Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ _____

Noah Mancuso Date

Assessing differential loss to follow-up and future implementation of a sexual health app intervention for men who have sex with men: a secondary survival analysis of a randomized control trial

By

Noah Mancuso

Degree to be awarded: Master of Science in Public Health

Department of Global Epidemiology

_____

Patrick Sullivan, DVM, PhD

Committee Chair

Assessing differential loss to follow-up and future implementation of a sexual health app intervention for men who have sex with men: a secondary survival analysis of a randomized control trial

By

Noah Mancuso

B.A., University of North Carolina at Chapel Hill, 2019

Thesis Committee Chair: Patrick Sullivan, DVM, PhD

An abstract of

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Science in Public Health

in Global Epidemiology

2023

Abstract

Assessing differential loss to follow-up and future implementation of a sexual health app intervention for men who have sex with men: a secondary survival analysis of a randomized control trial

By: Noah Mancuso

Introduction: Over the past ten years, the United States has seen an increase in sexually transmitted infections (STIs) and in HIV diagnoses among men who have sex with men (MSM) aged 25-34 and Hispanic/Latino MSM. mHealth interventions may offer a unique opportunity to provide necessary coverage of multiple primary intervention services, but there are concerns about equitable access. Studying loss to follow-up (LTFU) is important to understand potential selection bias in mHealth studies and to guide future implementation efforts of these interventions.

Methods: This is a secondary analysis of data collected from MSM in the M-Cubed trial in Atlanta, Detroit, and New York City from January 2018 to October 2019. A bias analysis was first conducted to assess potential differential LTFU in trial participants using predictors identified from the literature. An implementation assessment was then conducted among MSM who used the M-Cubed app (e.g., the intervention arm) using the e-commerce acceptance model (EAM). In both analyses, multivariate Cox regression models were used to evaluate associations with LTFU.

Results: In the bias analysis, 1,226 MSM were included with an average survival in the trial of 251 days. LTFU did not significantly differ between the intervention arm (17%, n=102) and the control group (18%, n=111). Three baseline variables were found to significantly modify the effect of randomization on survival: education level, employment status, and 3-month HIV testing history. Time-varying alcohol use also modified the association. A total of 611 MSM were included in the implementation assessment. In the final implementation model, LTFU was significantly associated with internet use, and there was significant interaction by mental health on both the relationship between internet use and LTFU and the relationship between medical mistrust and LTFU.

Discussion: mHealth interventions have the potential to improve sexual health promotion and overcome barriers to the continual engagement needed for STI and HIV prevention. To develop an unbiased understanding of the impact of these mHealth interventions, we need to assess differential LTFU in trials. To improve future uptake of mHealth technologies, researchers should focus on reducing intervention burden, improving trust in healthcare and mobile technology, and concurrently addressing alcohol abuse and mental health.

Assessing differential loss to follow-up and future implementation of a sexual health app intervention for men who have sex with men: a secondary survival analysis of a randomized control trial

By

Noah Mancuso

B.A., University of North Carolina at Chapel Hill, 2019

Thesis Committee Chair: Patrick Sullivan, DVM, PhD

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Science in Public Health

in Global Epidemiology

2023

Acknowledgements

I would like to thank my supervisor, Dr. Patrick Sullivan, who helped make this work possible. His guidance and advice offered throughout my thesis and time at Emory have been invaluable.

Thanks to Nicole Luisi and Dr. Ashley Naimi for their support in understanding how to tackle the large amount of data collected at multiple time points.

I would also like to thank my many friends and peers at Emory, who have encouraged me and provided social support during this process.

Lastly, I would like to thank my partner, Graham Booth, and our beautiful cat, Penelope, for their continued love and support while I completed this research.

