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Yohannes Tesema Date

Longitudinal predictors of unprotected anal intercourse among Internet-using men who have sex with men in United States

by

Yohannes Bekele Tesema
Master of Science in Public Health

Global Epidemiology

Patrick S. Sullivan, DVM, PhD
Faculty Thesis Advisor

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Yohannes Bekele Tesema

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An abstract of
A thesis submitted to the Faculty of the
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Master of Science in Public Health
in Global Epidemiology
2013

ABSTRACT

Longitudinal predictors of unprotected anal intercourse among Internet-using men who have sex with men in United States

By Yohannes Bekele Tesema

Background: Since the first official report of AIDS in the United States, men who have sex with men (MSM) have been and remain at substantial risk for HIV infection. Unprotected anal intercourse (UAI) is a primary risk factor for HIV acquisition and transmission among MSM.

Objective: To explore key behavioral and structural factors associated with UAI among Internet-using MSM aged 18 years and older, and estimate the relative association of each factor by accounting for the natural heterogeneity between subjects.

Methods: A prospective longitudinal online study was conducted from May 2010 through December 2011 in United States. 652 Internet-using MSM aged 18 years and older, having at least one male sex partner in past 12 months, and recruited from social networking Web sites were followed for 12 months with six self-administered interviews. Logistic regression was used to model frequencies of UAI experiences among MSM with independent variables. A generalized linear mixed modeling was used to estimate parameters and test for significant variations in risk of UAI between study participants.

Results: The factor most strongly associated with reporting UAI was number of male sex partners in the past 12 months. In multivariate analysis, compared with a man who reported a single male sex partner in past 12 months, a man who reported > 5 male sex partners (aRR=8.5, P <.0001) and a man who reported having three to five male sex partners (aRR=5.1, P <.0001) were at increased risk of engaging in UAI. Other factors that were independently associated with reporting UAI were experience of physical violence with a current male sex partner (aRR=1.7, P = 0.03) and meeting at least one male sex partner on Internet (aRR= 2.1, P = 0.002).

Conclusions: Comprehensive HIV prevention packages for MSM should address number of sex partners and intimate partner violence. More focused studies are needed to investigate the relationship between Internet use for meeting male sex partners and UAI.

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ACKNOWLEDGMENTS

I would like to send my warm and special thanks to my thesis advisor Dr. Patrick Sullivan for his generosity, support, and guidance. This thesis would not have been possible without his generosity.

I am also grateful to Dr. Brent Johnson for his insightful comments and advice.

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1. INTRODUCTION

Since the first official report of AIDS in the United States, gay, bisexual, and other men who have sex with men (MSM) have been and remain at substantial risk for HIV infection [1]. According to the US Centers for Disease Control and Prevention, in 2011 MSM accounted for 79% of the 38, 825 estimated new HIV diagnosis among all adult and adolescent males in U.S. and 62% of the 49,082 estimated new HIV diagnosis among all adults and adolescents in U.S. In the same year, MSM accounted for 52% of 32,037 estimated new AIDS diagnoses among all adults and adolescents in U.S. [2]. Analysis of population based survey in New York City by Pathela P. et al. (2011) estimated that risk of HIV diagnosis among MSM was 140 times risk of HIV diagnosis among heterosexual men [3].

Unprotected anal intercourse (UAI) is a primary risk factor for HIV acquisition and transmission among MSM. According to CDC report in 2011, males accounted for 78% of 194,571 estimated new HIV diagnosis among adults and adolescents during 2008 through 2011 in U.S. 75% of estimated 151,239 diagnosed new HIV infection in adult and adolescent males during 2008 through 2011 in U.S. were attributed to male-male sex [2].

A systematic review and meta-analysis of HIV transmission risk through anal intercourse by Baggaley R. F. et al. (2010) reported that the efficacy of HIV spread is higher in UAI among MSM as compared to UAI among heterosexuals and unprotected vaginal intercourse [4]. Specifically, the review indicated a 1.4%

(95% CI: 0.2% — 2.5%) per-sexual-act probability of HIV transmission for UAI which is approximately 18 times greater than the per-sexual-act probability of HIV transmission for unprotected vaginal intercourse. Moreover, the review estimated that the per-partner chance of HIV transmission through UAI between MSM is about 40.4% (95% CI: 6.0% — 74.9%). This high level HIV transmission efficacy through UAI among MSM is mainly explained by the unique anorectal anatomy, immunology, and histology in males; and the practice of role versatility that is common within men in male relationships [5-7].

Studies conducted in U.S. and various regions of the world have documented behavioral factors associated with UAI among MSM; previously associated factors include demographic characteristics, sexual orientation, type of sexual relationships, number of male sex partners, transactional sex, drug use, alcohol use, and venues where MSM meet their male sex partners. However, most efforts to understand factors associated with UAI among MSM focused mainly on behavioral dimensions of HIV/AIDS. Few data are available on the role of those broader structural factors including social, economic, legal, and political factors that might be associated with UAI among MSM. Therefore, our understanding of factors associated with UAI among MSM is far from complete.

Hence, this study explored key behavioral and structural factors associated with UAI among MSM using prospective longitudinal data. Heterogeneity between subjects in risk of UAI was examined, and the relative strengths of the subject-specific effects were estimated for each predictor variables. The findings from this

study will help to inform novel HIV prevention policies and interventions for MSM.

Socio-demographic characteristics

Age: Findings from studies that have examined the associations between age and risk of UAI among MSM were inconsistent. Some studies have shown that older MSM were more likely to engage in UAI. For example, a study by Hampton M. C. et al. (2013) in New York City among African American MSM found that MSM 30 years of age or older were approximately three times more likely to engage in insertive UAI as compared to those 29 years of age or younger (adjusted OR=3.04, 95% CI: 2.00 - 4.63) [8]. Moreover, a population based survey of MSM in 2003 and 2006 in Seattle, Washington showed that the likelihood of UAI among HIV seronegative gay men was getting higher as they get older [9]. According to this survey, MSM aged between 40 and 49 years were more than five times more likely to engage in UAI than MSM aged 19 to 29 years old; and MSM aged 50 years age or older were more than eight times more likely to engage in UAI as compared to MSM aged 19 to 29 years old.

Other studies have found the opposite pattern. For example, a study of MSM in San Francisco found that HIV negative MSM 30 years age or younger were more likely to engage in UAI as compared to MSM older than 30 years [10]. Furthermore, a national online survey in 2010 in Norway indicated that MSM 29 years of age or younger were approximately two times more likely to engage in UAI as compared MSM aged 30 years or older [11]. The majority of studies have

found no significant association between age and UAI among MSM [12-18].

School attainment: Some studies have examined the relationship between school attainment and UAI among MSM. However, few have suggested lower level of school attainment is linked with greater risk of UAI among MSM [8, 11, 19]. The cross-sectional study of African American MSM in 2010 in New York City found that African American MSM who had completed a high school diploma or less were more likely to engage in both insertive and receptive UAI as compared to those who completed at least some collage or more [8]. Another study by Chiasson M. A. et al. (2007) found that MSM who have no collage degree were more likely to engage in UAI as compared to those who have at least collage degree (adjusted OR = 1.63; 95% CI: 1.13 - 2.35) [19]. Most studies that have investigated the association of educational attainment and UAI among MSM showed no significant association [12-16].

Race/ethnicity: Findings from studies that have examined the effect of racial differences on risk of UAI among MSM were also found inconsistent. A cross-sectional study carried-out in 2008 in New York City showed that black young MSM were more likely to report receptive UAI than white young MSM during their most recent sexual encounter [20]. On the other hand, analysis of prospective sexual diary study of MSM by Newcomb et al. (2012) showed that black MSM were less likely to report UAI as compared to other racial groups (OR= 0.32, $P < 0.01$) [18].

A cross sectional study of young MSM at risk of HIV infection in Baltimore, MD found that young Hispanic men (AOR = 1.0; 95% CI: 0.4 –2.4) and non-Hispanic black men (AOR = 0.7; 95% CI: 0.5 –1.1) were as likely as non-Hispanic white men to engage in UAI with their male sex partners [17]. A meta-analysis of 53 quantitative studies of MSM published from 1980 through 2006 by Millett et al. (2006) found no significant difference in reported UAI between black and white MSM (OR = 1.1; 95% CI: 0.7 –1.5) [21]. Another meta-analysis by Millett et al. (2012) examined and compared behavioral risk factors explaining the high rate of HIV infection among black MSM in Canada, UK, and the USA. The analysis indicated that race was not significantly associated with UAI, and black MSM were as likely as white MSM to report UAI with male partner in all of the three countries [22].

