, it is possible to develop a highly interactive Internet-based intervention program that MISM can use. Second, it is possible to conduct an Internet-based RCT and retain MISM over long periods (76–99% over 12 months). Third, among our participants who reported UAIMP at baseline, at 3 months those randomized to the

Table 2. Three-month and 12-month change in incident unprotected anal intercourse with male partners, by treatment arm.

	Treatment arm, % (n = 267)	Control arm, % (n = 292)	Difference	Ratio ^a
Difference in partners between baseline and 3-months				
More than one fewer partners	40.8	38.4	2.5	1.064
One fewer partner	21.0	20.9	0.1	1.004
No change in partners	20.2	20.2	0.0	1.000
One more partner	8.2	8.2	0.0	1.002
More than one additional partner	9.7	12.3	-2.6	0.790
Total	100.0	100.0	0.0	-
	Treatment arm, % (n = 273)	Control arm, % (n = 277)	Difference	Ratio ^a
Difference in partners between baseline and 12-months				
More than one fewer partners	39.2	50.5	-11.3	0.775
One fewer partner	24.2	21.7	2.5	1.116
No change in partners	17.2	13.0	4.2	1.325
One more partner	7.3	5.8	1.5	1.268
More than one additional partner	12.1	9.0	3.1	1.339
Total	100.0	100.0	0.0	-

^aRatio, treatment value/control value.

intervention group reported a marginally significant decrease in the number of men with whom they engaged in risk behavior compared with the control group. This longer term follow-up showed no meaningful differences does not negate this promising fact. Taken together, the results suggest that the highly interactive online intervention can have at least short-term effects on reducing sexual risk behavior among MSM. Because reduction in UAIMP predicts lower HIV/STI incidence, the effects of the intervention carry considerable public health importance.

At least four directions for future research are implied by these results. First, our next steps include developing and testing methods to strengthen the long-term effects of the intervention. Second, we highlight the reduction in risk reported by participants in the control condition as a

challenge (see Fig. 2). Although similar effects can be seen in offline RCTs (see, for example, Morin *et al.* [25]), research into panel conditioning and context effects is needed to better understand these results. Third, reach (getting people to the site) and retention (keeping people on site) have been identified as the two major challenges for Internet-delivered interventions for adolescents [26–28]. We hypothesize that these are also the major challenges for successful online interventions for MSM and recommend that researchers measure and report these in their evaluations. Finally, because online interventions can be accessed globally, next steps in this line of research include testing replicability, language equivalency, cultural appropriateness, and differences in effectiveness internationally.

Given the study design and the complexity of the intervention, it is not possible to identify the specific program components that led to behavior change in this study; a large and complicated factorial experiment is needed to definitively answer such questions. However, we speculate that the following factors contributed to the short-term effectiveness of our program: a Web site that was engaging, highly interactive, and fun, with a complexity of cognitive intervention tasks, based on the Sexual Health Model, informed by credible data, addressing topics identified by the target population as highly relevant, supported by personal testimonies, dominance of visual over verbal information including sexually explicit and realistic images, written in a real-world direct peer-to-peer style, and allowing participants to compare their responses to other peers. For enhancing retention, key features included a strong retention protocol, interactive engaging activities, appropriate visual learning elements, and for this population and content, frequent use of realistic sexually explicit images.

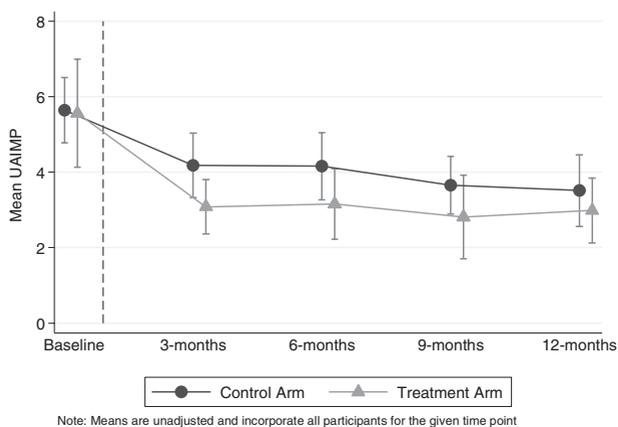


Fig. 2. Mean number of male unprotected anal intercourse with male partners (UAIMP) by Time Point and Treatment Group (N = 650 MSM at baseline).