Table of Contents

Introduction

In the United States (US), there has been an alarming increase in reported sexual transmitted infections (STIs) – which potentiate HIV infection – over the past ten years, especially among gay, bisexual, and other men who have sex with men (MSM) (1). HIV diagnoses have also increased among individuals aged 25-34 years and among Hispanic/Latino MSM, despite the Ending the HIV Epidemic in the US initiative's goal of reducing HIV diagnoses by 90% by 2030 (2–4). These trends in STI and HIV diagnoses reflect national trends of increased sexual risk behavior and decreased reported condom use among MSM (5–7).

Although a range of STI and HIV prevention methods exist, uptake of these tools has been sub-optimal. National surveys show only about half of MSM test annually for HIV (6) and even fewer test annually for STIs (8), despite CDC recommendation for screening at least every 6 months for STIs (9) and at least every 12 months for HIV – and more frequently for those at increased risk (10). Additionally, there is a large underuse of pre-exposure prophylaxis (PrEP) among MSM, with only about a third of those indicated currently taking PrEP (11). mHealth interventions may offer a unique opportunity to provide the necessary coverage of multiple primary HIV prevention services to MSM, and taking services out of clinical settings might reduce stigma-related barriers to using STI and HIV services (12–16).

mHealth interventions have been increasingly used to try to address STI and HIV needs, but most studies have been small pilots with little focus on participant attrition (15,17–22). There is concern about equitable access and willingness to use these mHealth interventions, which may further exacerbate the current disparities in HIV and STI burden among racial/ethnic minorities,

young MSM, and MSM in the South (2,23–25). Studying attrition in trials of mHealth interventions is important for at least two reasons: first, differential loss to follow-up may induce selection bias in the results of a trial. Second, to the extent that factors associated with vulnerability to HIV are related to attrition of apps outside of trial settings, those at high risk for HIV might be less likely to persist in app use, threatening the health impact of an efficacious app in the implementation phase. Predictors of interest in studying attrition related to app use in a research trial of an mHealth intervention include age, socioeconomic status (SES), race/ethnicity, substance use, mental health, and previous healthcare engagement (26–33). Beyond randomized controlled trials, many challenges persist in the translation of mHealth research into practice as evidenced by the fact that no NIH-funded sexual health apps have become available to the general public yet (34). Impactful implementation of mHealth interventions to promote HIV and STI testing will require a better understanding of uptake and persistence in use among different populations, and continued funding to ensure sustained use given the frequency of testing recommendations for most MSM.

The Mobile Messaging for Men (M-cubed) randomized control trial was an mHealth intervention that showed efficacy in improving engagement with STI and HIV prevention methods among MSM in the US (35,36). In this analysis, we sought to conduct a bias analysis to describe attrition among all MSM, regardless of allocation to the intervention, in the M-cubed study to better understand potential differential loss of certain participant groups over time. We then used an implementation science framework for mobile technology adoption to provide insight into app uptake among MSM allocated to the intervention arm to guide future scale-up of the app. It is important to understand which MSM are more likely to stop engaging with mHealth

technologies, when they disengage, and associated factors to implement more effective STI and HIV prevention programming.

Methods

Study Design

This is a secondary analysis of data collected from MSM enrolled in the M-cubed randomized controlled trial from January 24, 2018 to October 31, 2019 in Atlanta, Detroit, and New York City (35,36). The trial was registered at ClinicalTrials.gov prior to the start of enrollment (NCT0366624). The M-cubed study collected informed consent in person at study enrollment and then randomized eligible MSM 1:1 to either receive an app intervention immediately or to be wait-listed in a control group that received app access after final outcome assessments at nine months post-randomization. The M-cubed app incorporated sexual health messaging into written content and videos (37). It allowed app users to screen for HIV and STI risk, screen for eligibility of PrEP and non-occupational post-exposure prophylaxis (nPEP), schedule reminders for routine testing, and order free commodities like at-home STI and HIV test kits, condoms, and lubricant. Self-reported data on demographics, testing history, risk behaviors, mental health, technology use, medical mistrust, and substance use were collected from all participants at baseline and at three-month intervals for a total of nine months. Data on app use and commodity ordering was collected in-app. Additional methods and primary results from the study have been described previously (35,36).