Income: The available literature indicated that the association of income with reporting UAI among MSM was not uniform. Study by Arnold et al. (2013) in Soweto, South Africa showed that income was a significant predictor of UAI. According to this study, gay men with low income levels had an estimated 39% decrease in the per partner rate of UAI as compared to those with high income levels (adjusted IRR = 0.61, 95% CI: 0.40 - 0.93) [14]. In contrast, population based surveys of MSM in 2003 and 2006 in Seattle, Washington indicated that HIV negative MSM who made USD 30,000 or greater per year were less likely to engage in UAI as compared to those who made less than USD 30,000 (adjusted OR=0.3, 95% CI: 0.1 - 0.6) [9].

Sexual orientation

Some studies have examined the association between self-identified sexual identity with reporting UAI among MSM. Most of these studies reported lack of significant association between sexual identity and UAI among MSM [8, 23]. For instance, analysis of data from a cohort study of young MSM in New York City between 2009 and 2011 failed to indicate a significant association between sexual identity and UAI among young MSM. However, analysis of data from 10 Brazilian cities in 2008 and 2009 showed that MSM who identify themselves as exclusively homosexual were approximately two times more likely to report UAI as compared to those who identify themselves as heterosexual [12].

Type of sexual relationship

Sexual relationship is considered as one of the key predictors of UAI among MSM that has been examined in many studies. Studies have consistently shown that UAI was greater among MSM who had a main male sex partner, as compared to those who have casual male sex partners [11, 14, 15, 24, 25]. According to the national HIV behavioral surveillance data of approximately 8,175 MSM from 21 U.S. Cities at the end of 2008, 54% reported having UAI with a male partner within 12 months prior to the assessment. Of the 8,175 MSM, 37% of MSM reported UAI with a main partner, and 25% reported UAI with a casual partner within 12 months prior to the assessment [25].

Moreover, a longitudinal study by Mustanski et al. (2011) found that the rate of UAI among MSM who had a main male sex partner was eight times that of MSM

who have had casual partner [24]. Furthermore, the cross sectional study conducted in 10 Brazilian cities showed that the odds of UAI was about more than two times greater for men who had main male sex partner as compared to men who had casual male sex partners [12].

Number of male sex partners

Epidemiologic researches have uniformly reported that MSM with multiple male sex partners were more likely to engage in UAI. For instance, a cross sectional survey conducted in 2010 in Norway found that the likelihood of UAI was higher among MSM who had a large number of casual sex partners (adjusted OR=1.20, 95% CI: 1.12 – 1.28) [11]. Moreover, a longitudinal study conducted in Sydney in 1997 has shown that MSM who had more than 10 casual male sex partners were more than three times more likely to report repeated UAI than those MSM who have had less than or equal to 10 casual partners (adjusted OR = 3.63, 95% CI: 1.09 - 12.06) [26]. Furthermore, a study carried-out in Catalonia, Spain in 2006 found that MSM who had more than 20 male sex partners in 12 months prior to the survey were 1.56 times more likely to engage in UAI as compared to those who had 1 to 10 male sex partners (adjusted OR=1.56, 95% CI: 1.03 - 2.38) [16].

Venue where MSM meet their sex partners

Findings from available literature on the relationship between venue of meeting male sex partners and risk of UAI among MSM were also found inconsistent. Some studies have indicated that meeting male sex partners via Internet increases the likelihood of engaging in UAI among MSM [27, 28]. A meta-

analysis by Liau et al. (2006) revealed that gay men who sought sex partner on Internet were more likely to engage in UAI with their sex partners as compared to those men who didn't use Internet (OR= 1.68, 95% CI: 1.18 – 2.40) [29]. According to the Catalonian survey in 2006, MSM who met their casual male sex partners online were 1.45 times more likely to report UAI than those who met their male sex partners offline (adjusted OR= 1.45, 95% CI: 1.10 - 2.06) [16].

In the contrary, a retrospective and daily diary analysis of data on internet use and sexual risk behavior by Mustanski et al. (2007) has shown that UAI was less likely to occur among MSM who met their male sex partner online as compared to those who met their male sex partners by other means (adjusted OR=0.40, 95% CI: 0.17 - 0.97) [30]. Other studies have found that venue of meeting a male sex partner had no significant effect on experience of UAI among MSM [9, 19, 24, 31].

Transactional sex

Very few studies have examined the relationship between transactional sex (i.e., sex in exchange of material goods or money) and UAI. A survey conducted in Alamaty, Kazakhstan in 2002 found that MSM who reported transactional sex with a male sex partner during 12 months prior to the interview were about three times more likely to engage in UAI than those who didn't report transactional sex (adjusted OR = 3.21, 95% CI: 1.66 - 6.22) [32]. Similarly, a survey by Ruan et al. (2008) in Jinan, China found that MSM who had sex in exchange of material goods or money were more likely to engage in UAI as compared to MSM who

didn't have exchanged sex [33].

Physical and sexual violence with male partner

Few studies have examined the relationship between experience of physical and/or sexual violence and UAI among MSM. But findings from the available studies showed that experiences of physical and/or sexual violence from a male sex partner were significantly associated with UAI among gay men. For example, a cross-sectional survey among Internet-using MSM by Stephenson et al. (2011) found a significant association between recent UAI and experience and perpetuation of physical violence among MSM [34]. According to this study, MSM who reported perpetuation of physical violence during 12 months prior to the interview were more than six times more likely to report a UAI (adjusted OR = 6.33, 95% CI: 1.19 - 33.66). The same study indicated that MSM who reported recent UAI were more than three times more likely to report experience of physical violence with male sex partner during 12 months prior to the interview (adjusted OR = 3.48, 95% CI: 1.29 - 9.36).

Moreover, the longitudinal data analysis by Mustanski et al. (2011) has shown that the incidence rate of UAI among young MSM who reported physical violence from an intimate male sex partner was nearly two times that of MSM who didn't report physical violence (adjusted IRR=1.88, 95% CI: 1.13 - 3.13) [24]. The same study has shown that the incidence rate of UAI among young MSM who reported sexual violence from intimate male sex partner was more than five times that of MSM who didn't report sexual violence (adjusted IRR=5.46, 95% CI: 1.64 -

18.25). Furthermore, a cross sectional study of MSM in Shanghai, China in 2008 found that MSM who reported experience of either physical or sexual violence from a male sex partner were nearly two times more likely to engage in UAI as compared to those who didn't report neither physical nor sexual violence (adjusted OR = 1.85, 95% CI: 1.03 - 3.32) [33].

History of incarceration

Few studies have examined the association of incarceration and UAI. Two studies of black MSM by Jones et al. (2008) and Bland et al. (2012) demonstrated black MSM were more likely to report UAI if they also reported history of recent incarceration [35, 36]. The study carried out in New York City between 2009 and 2011 found that the odds of reporting arrest were twice as high among men who reported UAI, compared to those who did not report UAI (adjusted OR = 2.01, 95% CI: 1.15 - 3.52) [37]. However, a secondary analysis of data from the first cycle national HIV behavioral surveillance in U.S. from 2003 to 2005 found that history of recent arrest was not significantly associated with UAI during 12 months prior to the interview, but the analysis indicated that history of recent arrest was significantly associated with insertive UAI among MSM [38].

2. OBJECTIVE

The primary objective of this study was to explore key behavioral and structural factors associated with UAI among Internet-using men who have sex with men (MSM) aged 18 year and older, and estimate relative association of each factor by accounting for the natural heterogeneity between subjects.

3. METHODS

3.1. STUDY DESIGN AND PARTICIPATION

A prospective longitudinal online study was conducted among Internet-using MSM in United States between May 2010 and December 2011. Internet-using MSM were targeted and recruited on an-going basis from 18 May 2010 to 31 May 2010 through banner advertisements placed on social networking websites such as Facebook, MySpace, Black Gay Chat, and Adam4Adam.