Table 3. Treatment effect estimates from random effects negative binomial regression models of unprotected anal intercourse with male partner at both 3 months and 12 months on treatment indicator among full sample and among users who reported risk at baseline.

	<i>N</i>	Incident rate ratio	Lower 95% CI	Upper 95% CI	<i>P</i>
3-month outcome					
Full Sample					
Unadjusted	650	0.832	0.691	1.000	0.050
Adjusted ^a	650	0.844	0.704	1.013	0.068
Nonzero risk at baseline ^b					
Unadjusted	584	0.825	0.684	0.995	0.044
Adjusted ^a	584	0.843	0.701	1.014	0.069
12-month outcome					
Full sample					
Unadjusted	650	0.998	0.952	1.046	0.921
Adjusted ^a	650	0.998	0.952	1.046	0.937
Nonzero risk at baseline ^b					
Unadjusted	584	0.991	0.945	1.040	0.728
Adjusted ^a	584	0.993	0.947	1.042	0.786

95% CI, 95% confidence interval.

^aAdjusted for continuous age, categorical race as presented in Table 1, and categorical income group as presented in Table 1.

^bSixty-six users reported having no risk (0 unprotected anal intercourse partners) at baseline; these users are excluded from following analyses.

There were four principal limitations to the study. First, Internet-based studies cannot guarantee that participants are actually members of the target population. Strategies employed in this trial to reduce the likelihood of false respondents included recruitment from sites exclusively targeting the intended population, eligibility screening prior to explanation of the study, an extensive consent process, and a strong de-duplication and cross-validation protocol to ensure internal consistency and reliability of responses. Second, the choice of a null control means that change may have been due to access to content, time, and attention. The primary weakness of a null control is the potential for participant awareness that they did not receive the intervention. We considered a treatment-as-usual or a time-and-attention control option, but rejected the former as nonexistent and the latter as not easy to identify. Third, participants completed the study under highly controlled conditions – including being required to complete all modules and being compensated. We cannot generalize from this trial how MISM may use it in the real world. Fourth, HIV risk assessments use self-reports of sexual behavior, which may be prone to recall and/or social desirability biases [29]. Although computer-based methods, such as those used in this study, appear to lessen such biases [30], accurate recall requires correct reconstruction of details and sequence of events [31,32], with errors increasing for distantly occurring or high-frequency behaviors [33,34]. Although improbable, given the impossibility of blinding participants to treatment conditions, differential response-bias and related effects of attrition could explain results.

Our results have important implications for research and practice of HIV prevention, specifically, and more broadly for e-Public Health. This study demonstrates that challenges encountered by other e-Public Health research teams, including high attrition, can be over-

come. Further, using an RCT design, Internet-based interventions appear potentially useful for reducing risk behavior. Future research should focus on establishing the effectiveness of online interventions and then comparing the effectiveness of new approaches to existing methods.

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B.R.S.P. is principal investigator of the MINTS-II study and also wrote the first draft of the introduction, methods, and discussion.

J.M.O. is lead methodologist and statistician for the study who designed the analysis and wrote the results section.

J.K. is the lead computer scientist for the study who oversaw the design and development of the intervention, its testing, and the testing and implementation of the online survey and methods. On this article he wrote the sections specific to computer science.

S.H. is the e-learning educational theorist who oversaw the software development process and led the formative research process, which informed the intervention.

K.J.H. is the coinvestigator who focused on the intervention's effectiveness, particularly on young MSM and on HIV-positive populations. He attended weekly meetings, advised substantially on what the intervention and survey should look like, and cowrote the introduction and discussion sections.

G.P.D. is the project coordinator for the study. In addition to implementing all aspects of the study and overseeing their day-to-day operation, he contributed substantially to the science of this study by proposing study of e-learning constructs. His doctoral dissertation, based on this trial, examines the effectiveness of different instructional scaffolding on the effectiveness of the intervention. On this article he wrote the section detailing e-learning practices.

K.E.N. conducted all the analyses for this study under the supervision of J.M.O. In this role she wrote the analysis section, conducted all analyses, and proposed some additional analyses (reported in this article) that helped contextualize these results.

D.S. is a postdoctoral fellow who has worked on the MINTS-II study for the last year, and in addition, took the lead in conducting analyses about order effects (as requested by reviewer 1).

We confirm that all authors participated in regular meetings overseeing the implementation of the study at a level appropriate for coauthorship and further contributed specifically to this article either by writing sections and/or by providing substantial comments to improve the manuscript.

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