Outcome of Interest

The outcome of interest in both analyses was loss to follow-up (LTFU), which was defined as leaving the study before the end of the planned nine-month follow-up. This was dichotomized based on completion of the final month-nine survey. Time to LTFU was a composite variable that used the latest date of contact among three data sources: survey completion, app interaction,

or self-test kit ordering. For some participants, the 3-month survey intervals were significantly delayed, resulting in their final month-nine survey being completed after 12 months; these participants were considered as retained in the study as long as they completed the last study survey, regardless of the date of that last contact.

Bias Analysis Measures

Potential predictors of loss to follow-up were identified from the literature and assessed for effect modification of the effect of randomization to the app on LTFU. Substance use and mental health indicators were collected at baseline and at each three-month follow-up survey. Substance use was assessed using both the Alcohol Use Disorders Identification Test (AUDIT) (38) and the Drug Use Dependency Identification Test (DUDIT) (39). Mental health was assessed using the Centers for Epidemiological Studies on Depression 10-item (CESD-10) scale (40). Other factors related to age, SES, race/ethnicity, and prior healthcare engagement were assessed via self-report at baseline only.

Implementation Assessment Measures

The e-commerce acceptance model (EAM) was used to try to understand uptake of the M-cubed app among those who received the app at baseline. The EAM, which has been previously used to study mHealth technology adoption in the HIV field (41), builds off the Technology Acceptance Model by incorporating components of trust and perceived risk into the existing framework of perceived usefulness and perceived ease of use (42,43). We hypothesized that factors related to the EAM would predict LTFU. In this analysis, trust was assessed using both self-reported vaccination history and scores from the Group-Based Medical Mistrust Scale (44). Perceived risk

was assessed from self-reported concern for acquiring or transmitting HIV. Perceived usefulness was assessed based on self-reported scores for the level of protection that HIV/STI testing provides. Perceived ease of use was assessed from a modified technology use scale from the Pew Research Center (45).

Statistical Analysis

All analyses were conducted using RStudio v2022.12.0. The proportional hazards assumption was assessed using graphical methods and the goodness-of-fit test with Schoenfeld residuals for all time-independent variables. Heaviside functions were used for those variables that did not meet the proportional hazards assumption. Multicollinearity was assessed for each model using cut-off criteria of condition indices of 30 with variance decomposition proportions of less than 0.5. If two variables were found to be collinear, the model with the variable most likely to be influenced by the intervention was kept.

For the bias analysis, bivariate Cox regression models were used to assess associations between predictors of interest and the outcome (LTFU). Multivariate Cox regression models were then used to assess for effect modification of the effect of randomization on LTFU using the likelihood ratio test. Hazard ratios (HRs) and 95% confidence intervals (Cis) are presented for models with significant interaction.

For the implementation assessment, bivariate Cox regression models were used between predictors of interest and the outcome in a sample restricted to MSM allocated to the app. Then, each domain of the EAM (trust, perceived risk, perceived usefulness, and perceived ease of use)

was analyzed using multivariable Cox regression with the predictor of interest, potential confounders, and the LTFU outcome. Details of the EAM models are presented in **Figure 1**. Effect modification was assessed using the likelihood ratio test with baseline and time-varying substance use (alcohol and drug) and mental health. Potential confounders were then assessed against the fully adjusted model of each domain and if no meaningful change in the effect estimate was observed (<10%), the potential confounders were removed from the model. Adjusted hazard ratios (aHRs) and 95% CIs for the reduced model of each domain are presented. A final model was then constructed from domains with significant explanatory value of LTFU (*p-values* < 0.10). aHRs and 95% Cis are presented for the final model.