The methods of the study have been previously reported by Rosenberg, E.S., Khosropour, C.M., & Sullivan, P.S. (2012) [39]. Briefly, men who clicked on a banner advertisement were taken to the study website for registration and screening. Screening criteria for men's entry into the baseline survey were being 18 years of age or older; had anal sexual intercourse with a male partner in the previous 12 months; being non-Hispanic white or non-Hispanic black or Hispanic; agreeing to receive at-home HIV test kit and return the blood sample; and agreeing to complete six follow-up interviews about 2 months apart. Participants meting screening criteria signed an online informed consent form, and completed the first self-administered online questionnaire — a baseline survey.

MSM who completed the baseline survey were mailed the at-home HIV test kits to their indicated mailing address. Moreover, they were advised to carefully

follow the instructions provided in the test kit, mail their blood sample back to Home Access Laboratory, and get their test results. Men found positive for HIV test were excluded from the follow-up study. Participants found HIV negative were recruited for prospective longitudinal study and were invited to self-administered online interviews and at-home HIV testing every 2 months for six consecutive periods.

Data were collected and stored in a separate and secured database on a HIPAA-compliant Survey Gizmo Server in Boulder, Colorado. The research protocol was reviewed and approved by the institutional review board (IRB) of Emory University.

3.2. Measures

Baseline self-administered online interviews provided information on participants' socioeconomic characteristics, sexual and behavioral information at time of interview, during 12 months prior to the interview, and during their lifetime. Socioeconomic data on participants' age, race/ethnicity, educational status, and annual income were collected at baseline interview and were time independent variables. Participants reported their age (in years) and ethnicity/race (Hispanic or Latino, non-Hispanic white, non-Hispanic black, Hispanic, others). They also reported their educational status on a scale ranging from 1 (completed college, post graduate, or professional school) to 6 (Never attended school).

Data on participants' sexual orientation, type and number of sexual relationships, type and number of sexual contacts, and venues for meeting male sex partner were collected at baseline and were time independent variables. Participants reported their sexual orientation (bisexual, homosexual/gay, heterosexual or "straight"); type of sexual relationships with their male partners (exclusively casual, exclusively main, both casual and main); number of male partners for each type of sexual relationship; and number of male sex partners during the 12 months prior to the baseline interview (1, 2, 3-5, >5). Moreover, participants reported whether they have had sex with a male partner in exchange of money or drug or else of value (yes, no, no response), and met male sex partner online during 12 months prior to the baseline interview (yes, no, no response).

At baseline, participants reported whether they had ever tested for HIV (yes, no, no response); had ever arrested (yes, no, no response); had ever experienced sexual violence with male sex partner (yes, no, no response); and had ever experienced physical and sexual violence with male sex partner (yes, no, no response).

Reporting UAI with a male sex partner (yes, no, no response) and HIV test (yes, no, no response) were time-dependent variables and collected at each self-administered follow-up interviews.

Coding and description of each variable is presented in ***Supplemental Table 1***.

3.3. STATISTICAL ANALYSIS

UAI with male sex partner was the outcome of interest. It was a time-dependent binary variable (0=no, 1=yes), and therefore proportions of UAI experiences among MSM in each follow-up time were used to summarize the data, and were presented by a plot with smoothed line (Figure 1). Fourteen time-independent and one time varying variables were considered as potential predictors.

The time independent variables were age; race/ethnicity; school attainment; annual personal income; sexual orientation; type of sexual relationship; number of male sex partners 12 months prior to the baseline interview; had UAI partners 12 months prior to the baseline interview; transactional sex during 12 months prior to the baseline interview; met male sex partner online during 12 months prior to the baseline interview; history of HIV test; history of arrest; experience of sexual and physical violence.

HIV testing since last survey (yes/no) was the only time-varying variable considered as potential predictor. Therefore, the trend of proportions of those who tested for HIV in 2 months was fitted and presented by plots with smoothed line (Figure 2). Proportions were computed and presented as n (%) for all time independent categorical variables.

Logistic regression was used to model proportion of UAI experience with independent variables. Given the repeated nature of the data, a generalized linear

mixed model (GLMM) was used to describe the data. GLMM helped to take the correlation among the outcome observations from the same subject (i.e., within-subject variation) and variations of individuals' data from subject-to-subject (i.e., between-subject variation) into account when analyzing data in order to generate valid inferences from the data. Random intercept effect was explicitly used to model the variation between subjects in GLMM. Therefore, a univariate GLMM logistic regression models with random intercept effect was fitted into GLIMMIX procedure to examine the relationship between each independent predictor (or covariate) and UAI among MSM.

The correlation between successive observations of the outcome variable was examined using Pearson Correlation Coefficients *(**Supplementary Table 2**)*. Based on the values of Pearson Correlation Coefficients, toeplitz-1 band (TOEP(1)) correlation structure appeared to be the appropriate working correlation structure, and used with robust variance estimate technique in GLIMMIX procedure to calculated standard errors and confidence intervals.

These univariate analyses allowed for selection of variables most likely associated with reporting UAI, and this procedure was used to screen variables for multivariate analysis. Variables were selected for multivariate generalized linear mixed model (GLMM) when their statistical significance was <0.05 using the score test.

The full GLMM multivariate logistic regression model included variables that

were selected by univariate GLMM analysis as being significant predictors of the outcome variable, two-way interactions between the predictor variables, and the random intercept.

A collinearity assessment was performed using the COLLINGLIMMIXv9 macro for SAS. Toeplitz-1 band (TOEP(1)) correlation structure with robust variance estimate technique was utilized during the collinearity assessment. However, no multicollinearity problem was detected, because the value of condition indices (CNI) on the first procedure of collinearity assessment was less than 30 (i.e., CNI = 18). Therefore, no variable was dropped during the collinearity assessment. Partial output of the first procedure in collinearity assessment is presented in ***Supplementary Table 3***.

Following the collinearity assessment, the full multivariate generalized linear mixed model (GLMM) was fitted in to GLIMMIX procedure to evaluate fixed effect interactions between each independent variable. A backward elimination algorithm was performed to identify interaction terms that were statistically not significant, and therefore should be dropped from the model. A score test at P -value < 0.05 was used to evaluate the statistical significance of interaction terms. When two or more interaction terms were found insignificant, only the interaction term with the largest P -value was dropped from the model and backward elimination algorithm was performed further on the remaining interaction terms. All interaction terms were dropped from the full model during the interaction assessment because they were found to be insignificant fixed

effects.

The gold standard model contained eight independent variables as fixed factors, and was fitted into GLIMMIX procedure to evaluate the presence of confounding effect and identify potential confounders. A 10% change in the remaining risk ratio estimates and an improvement in precision were used to identify potential confounders and define the best multivariate generalized linear mixed logistic regression model describing factors significantly associated with UAI among MSM. Of the eight independent variables considered in the multivariate generalized linear mixed logistic regression model (i.e., the gold standard model) as fixed factors, five variables were dropped because they were neither significant predictors of UAI among MSM nor confounders.

The final multivariate generalized linear mixed logistic regression model contained three fixed factors as significant predictors of UAI among MSM. These were number of male sex partners during the 12 months prior to the baseline interview, experience of physical violence with the most recent male sex partner, and meeting a male sex partner online during the 12 months prior to the baseline interview. The final GLMM model containing the three fixed factors and random intercept was fitted into GLIMMIX procedure with toeplitz-1 band (TOEP(1)) correlation structures. Robust variance estimation technique was used to calculated standard errors and confidence intervals.

The random intercept was included in the model to examine whether there was

significant natural variation among individuals in the study. The significance of the random intercept was evaluated using the Z-statistics, which is the ratio of the random estimate, θ and standard error, and was statistically significant at p-value less than or equal to 0.05 (θ = 2.8; standard error = 0.24; Z = 11.7; *P*-value < .0001). This suggests that there was a statistically significant natural heterogeneity between the 652 study subjects in engaging in UAI. Hence, the random effect was kept in the final model to account for the effect of the natural heterogeneity between individuals.

All data processing and analysis were performed using SAS 9.3 Version (SAS Institute, Inc., Cary, NC).

4. RESULTS

4.1. DESCRIPTIVE ANALYSIS

Of the 896 MSM who completed the baseline survey and received the at-home HIV test kit, approximately 82% (n=735) returned their blood sample for HIV test at Home Access Laboratory. Of the 737 gay men who provided blood sample for HIV test, 3.4% (n=25) were diagnosed with HIV infection and excluded from the prospective longitudinal study.

652 MSM who enrolled in the prospective cohort and completed at least one follow-up interview were included in this analysis. Of the 652 men, 460 (71%) had completed all the six online follow-up interviews, 555 (85%) had completed five follow-up interviews, and 594 (91%) had completed three follow-up interviews (***Supplementary Table 4***).

Characteristics of study participants at baseline were presented in ***Table 1.*** More than 58% (n=380) of participants were between 18 and 29 years old, and about 6% (n=40) participants were aged 50 years or older. About 67% of participants reported being non-Hispanic white. More than 83% of study participants had more than an associate degree. Less than one-third of study participants reported household annual income of less than $15,000.

88% of participants identified themselves as homosexuals, exclusively. More than

half of participants (56%) had both main and casual male sexual partners during 12 months prior to the baseline interview. Less than 14% of participants had only causal male partners. Most (69%) participants had more than 2 anal sex partners 12 months prior to the baseline interview. About 80% of participants reported they had been tested ever for HIV. A quarter of participants reported that they had been arrested at least once in their lifetime. About 10% and 4% of study participants had experienced physical and sexual violence with their male partners, respectively.

At the baseline, about 18% (n=117) of MSM reported having UAI with male sex partner during 12 months prior to baseline interview. As shown in ***Figure 1***, the proportion of men who reported having UAI with male sex partners since last follow-up interview generally increased over the follow-up period, and reached about 30% at the end of 12 month. About 42% (n=267) participants were tested for HIV during the first follow-up period (i.e., approximately the first 2 months). However, the proportion of men who had tested for HIV was lower (22%) during the second follow-up period but remained constant there after (***Figure 2***).

4.2. Univariate analysis

Table 2 displays the results of the univariate GLMM predicting the risk of UAI among MSM. Of the fifteen potential independent predictors considered in univariate GLMM analysis, eight were significantly associated with UAI among MSM at *P*-value ≤0.05, and were retained for multivariate analysis. These were

type of sexual relationship ($P < 0.0001$); number of anal sex partners 12 months prior to the baseline survey ($P < 0.0001$); experience of UAI with male sex partner 12 months prior to the baseline survey ($P < 0.0001$); had anal sex in exchange for money, drugs, food or else of value ($P = 0.005$); met male sex partner online 12 months prior to the baseline survey ($P < 0.0001$); ever tested for HIV ($P = 0.0006$), experience of physical violence with the most recent male sex partner ($P = 0.0001$); and experience of sexual violence with the most recent male sex partner ($P = 0.0001$).

The univariate GLMM results showed that socio-economic characteristics such as age, race, school attainment, and personal annual income had no significant effects on risk of UAI among MSM; therefore, they were not considered in multivariate GLMM analysis. Similarly, self-identified sexual orientation ($P =0.83$), history of incarceration ever ($P =0.14$), and tested for HIV since last 2 months ($P =0.8$) were not significantly associated with UAI among MSM; and were not considered in multivariate analysis.

4.3. Multivariate analysis

Table 3 shows the results of the multivariate generalized linear mixed model (GLMM) predicting risk of UAI among specific subjects (or individuals). Of the eight independent variables considered in the multivariate generalized linear mixed model, only three were retained in the final model as significant predictors of UAI among MSM. These were number of male sex partners during the 12

months prior to the baseline interview, experience of physical violence with the most recent male sex partner, and meeting a male sex partner online during the 12 months prior to the baseline interview. The remaining five variables were dropped from the final multivariate GLMM because they were neither significant predictors of UAI among MSM nor confounding factors.

Having multiple male sex partners 12 months prior to the baseline interview has the largest effect on risk of UAI among a man who has sex with a man. Having large number of male sex partners significantly increased the risk of UAI among a man who had sex with a man. Specifically, the risk of UAI for a respondent who reported having more than five male sex partners in the past 12 months was more than eight times that of a man who reported a single male sex partner during the same time period (adjusted RR=8.5, P <.0001). A respondent who reported having 3 to 5 male sex partners 12 months prior to the baseline interview had nearly five times risk of UAI as compared to a man with a single male sex partner (adjusted RR=5.1, P <.0001). Similarly, a respondent who reported having two male sex partners 12 months prior to the baseline interview had more than two times risk of UAI as compared to a man with a single male sex partner in the same time period (adjusted RR=2.6, P = 0.0004).

Experiencing of physical violence with the current male sex partner significantly increased the risk of UAI among a man who has sex with a man. As compared to a respondent who had not experienced any physical violence with his current partner, a respondent who had experienced physical violence with his current

male sex partner had a 69% increase in risk of UAI (adjusted RR=1.7, *P* = 0.03).

Similarly, meeting male sex partners online showed a significant effect on risk of UAI among MSM. A man who had met at least one of his male sex partners online 12 months prior to the baseline interview had a 111% increase in risk of engaging in UAI as compared to a man who met his male sex partner by other means (adjusted RR= 2.1, *P* = 0.002).

5. DISCUSSION

To my knowledge, this is the first study to use longitudinal data to explore factors associated with UAI among Internet-using MSM aged 18 years and above in U.S. by accounting the natural heterogeneity between subjects.

This study revealed that the number of male sex partners was the most important predictor of UAI among MSM. The risk of UAI was greatest for a man who had more than five male sex partners during 12 months prior to the baseline interview. This result is consistent with findings of previous research [11, 17]. However, the relative effect size between number of male sex partners and UAI found in this study was different to that in prior cross-sectional studies. Differences in relative effect of number of male sex partners on risk of UAI among MSM between the longitudinal and cross sectional findings are likely due to the greatest statistical power for longitudinal test and the use of different comparison groups in the prior cross-sectional studies. The results of this study reinforce the continued need for traditional prevention programs and initiatives including behavioral change education and communication strategies to reduce number of male sex partners among MSM.

The findings from this study showed that a man who experienced physical violence with the current male sex partner was at higher risk of engaging in UAI as compared to a man who didn't experience physical violence with his current male partner. This result corroborates findings from some studies that have

indicated experience of physical violence with male partner was significantly associated with UAI among MSM [24, 32, 33].

Partner physical violence, the most disturbing form of power imbalance between sexual partners, limits individuals' choices and options to reduce their risk of HIV infection. In heterosexual relationships, researches indicate that physical violence and the threat of violence limit women's ability to consistently negotiate and use the available HIV prevention technologies and services; make decisions on whether, when and how to engage in sexual relations; and to leave unsafe sexual relationships [40-42]. Unequal power relationships in heterosexual partners are rooted in gender norms and roles that are assigned to men and women on the basis of their biological makeup - sex; and further reinforced by the existing socio-economic, political, and legal inequalities between them [40, 43].

However, the nature and dimensions of power imbalances that might exist between men in male relationships and how such imbalances influence their risk and vulnerability to HIV have not been sufficiently studied. Therefore, future HIV research should focus on investigating the nature and dimensions of power imbalances between men in male couples and influence of these power imbalances on how male couples seek out and understands information about HIV, choices and options to reduce their risk, make decisions on how to engage in sex, and access and use of HIV services and treatments.

In this study, meeting at least one male sex partner online last year was another important predictor of UAI among MSM. More than three-quarters of study participants met at least one of their male sex partners online. Although there are conflicting findings in previous studies on the link between meeting male sex partners online and risk of UAI among MSM, result of this study corroborates studies that have indicated MSM who met their male sex partner online were more likely to engage in UAI as compare to men who met partners offline [16, 27-29].

In this longitudinal study, participants who had multiple sex partners were not asked to report on their UAI experience with each male sex partner; therefore, it is not appropriate to conclude that meeting male sex partners using Internet increases the risk of UAI among MSM. To draw a more compelling conclusion, future community based longitudinal studies should gather data on frequency of UAI experience among MSM over time with each online and offline male sex partner, and utilize a more advanced longitudinal data analysis methods.

6. STRENGTHS AND LIMITATIONS

6.1. STRENGTHS

The prospective longitudinal design with relatively long follow-up period and use of generalized linear mixed modeling approache are the strengths because they allowed a reliable estimation of effects of socio-economic, behavioral, and sexual factors on frequency of UAI among MSM. The evaluation of correlation structures suggests that there were statistically significant variations not only in frequencies of UAI at different follow-up periods for specific individuals (i.e. within-individual variation) but also in average frequencies of UAI between individuals (i.e. between-individuals variation). The use of generalized linear mixed modeling allowed to adjust for within-individual and between-individual variation, and therefore to make individual level inferences. The large sample size is also strength because it affords adequate power to detect small differences.