Results

Bias Analysis

A total of 1,226 MSM were included in the bias analysis. The average age was 36 years (sd=12 years) and over half (53%) had a bachelor's degree or higher. About 1 in 3 of the participants were living with HIV (n=388) and the majority of participants were MSM of color (31% Black, non-Hispanic; 16% Hispanic/Latino; 6% Asian and Pacific Islander; 6% Other/Mixed). Mental health at baseline was poor, with roughly 1 in 4 MSM screening positive for depression by the CESD-10 scale. There were no significant differences in baseline characteristics found between the intervention arm and the control group. Additional sample characteristics can be found in **Table 1**.

The average survival time for all participants was 251 days (sd=67 days), and similar proportions of MSM were lost to follow-up in both the intervention arm (17%, n=102) and the control group (18%, n=111) with a HR of 0.91 [95% CI: (0.70, 1.19)] (**Figure 2**). In bivariate analyses, MSM were less likely to be lost to follow-up if they were over the age of 45 years [(HR=0.62, 95% CI: (0.41,0.94)], had an income greater than $75,000 [HR=0.61, 95% CI: (0.38, 0.97)], had a bachelor's degree [HR=0.57, 95% CI: (0.39, 0.85)] or post-graduate degree [HR=0.45, 95% CI: (0.28, 0.70)], or were currently on PrEP/ART [HR=0.75, 95% CI: (0.57, 0.98)]. MSM who reported having 5 or more drinks on a typical day at baseline were more likely to be lost to follow-up [HR=1.53, 95% CI: (1.03, 2.29)]. In time-varying bivariate analyses, reporting four or more sexual partners in the past three months was significantly associated with increased LTFU [HR=1.36, 95% CI: (1.01, 1.86)] and PrEP/ART use remained significantly associated with

decreased LTFU [HR=0.71, 95% CI: (0.57, 0.89)]. Additional details for the baseline and time-varying bivariate analyses can be found in **Table 2**.

Three baseline variables were found to significantly modify the effect of randomization on LTFU with the control group being the reference: education level [Some college or below HR=0.97, 95% CI: (0.68, 1.38); Bachelor's Degree HR=0.63, 95% CI: (0.40, 0.99); Post-graduate Degree HR=0.45, 95% CI: (0.26, 0.79)], employment status [Full-time employment HR=0.82, 95% CI: (0.56, 1.19); Part-time employment HR = 0.78, 95% CI: (0.46, 1.33); Unemployed HR=1.40, 95% CI: (0.92, 2.12)], and 3-month HIV testing history [No HIV test in the past 3 months HR=1.18, 95% CI: (0.83, 1.67); HIV test in the past 3 months HR=0.87, 95% CI: (0.56, 1.33)]. One time-dependent variable was found to significantly modify the effect of randomization on survival: number of alcoholic drinks in a typical day [1 or 2 drinks HR=0.61, 95% CI: (0.41, 0.89); 3 or 4 drinks HR=1.02, 95% CI: (0.70, 1.49); 5 or more drinks HR=1.09, 95% CI: (0.66, 1.81)]. Graphical depictions of these interactions can be seen in **Figure 3** with additional details in **Table 3**.

Implementation Assessment

A total of 611 MSM received the M-cubed app at baseline and were included in the implementation assessment. The average age was 36 years (sd=12 years) and over half (56%) were employed full-time. About 1 in 3 of the participants were living with HIV (n=194) and the majority of participants were MSM of color (32% Black, non-Hispanic; 14% Hispanic/Latino; 5% Asian and Pacific Islander; 6% Other/Mixed). Mental health at baseline was poor, with roughly 1 in 4 MSM screening positive for depression by the CESD-10 scale. More than two-

thirds of MSM reported drinking alcohol more frequently than monthly at baseline, and more than one-third reported using non-prescribed drugs in the past three months at baseline. Additional sample characteristics can be found in **Table 4**.

In bivariate analyses, lower levels of internet use in the past 3 months was the only significant predictor of LTFU. Participants who spent 4 or more hours a day on the internet had a hazard of LTFU 0.71 [95% CI: (0.51, 0.99)] times that of participants who spent less than 4 hours a day on the internet. In multivariable analyses, there was significant interaction by mental health on the effect of medical mistrust and on the effect of internet use in the past 3 months. In the EAM domain of trust, age remained a confounder of medical mistrust, and both age and race/ethnicity remained confounders of vaccination history. In the EAM domain of perceived risk, the number of sexual partners, current ART/PrEP use, and education remained confounders. In the EAM domain of perceived usefulness, education and employment remained confounders. In the EAM domain of perceived ease of use, age was the only confounder that remained. The EAM domains of trust and perceived usefulness were the only domains included in the final model based on the prespecified significance level (*p-values* < 0.10).

In the final model (**Figure 4**), among those who were not depressed, the hazard of LTFU for participants who spent 4 or more hours a day on the internet was 0.43 [95% CI: (0.25, 0.72)] times the hazard for participants who spent less than 4 hours a day on the internet. This was significantly different than the hazard observed among participants who were depressed [aHR=0.72 , 95% CI: (0.39, 1.34)]. The hazard of LTFU among participants with moderate-to-high mistrust compared to participants with low mistrust was significantly higher among those

who were depressed [aHR=0.53, 95% CI: (0.18, 1.54)] compared to those who were not depressed [aHR= 0.31, 95% CI: (0.09, 1.02)]. There were no other significant predictors of LTFU or significant interactions in the final model (**Table 5**).

Discussion

Bias analysis

We conducted a bias analysis to better understand attrition in the M-Cubed trial: if biases in attrition exist overall, it might threaten the validity of the trial results; if biases in attrition exist among those allocated to the intervention, it might indicate the mHealth intervention may not be equally appropriate or beneficial to all MSM in the US. Our results show differential LTFU between the intervention and control group by baseline education level, employment status, and history of healthcare engagement. The results also showed differential LTFU by time-varying alcohol use. Despite controlling for baseline confounding through randomization, these systematic differences in LTFU may have introduced post-randomization confounding and thus biased the final reported results in the M-Cubed trial (46–49). This is concerning given the established relationship between the identified effect modifiers and many of the sexual health and prevention behavior outcomes assessed in M-Cubed (50–55). Further sensitivity analyses will need to be conducted to better understand the possible impact of differential LTFU on the M-Cubed study findings.

Our results showed significantly less LTFU in the intervention arm compared to the control arm for those with higher educational attainment. Education level has been commonly found to predict participant attrition in clinical trials using mHealth-based interventions, with higher education associated with better retention (30,33,56). Among MSM, higher education is associated with increased sexual health testing and knowledge and decreased HIV prevalence (50,51,53), which could bias the trial outcomes related to these measures. This is especially

important to consider given that the M-Cubed sample was more highly educated than the general MSM population in the US.

Our findings showed that employment status significantly modified the association between randomization and LTFU, with participants who were unemployed 40% more likely to be lost to follow-up in the intervention than in the control arm compared to participants who were full- or part-time employed being less likely to be lost to follow-up in the intervention than in the control arm. This is consistent with findings from other mHealth and HIV-related studies, which have found employment status to be significantly associated with LTFU (29,30,57). Employment status has been found to be strongly correlated with HIV risk, especially among racial and ethnic minority MSM, with people reporting an unemployment status also reporting higher levels of risk for HIV acquisition (52,55,58,59). Trial burden is an often-cited reason for drop-out among under- or unemployed trial participants, which may partially explain these results (60,61). Future implementation research with the M-Cubed app should ensure that participant burden is low to improve uptake and reduce potential biases due to differential LFTU.