6.2. LIMITATIONS

There were some limitations for this study. First, all men involved in this Internet-based longitudinal HIV behavioral study were HIV seronegative who were not randomly selected into the study, as such, they may be representative of neither Internet-using MSM nor the general MSM aged 18 years or above in the USA. Therefore, results of this study are not generalizable for MSM aged 18 years or above in USA. Second, Internet-using MSM were targeted for participation in the study through banner advertisements placed on social networking sites. Men who were willing to click on banner advertisements and were participated in the

study might differ from men who were not willing to click on banner advertisements and were not participated in the study with respect to some socio-demographic, behavioral, sexual, or other characteristics. This might have introduced a selection bias.

Third, data were collected from study participants via online self-administered questionnaire. Once subjects fill the questionnaire and submit their responses, the data were automatically stored in a separate and secured database. Although there were built-in checks in the system to make certain responses required and check for consistency with earlier responses; checking each and every questionnaire for completeness and accuracy, and making appropriate corrections before the study subjects leave the study Web site was very challenging. This might have introduced a misclassification bias. Finally, study subjects were required to report on their behavioral and sexual characteristics that were entirely based on memories. This might have introduced recall bias.

7. CONCLUSION

The findings from this prospective online cohort study suggest that the risk of UAI among MSM stem not only from the influence of behavioral factors but also from the influence of broader structural factors including the power imbalances between men in male couples.

Having multiple male sex partners remains the strongest risk factor for engaging in UAI over time among MSM. This reinforces the continued need for traditional HIV prevention strategies including behavioral change education and communication interventions to educate and motivate MSM reduce number of male sex partners.

Experience of physical violence with the current partner is another risk factor for UAI among MSM. This highlight the need for addressing the broader structural factors including social, economic, legal/political inequalities underlying or reinforcing power imbalances between men in male couples. Understanding the dimensions and sources of power imbalances in homosexual relationships in context of HIV transmission, treatment, care, and support is necessary to identify structural interventions that are appropriate for MSM.

Meeting at least one male partner on Internet also increases the risk of UAI for a man who has sex with men. However, focused studies are needed to examine the

association between Internet use for meeting male sex partner and UAI among MSM.

Comprehensive HIV prevention packages for MSM should address number of male sex partners and intimate partner physical violence. To this end, HIV prevention strategies should integrate the traditional behavioral change and communication interventions with evidence-based structural interventions. A more focused community based longitudinal studies are needed to accurately examine if meeting male sex partner via Internet increases the risk of UAI among MSM.

8. REFERENCES

1. CDC, *Kaposi's sarcoma and Pneumocystis pneumonia among homosexual men--New York City and California.* MMWR Morb Mortal Wkly Rep, 1981. **30**(25): p. 305-8.
2. CDC, *HIV Surveillance Report, 2011; vol. 23.* http://www.cdc.gov/hiv/topics/surveillance/resources/reports/. *Published in February 2013*
3. Pathela, P., et al., *Men who have sex with men have a 140-fold higher risk for newly diagnosed HIV and syphilis compared with heterosexual men in New York City.* J Acquir Immune Defic Syndr, 2011. **58**(4): p. 408-16.
4. Baggaley, R.F., R.G. White, and M.C. Boily, *HIV transmission risk through anal intercourse: systematic review, meta-analysis and implications for HIV prevention.* Int J Epidemiol, 2010. **39**(4): p. 1048-63.
5. Grulich, A.E. and I. Zablotska, *Commentary: probability of HIV transmission through anal intercourse.* Int J Epidemiol, 2010. **39**(4): p. 1064-5.
6. Goodreau, S.M., et al., *Role versatility among men who have sex with men in urban Peru.* J Sex Res, 2007. **44**(3): p. 233-9.
7. Li, H., et al., *High Multiplicity Infection by HIV-1 in Men Who Have Sex with Men.* PLoS Pathog, 2010. **6**(5): p. e1000890.
8. Hampton, M.C., et al., *Sexual risk taking in relation to sexual identification, age, and education in a diverse sample of African American men who have sex with men (MSM) in New York City.* AIDS Behav, 2013. **17**(3): p. 931-8.

9. Menza, T.W., et al., *Stable sexual risk behavior in a rapidly changing risk environment: findings from population-based surveys of men who have sex with men in Seattle, Washington, 2003-2006.* AIDS Behav, 2011. **15**(2): p. 319-29.

10. Chen, S.Y., et al., *Unprotected anal intercourse between potentially HIV-serodiscordant men who have sex with men, San Francisco.* J Acquir Immune Defic Syndr, 2003. **33(**2): p. 166-70.

11. Berg, R.C., *High rates of unprotected sex and serosorting among men who have sex with men: a national online study in Norway.* Scand J Public Health, 2012. **40**(8): p. 738-45.

12. Rocha, G.M., et al., *Unprotected Receptive Anal Intercourse Among Men Who have Sex with Men in Brazil.* AIDS Behav, 2013. **17**(4): p. 1288-95.

13. Barron-Limon, S., et al., *Correlates of unprotected anal sex among men who have sex with men in Tijuana, Mexico.* BMC Public Health, 2012. **12**: p. 433.

14. Arnold, M.P., et al., *Contextual Correlates of Per Partner Unprotected Anal Intercourse Rates Among MSM in Soweto, South Africa.* AIDS Behav, 2013. **17 Suppl 1**: p. 4-11.

15. Poppen, P.J., et al., *Predictors of unprotected anal intercourse among HIV-positive Latino gay and bisexual men.* AIDS Behav, 2004. **8**(4): p. 379-89.

16. Folch, C., et al., *Sexual risk behaviour and its determinants among men who have sex with men in Catalonia, Spain.* Euro Surveill, 2009. **14**(47).

17. Sifakis, F., et al., *Racial disparities in HIV incidence among young men who have sex with men: the Baltimore Young Men's Survey.* J Acquir Immune Defic Syndr, 2007. **46**(3): p. 343-8.

18. Newcomb, M.E. and B. Mustanski, *Racial Differences in Same-Race Partnering and the Effects of Sexual Partnership Characteristics on HIV Risk in MSM: A Prospective Sexual Diary Study.* J Acquir Immune Defic Syndr, 2012.

19. Chiasson, M.A., et al., *A comparison of on-line and off-line sexual risk in men who have sex with men: an event-based on-line survey.* J Acquir Immune Defic Syndr, 2007. **44**(2): p. 235-43.

20. Halkitis, P.N., et al., *Sexual behaviors of adolescent emerging and young adult men who have sex with men ages 13-29 in New York City.* J Acquir Immune Defic Syndr, 2011. **56**(3): p. 285-91.

21. Millett, G.A., et al., *Explaining disparities in HIV infection among black and white men who have sex with men: a meta-analysis of HIV risk behaviors.* AIDS, 2007. **21**(15): p. 2083-91.

22. Millett, G.A., et al., *Comparisons of disparities and risks of HIV infection in black and other men who have sex with men in Canada, UK, and USA: a meta-analysis.* Lancet, 2012. **380**(9839): p. 341-8.

23. Halkitis, P.N. and R.P. Figueroa, *Sociodemographic characteristics explain differences in unprotected sexual behavior among young HIV-negative gay, bisexual, and other YMSM in New York City.* AIDS Patient Care STDS, 2013. **27**(3): p. 181-90.

24. Mustanski, B., M.E. Newcomb, and E.M. Clerkin, *Relationship characteristics and sexual risk-taking in young men who have sex with men.* Health Psychol, 2011. **30**(5): p. 597-605.

25. Finlayson, T.J., et al., *HIV risk, prevention, and testing behaviors among men who have sex with men--National HIV Behavioral Surveillance System, 21 U.S. cities, United States, 2008.* MMWR Surveill Summ, 2011. **60**(14): p. 1-34.

26. van de Ven, P., et al., *Gay men who engage repeatedly in unprotected anal intercourse with casual partners: the Sydney Men and Sexual Health Study.* Int J STD AIDS, 1998. **9**(6): p. 336-40.