We found that previous healthcare engagement, as assessed by self-reported HIV testing history, modified the effect of randomization on LTFU. Participants who had tested in the past three months were 13% less likely to be lost to follow-up in the intervention arm than in the control arm compared to participants who had not tested in the past three months, who were 18% more likely to be lost to follow-up in the intervention arm than in the control arm. These results could be expected from participants who had recently tested, because their history of healthcare engagement might make them more inclined to stay involved in a health study. Among those

without a history of healthcare engagement, it is possible that the control group was more likely to remain in the study to get the benefits of the app after the initial 9-month waitlist time was up. Participants in the intervention group may have enrolled in the study for these benefits, and after initial free testing early in the study they did not see a benefit in remaining involved. To improve future retention, researchers may want to take proactive initiatives to ensure easy and accessible engagement with participants who do not have a history of healthcare engagement.

Alcohol use was a time-varying covariate collected every three months throughout the trial, and our results show an increase in LTFU in the intervention arm compared to the control arm as reported alcohol use increased. Alcohol use has been found to be associated with participant attrition in several studies, including mHealth interventions (32,56,62). It has also been shown to increase engagement in behaviors that put MSM at risk for HIV and STIs (54,55). Further research on mHealth interventions for MSM that addresses both sexual health risk and alcohol abuse may be beneficial for improved retention in trials.

Despite other studies finding differences in loss to follow-up by age (26–29,31,57), race/ethnicity (32,48,63), and mental health (27,29,57,64), our bias analysis did not find significant interaction by these variables which indicates that randomization was successful in evenly distributing these characteristics between the intervention and control arm.

Implementation Assessment

We conducted an implementation assessment to better understand uptake of the M-Cubed app via LTFU among participants who received access at baseline. We found that two domains of the

EAM, trust and perceived ease of ease, were significant predictors of LTFU. In the domain of trust, moderate-to-high medical mistrust was associated with better retention than low-mistrust. This effect was significantly modified by mental health, in that the association between medical mistrust and LTFU was bigger among those who did not screen positive for depression than among those who did screen positive. In the domain of perceived ease of use, participants who reported 4 or more hours of internet use per day at baseline had better retention than participants reporting less than 4 hours of internet use per day. This effect was also significantly modified by mental health. These results may guide further development of the app for improved engagement and provide insight into potential obstacles to overcome in the translation of this research into practice.

Our findings show that among participants who did not screen positive for depression, those with moderate-to-high medical mistrust were 69% less likely to be LTFU than those with low medical mistrust. This association was significantly different among participants who screened positive for depression: those with moderate-to-high medical mistrust were 47% less likely to be LTFU than those with low medical mistrust. These findings are contrary to the literature, where higher levels of medical mistrust is often associated with less healthcare engagement and lower uptake of prevention behaviors (65–68). Because the app intervention allowed for ordering of commodities and test kits to a participant's home and did not include direct face-to-face engagement with a healthcare professional, it may have been able to overcome barriers related to lack of trust. Studies on the acceptability of HIV and STI self-testing have shown that these self-directed methods can empower participants, reduce concerns about stigma and privacy, and overcome barriers related to mistrust of health institutions (69–72). It will be important to

continue to understand and address the role of medical mistrust in the uptake of mHealth interventions – especially among populations impacted by the legacy of medical racism and homophobia in the US – while exploring new themes of trust related to online security and confidentiality.

We found that for participants who did not screen positive for depression at baseline, those who reported using the internet for 4 or more hours a day were 57% less likely to be LTFU than those who reported using the internet less than 4 hours a day. This is consistent with the literature on facilitators and barriers to mHealth adoption, where increased internet and phone use is associated with improved health literacy and mHealth technology uptake (73,74). To improve future implementation of mHealth strategies for MSM, researchers should prioritize accessibility and usability of interventions for those with low technology use.

In both the domains of trust and perceived ease of use, mental health was a significant effect modifier; LTFU was lower among participants who did not screen positive for depression. Among those who did screen positive for depression, the increase in LTFU is likely due to the higher rate of LTFU among those with depression in the predictor variables. This finding is consistent with literature from HIV clinical trials and other mHealth interventions that found associations between depression and increased trial attrition (27,29,57,64). The relationship between phone and internet use with poor mental health should not be ignored when implementing health interventions that rely on these technologies. A focus on addressing mental health challenges in addition to improving sexual health may improve future uptake and/or impact of the app.

Limitations

This work is subject to several limitations. MSM in the recruited M-Cubed study sample tended to have bother higher education and higher baseline HIV testing rates; this represents some extent of selection bias compared to MSM in the study cities. The study was also conducted only in large US cities. These selection biases limit the external generalizability of our findings because attrition may vary in more rural populations. Second, our outcome of LTFU lacked some precision because it was based on categorical survey completion at three-month intervals; participants may have been LTFU sometime during the interval between surveys. This interval censoring may have impacted the magnitude of our effect estimates. Third, in our implementation assessment, we used participants in the intervention arm as a hypothetical population to which the app would be implemented. However, due to the inability to mask the environment and incentives of participation in the RCT, the experiences of participants in the intervention arm might not mirror the true experiences of app implementation to the public. Specifically, study incentives might lead to an overestimate of persistence of app use, compared to implementation of the app in a future program. Fourth, because the app was not developed using the EAM framework, we used proxies to evaluate each of the four EAM domains. These proxies may not fully capture the effects of trust, perceived risk, perceived usefulness, and perceived ease of use. Lastly, the study was conducted prior to the COVID-19 pandemic. It is possible that acceptability and use of mHealth technology and self-testing may have changed significantly, due to the normalization of virtual healthcare and self-testing practices.

Implications

mHealth interventions have the potential to improve sexual health promotion and overcome barriers to the continual engagement needed for STI and HIV prevention among MSM. To develop an unbiased understanding of the impact of M-Cubed and other mHealth studies, we need to assess differential LTFU and conduct sensitivity analyses based on these findings. To improve uptake of mHealth technologies, researchers should focus on reducing intervention burden, increasing engagement, improving trust in healthcare and mobile technology, and concurrently addressing alcohol/substance abuse and mental health. Implementation science needs to be better incorporated into study design to capitalize on the potential of mHealth to bridge gaps in health access, reduce STI transmission, and get us the last mile in ending new HIV infections.