27. Elford, J., et al., *Web-based behavioral surveillance among men who have sex with men: a comparison of online and offline samples in London, UK.* J Acquir Immune Defic Syndr, 2004. **35**(4): p. 421-6.

28. Bolding, G., et al., *Gay men who look for sex on the Internet: is there more HIV/STI risk with online partners?* AIDS, 2005. **19**(9): p. 961-8.

29. Liau, A., G. Millett, and G. Marks, *Meta-analytic examination of online sex-seeking and sexual risk behavior among men who have sex with men.* Sex Transm Dis, 2006. **33**(9): p. 576-84.

30. Mustanski, B.S., *Are sexual partners met online associated with HIV/STI risk behaviours? Retrospective and daily diary data in conflict.* AIDS Care, 2007. **19**(6): p. 822-7.

31. Grov, C., et al., *Exploring the venue's role in risky sexual behavior among gay and bisexual men: an event-level analysis from a national online survey in the U.S.* Arch Sex Behav, 2013. **42**(2): p. 291-302.

32. Berry, M., et al., *Risk factors for HIV and unprotected anal intercourse among men who have sex with men (MSM) in Almaty, Kazakhstan.* PLoS One, 2012. **7**(8): p. e43071.

33. Ruan, S., et al., *HIV prevalence and correlates of unprotected anal intercourse among men who have sex with men, Jinan, China.* AIDS Behav, 2008. **12**(3): p. 469-75.

34. Stephenson, R., A. de Voux, and P.S. Sullivan, *Intimate Partner Violence and Sexual Risk-taking among Men Who Have Sex with Men in South Africa.* West J Emerg Med, 2011. **12**(3): p. 343-7.

35. Bland, S.E., et al., *Sentencing risk: history of incarceration and HIV/STD transmission risk behaviours among Black men who have sex with men in Massachusetts.* Cult Health Sex, 2012. **14**(3): p. 329-45.

36. Jones, K.T., et al., *Nonsupportive peer norms and incarceration as HIV risk correlates for young black men who have sex with men.* AIDS Behav, 2008. **12**(1): p. 41-50.

37. Halkitis, P.N., et al., *Individual, psychosocial, and social correlates of unprotected anal intercourse in a new generation of young men who have sex with men in new york city.* Am J Public Health, 2013. **103**(5): p. 889-95.

38. Lim, J.R., et al., *History of arrest and associated factors among men who have sex with men.* J Urban Health, 2011. **88**(4): p. 677-89.

39. Rosenberg, E.S., C.M. Khosropour, and P.S. Sullivan, *High prevalence of sexual concurrency and concurrent unprotected anal intercourse across racial/ethnic groups among a national, Web-based study of men who have sex with men in the United States.* Sex Transm Dis, 2012. **39**(10): p. 741-6.

40. Gupta, G.R., *How men's power over women fuels the HIV epidemic.* BMJ, 2002. **324**(7331): p. 183-4.

41. Heise, L., M. Ellsberg, and M. Gottmoeller, *A global overview of gender-based violence.* Int J Gynaecol Obstet, 2002. **78 Suppl 1**: p. S5-14.

42. Campbell, C.A., *Male gender roles and sexuality: implications for women's AIDS risk and prevention.* Soc Sci Med, 1995. **41**(2): p. 197-210.

43. Gupta, G.R., *Gender, sexuality, and HIV/AIDS: the what, the why, and the how.* Can HIV AIDS Policy Law Rev, 2000. **5**(4): p. 86-93.

TABLE 1. SOCIO-ECONOMIC, SEXUAL, AND BEHAVIORAL CHARACTERISTICS OF MEN WHO HAVE SEX WITH MEN ENROLLED IN AN ONLINE PROSPECTIVE LONGITUDINAL HIV BEHAVIORAL STUDY (N=652), UNITED STATES, 2011

CHARACTERISTICS	(N = 652)	%
SOCIO-ECONOMIC CHARACTERISTICS		
Age (in years) ✦		
18 - 29	380	59
30 - 39	152	24
40 - 49	74	11
50 or older	40	6
Race / ethnicity ✦		
Hispanic	121	19
Non-Hispanic black	89	14
Non-Hispanic white	436	67
Highest level of school completed ✦		
College, post graduate, or professional school	251	39
Some college, Associate's degree, and/or Technical school	289	45
High school or GED ¶	88	14
Some high school or less than high school	18	3
Gross personal income, last year ✦		
Less than $14,999	195	30
$15,000 to $29,999	137	21
$30,000 to $49,999	123	19
$50,000 to $74,999	90	14
Greater than $75,000	81	13
SEXUAL CHARACTERISTICS		
Sexual orientation ✦		
Homosexual	569	88
Bisexual	77	12
Type of sexual partnership ✦		
Regular, exclusively	88	14
Casual, exclusively	194	30
Both regular and casual partners	360	56
Number of anal sex partners ✦		
in past 12 months		

One	198	31
Two	103	16
3 - 5	187	29
Greater than 5	153	24
Had unprotected anal intercourse ✦ in past 12 months		
No	529	82
Yes	117	18
Compensated‡ for sex ever ✦		
No	596	93
Yes	42	7
Met male sex partner online in past 12 months		
No	140	22
Yes	504	78
OTHER RISK FACTORS		
Ever been tested for HIV		
No	130	20
Yes	514	80
History of arrest in past 12 months ✦		
No	483	75
Yes	161	25
Experience of physical violence from the most recent male sex partner ✦		
No	573	90
Yes	66	10
Experience of sexual violence from the most recent male sex partner ✦		
No	584	96
Yes	25	4

✦ Numbers may not add-up to totals because of missing values, lost to follow-up, and non-response

‡ Compensated sex: had sex with male partner for money, drugs, food, or something else of value

¶ General Education Diploma

TABLE 2. UNIVARIATE GENERALIZED LINEAR MIXED MODEL (GLMM) OF EFFECTS OF SOCIO-ECONOMIC, SEXUAL AND BEHAVIORAL CHARACTERISTICS ON RISK OF UAI* AMONG MEN HAVING SEX WITH MEN WHO ENROLLED IN AN ONLINE PROSPECTIVE LONGITUDINAL HIV BEHAVIORAL STUDY (N= 652), UNITED STATES, 2011

FIXED FACTORS	RR†	95% CI†	*P* †
SOCIO-ECONOMIC CHARACTERISTICS			
Age (in years)			
18 - 29 (ref)	1.0		
30 - 39	1.2	0.9 - 1.7	0.25
40 - 49	1.5	1.0 - 2.2	0.04
50 or older	1.3	0.8 - 2.3	0.29
Race / ethnicity			
Hispanic (ref)	1.0		
Non-Hispanic black	1.0	0.6 - 1.5	0.88
Non-Hispanic white	1.1	0.8- 1.6	0.42
Highest level of education completed			
College, post graduate, or professional school (ref)	1.0		
Some college, Associate's degree, and/or Technical school	0.9	0.7 - 1.3	0.66
High school or GED ¶	1.5	0.8 - 1.7	0.47
Some high school or less than high school	1.1	0.5 - 2.7	0.83
Gross personal income, last year			
0 to $14,999 (ref)	1.0		
$15,000 to $29,999	1.0	0.7 - 1.4	0.80
$30,000 to $49,999	1.2	0.8 - 1.7	0.44
$50,000 to $74,999	1.1	0.7 - 1.6	0.80
Greater than $75,000	0.9	0.6 - 1.4	0.74
SEXUAL CHARACTERISTICS			
Sexual orientation			
Homosexual (ref)	1.0		
Bisexual	1.0	0.7 - 1.4	0.83
Type of sexual relationship §			
Regular, exclusively (ref)	1.0		
Casual, exclusively	3.5	2.0 - 6.1	<.0001

Both regular and casual partners	5.9	3.5 – 10.0	<.0001
Number of anal sex partners in past 12 months [§]			
One (ref)	1.0		
Two	3.1	1.9 - 5.2	<.0001
3 - 5	7.1	4.6 - 10.8	<.0001
Greater than 5	12.4	7.8 - 19.8	<.0001
Had unprotected anal intercourse in past 12 months [§]			
No (ref)	1.0		
Yes	0.3	0.2 - 0.5	<.0001
Compensated[‡] **for sex ever** [§]			
No (ref)	1.0		
Yes	1.9	1.2 - 3.0	0.005
Met male sex partner online in past 12 months [§]			
No (ref)	1.0		
Yes	3.8	2.6 - 5.5	<.0001
OTHER RISK FACTORS			
Ever been tested for HIV [§]			
No (ref)	1.0		
Yes	1.7	1.3 - 2.3	0.0006
Tested for HIV since last interview [§]			
No (ref)	1.0		
Yes	1.0	0.8 - 1.3	0.80
History of arrest ever			
No (ref)	1.0		
Yes	1.3	0.9 – 2.0	0.14
Experience of physical violence from the most recent male sex partner [§]			
No (ref)	1.0		
Yes	2.0	1.4 - 2.8	0.0001
Experience of sexual violence from the most recent male sex partner [§]			
No (ref)	1.0		
Yes	2.2	1.3 - 3.8	0.005

[*] UAI: Unprotected anal intercourse

[†] RR = Crude risk ratio; *P* = P-value for score test statistic; CI=Confidence interval

§ Statistically significant at p-value ≤ 0.05 and selected for the multivariate generalized linear mixed model

‡ Compensated sex: had sex with male partner for money, drugs, food, or something else of value

¶ General Education Diploma

ξ HIV test since last interview (i.e. since last 2 months), is a time dependent variable

TABLE 3. RESULTS OF MULTIVARIATE GENERALIZED LINEAR MIXED MODEL (GLMM) PREDICTING THE RISK OF UAI* AMONG INTERNET-USING GAY INDIVIDUALS ENROLLED IN PROSPECTIVE LONGITUDINAL HIV BEHAVIORAL STUDY (N= 652), UNITED STATES, 2011

FIXED FACTOR	RR†	95% CI†	P†
Number of anal sex partners in past 12 months			
One (ref)	1.00		
Two	2.62	1.53 - 4.48	0.0004
3 - 5	5.07	3.21 - 8.00	<.0001
Greater than 5	8.50	5.13 - 14.07	<.0001
Experience of partner physical violence with current male partner			
No (ref)	1.00		
Yes	1.69	1.04 - 2.73	0.03
Met male sex partner online in past 12 months			
No (ref)	1.00		
Yes	2.11	1.32 - 3.39	0.002

* UAI = Unprotected anal intercourse

† RR= adjusted subject-specific risk ratio; 95% CI = 95% confidence interval of adjusted risk ratio

Figure 1. Percentage of MSM who had unprotected anal intercouse (UAI) during the 12 months of follow-up period, an online prospective longitudinal HIV behavioral study (N=652), United States, 2011.

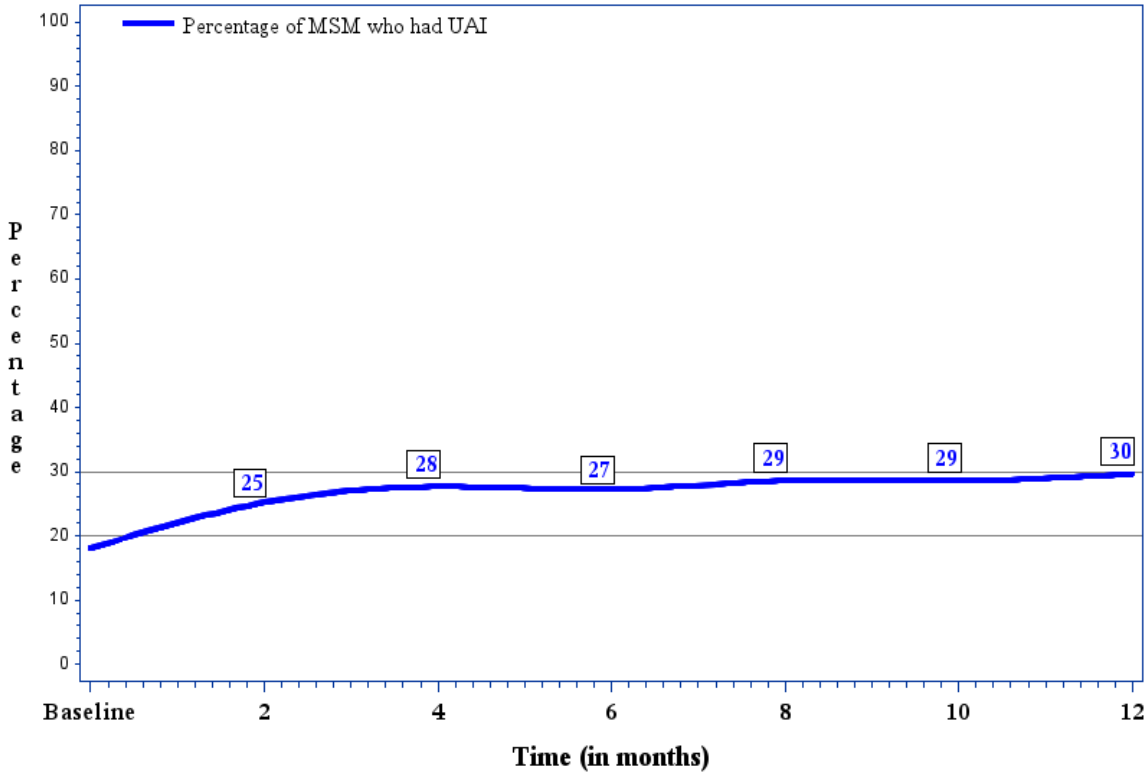
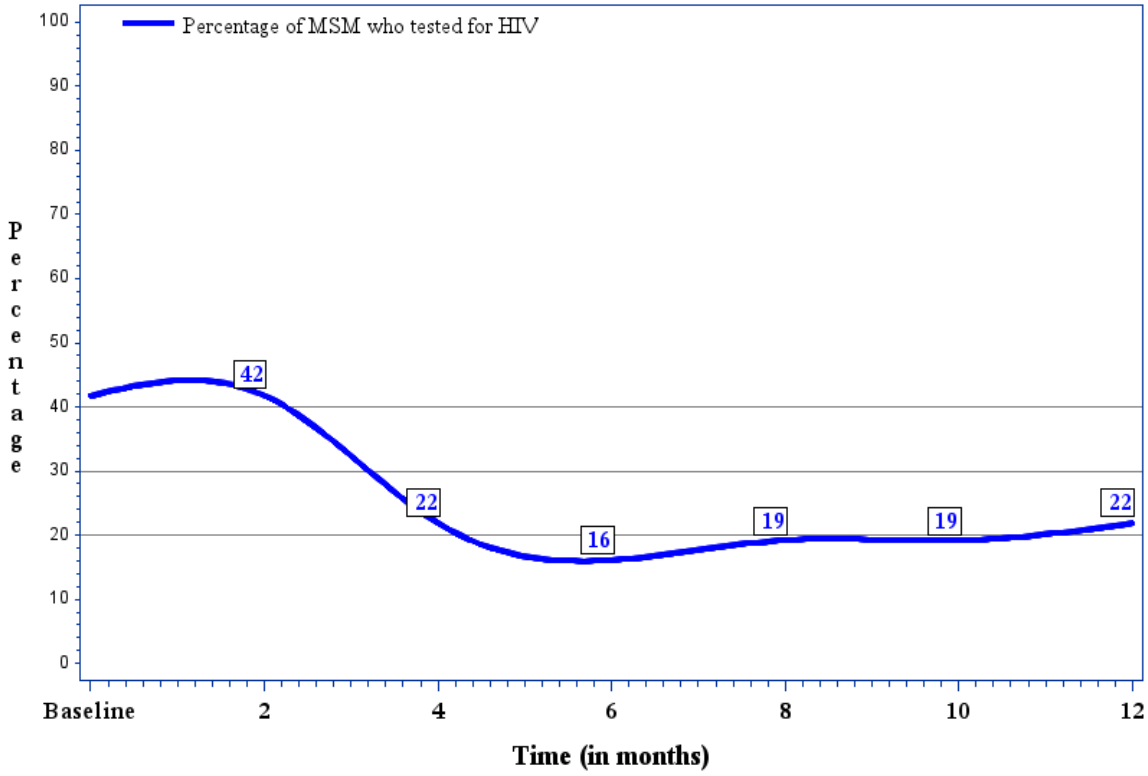


Figure 2. Percentage of MSM who tested for HIV during the 12 months of follow-up period, an online prospective longitudinal HIV behavioral study (N=652), United States, 2011.



SUPPLEMENTARY TABLE 1. CODING AND DESCRIPTION OF VARIABLES

SAS CODE		DESCRIPTION	SCALE
ID		***Subject identification number***	
OUTCOME VARIABLE			
UAIBIN		***Experience of UAI since last survey***	Binary
	0	= No	
	1	= Yes	
POTENTIAL PREDICTORS			
Socio-economic characteristics			
AGEGR		**Age (in years)**	Ordinal
	0	= 18 - 29	
	1	= 30 - 39	
	2	= 40 - 49	
	3	= 50 or older	
RACE		**Race / ethnicity**	Categorical
	0	= Hispanic	
	1	= Non-Hispanic black	
	2	= Non-Hispanic white	
EDUC		**Highest level of school completed**	Ordinal
	0	= College, post graduate, or professional school	
	1	= Some college, Associate's degree, and/or Technical school	
	2	= High school or GED [a]	
	3	= Some high school or less than high school	
INCOME		**Gross household income, last year**	Ordinal
	0	= Less than $15,000	
	1	= $15,000 to $29,999	
	2	= $30,000 to $49,999	
	3	= $50,000 to $74,999	
	4	= Greater than $75,000	
Sexual characteristics			
ORIENT		**Sexual orientation**	Categorical
	0	= Homosexual	
	1	= Bisexual	
PARTNR		**Type of sexual relationship**	Categorical
	0	= Regular, exclusively	

	1 = Casual, exclusively		
	2 = Both regular and casual partners		
ANALNUM		**Number of anal sex partners in past 12 months**	Ordinal
	0 = One		
	1 = Two		
	2 = 3 - 5		
	3 = Greater than 5		
UAI12M		**Had unprotected anal intercourse in past 12 months**	Binary
	0 = No		
	1 = Yes		
EXCHGE		**Compensated[b] for sex ever**	Binary
	0 = No		
	1 = Yes		
ONLINE		**Met male sex partner online in past 12 months**	Binary
	0 = No		
	1 = Yes		
Other risk factors			
TESTEVER		**Ever been tested for HIV**	Binary
	0 = No		
	1 = Yes		
TESTNEW		**Tested for HIV since last survey**	Binary
	0 = No		
	1 = Yes		
ARREST		**History of arrest ever**	Binary
	0 = No		
	1 = Yes		
PHYVIOLE		**Experience of physical violence from the most recent male sex partner**	Binary
	0 = No		
	1 = Yes		
SEXVIOLE		**Experience of sexual violence from the most recent male sex partner**	Binary
	0 = No		
	1 = Yes		

[a] Compensated sex: had sex with male partner for money, drugs, food, or something else of value

[b] General Education Diploma

SUPPLEMENTARY TABLE 2. CORRELATION OF UAI AMONG MSM (YES / NO) ACROSS 6 TIME POINTS AS MEASURED BY PEARSON CORRELATION COEFFICIENTS

	UAIBIN1	UAIBIN2	UAIBIN3	UAIBIN4	UAIBIN5	UAIBIN6
UAIBIN1	1.00000	0.41376	0.37069	0.36910	0.34571	0.35752
UAIBIN2	0.41376	1.00000	0.46129	0.42732	0.36721	0.36188
UAIBIN3	0.37069	0.46129	1.00000	0.47903	0.39157	0.39357
UAIBIN4	0.36910	0.42732	0.47903	1.00000	0.49984	0.37565
UAIBIN5	0.34571	0.36721	0.39157	0.49984	1.00000	0.44805
UAIBIN6	0.35752	0.36188	0.39357	0.37565	0.44805	1.00000

SUPPLEMENTARY TABLE 3. PARTIAL OUTPUT OF THE FIRST PROCEDURE IN COLLINEARITY ASSESSMENT

VARIABLE	VDP1	VDP2	VDP3	VDP4	VDP5	VDP6	VDP7	VDP8	VDP9	VDP10
EIGENVAL	0.0225	0.0350	0.0386	0.0516	0.0597	0.0677	0.09340	0.09469	0.12801	0.19005
CONDINDX	17.525	14.046	13.3776	11.5673	10.7616	10.1006	8.60139	8.54250	7.34715	6.02979
	.	.	.	.	.	.	.	.	.	.
Intercept	0.6151	0.0729	0.1859	0.0061	0.0034	0.0001	0.03424	0.05768	0.00126	0.00000
ANALl2m	0.4429	0.0239	0.3620	0.0039	0.0070	0.0494	0.02810	0.03392	0.01731	0.00755
PARTNRty	0.3530	0.0404	0.0064	0.0016	0.1494	0.0779	0.03262	0.09504	0.01547	0.15234
PARTNRty	0.2072	0.0667	0.1686	0.0136	0.1254	0.1025	0.12475	0.16598	0.00073	0.00017
EVERTEST	0.4800	0.0528	0.0171	0.0128	0.1834	0.0476	0.0000	0.01019	0.02912	0.11898
PHYVIOLENCE	0.1725	0.3527	0.0589	0.0027	0.0120	0.1218	0.06264	0.03283	0.13234	0.00732
VIOLENCE	0.0982	0.3639	0.0560	0.1105	0.0028	0.1195	0.15364	0.03814	0.01538	0.00971
EXCHANGE	0.000	0.0790	0.2070	0.1709	0.2532	0.2210	0.00659	0.01011	0.00024	0.00960
OLSEX	0.0364	0.0110	0.2957	0.0290	0.2982	0.0254	0.09148	0.12925	0.00932	0.01510
ANALl2m*PART	0.1686	0.0055	0.0817	0.0172	0.0048	0.0525	0.00102	0.01697	0.03185	0.03498
ANALl2m*PART	0.0353	0.0179	0.0594	0.0119	0.1698	0.1286	0.19095	0.20923	0.00299	0.01262
ANALl2m*EVER	0.3928	0.0265	0.3427	0.0154	0.0026	0.0154	0.03575	0.02897	0.04433	0.00401
ANALl2m*PHYV	0.0255	0.1195	0.0094	0.3708	0.0382	0.0005	0.03751	0.0008	0.28193	0.02921
ANALl2m*VIOL	0.0179	0.0460	0.0044	0.3775	0.0629	0.0000	0.10370	0.02187	0.09476	0.06853
ANALl2m*EXCH	0.0532	0.0005	0.0143	0.0956	0.0210	0.0723	0.00017	0.00217	0.13585	0.05251
EVERTEST*PAR	0.1781	0.0313	0.0354	0.0064	0.1489	0.1624	0.06394	0.18900	0.00444	0.03748
EVERTEST*PAR	0.1506	0.0569	0.0589	0.0080	0.0026	0.0028	0.02792	0.10251	0.00834	0.10005
PHYVIOLENCE*	0.0767	0.0398	0.0129	0.4015	0.0530	0.0159	0.00001	0.00918	0.16037	0.00120
PHYVIOLENCE*	0.0794	0.0806	0.0383	0.0049	0.0259	0.0261	0.04784	0.00047	0.09737	0.01940
VIOLENCE*PAR	0.0531	0.0411	0.0001	0.4375	0.0546	0.0475	0.00516	0.00372	0.11581	0.00292
EXCHANGE*PAR	0.0202	0.0005	0.0023	0.0470	0.0086	0.0144	0.00535	0.00906	0.00973	0.15683
EVERTEST*PHY	0.0899	0.5173	0.0484	0.0691	0.0009	0.1035	0.09130	0.01610	0.00215	0.00354
EVERTEST*VIO	0.2032	0.5503	0.0472	0.0071	0.0252	0.0143	0.04758	0.03902	0.02845	0.00039
EVERTEST*EXC	0.008	0.0811	0.2388	0.0788	0.2458	0.2018	0.00184	0.00414	0.00055	0.02235
PHYVIOLENCE*	0.0916	0.0104	0.0002	0.5948	0.0697	0.0610	0.00291	0.00111	0.02975	0.00012

SUPPLEMENTARY TABLE 4. FREQUENCY DISTRIBUTION OF TOTAL NUMBER OF FOLLOW-UP INTERVIEWS COMPLETED BY STUDY PARTICIPANTS

Number of follow-up interviews completed	Frequency (n)	Percent (%)
6	460	71
5	555	85
4	573	88
3	594	91
2	617	94
1	652	100
TOTAL	652	100