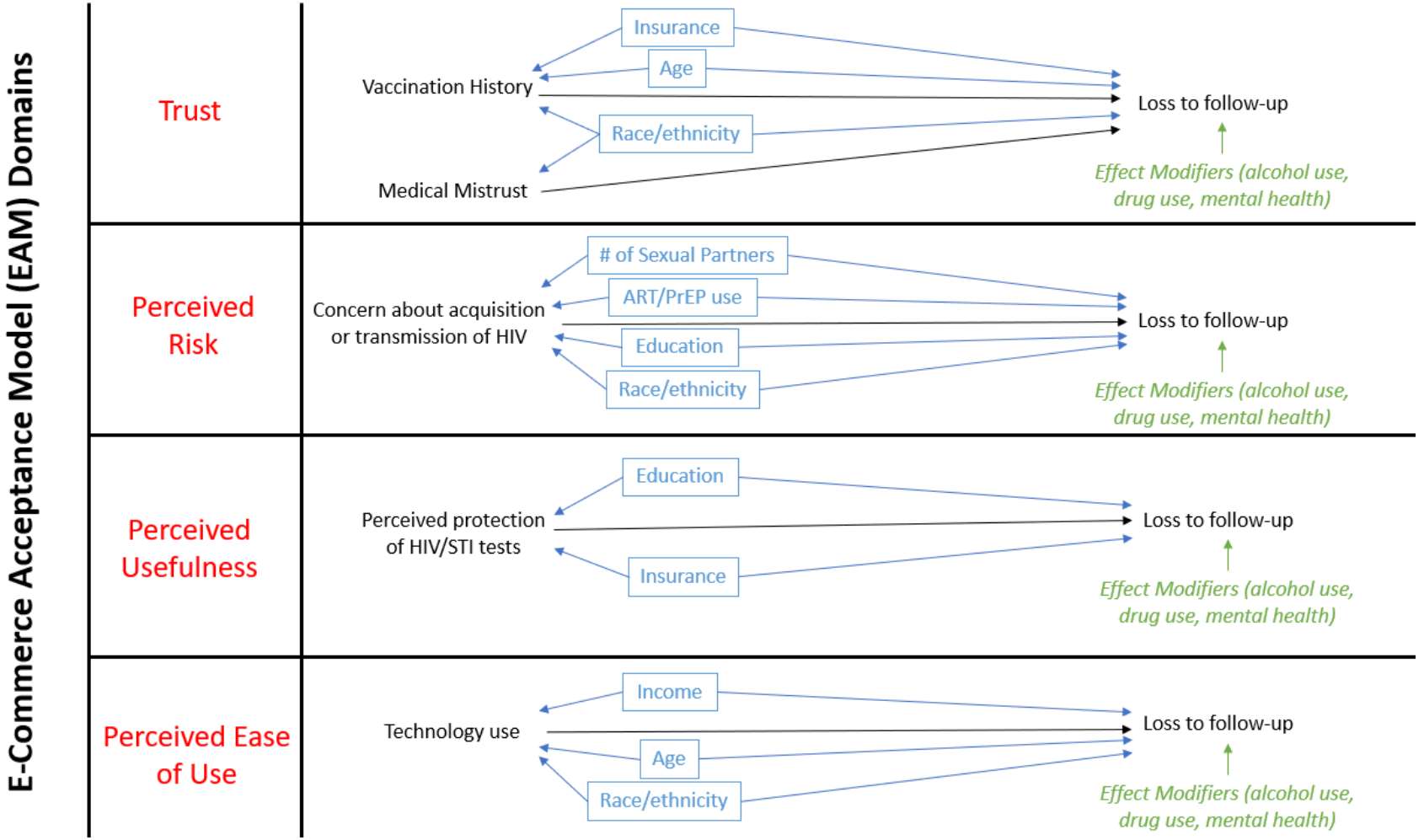

Figure 1. Directed acyclic graphs (DAGs) showing the predictors (black), confounders (blue), and effect modifiers (green) assessed in each domain of the e-commerce acceptance model (EAM) for an analysis of attrition in a study of an mHealth app in Atlanta, Detroit, and New York City, 2018-2019.

Table 1. Baseline characteristics of gay, bisexual, and other men who have sex with men in Atlanta, Detroit, and New York City in the M-cubed study, 2018-2019.

Variable	Total (n=1226) N (col %)	Survived (n=1013) N (row %)	LTFU (n=213) N (row %)
Survival (days)			
Mean (sd)	251 (67.0)	276 (18.8)	134 (86.9)
Randomization			
Control	504 (49.8%)	504 (82.0%)	111 (18.0%)
Intervention	509 (50.2%)	509 (83.3%)	102 (16.7%)
Age at Enrollment (years)			
18-25	235 (19.2%)	184 (78.3%)	51 (21.7%)
26-35	484 (39.5%)	394 (81.4%)	90 (18.6%)
36-45	203 (16.6%)	171 (84.2%)	32 (15.8%)
46+	304 (24.8%)	264 (86.8%)	40 (13.2%)
Race/Ethnicity			
White, non-Hispanic	512 (41.8%)	432 (84.4%)	80 (15.6%)
Black, non-Hispanic	378 (30.8%)	310 (82.0%)	68 (18.0%)
Hispanic/Latino	191 (15.6%)	153 (80.1%)	38 (19.9%)
Asian and Pacific Islander, non-Hispanic	74 (6.0%)	61 (82.4%)	13 (17.6%)
Other†	71 (5.8%)	57 (80.3%)	14 (19.7%)
Income			
$0-$14,999	282 (23.0%)	223 (79.1%)	59 (20.9%)
$15,000-$29,999	250 (20.4%)	210 (84.0%)	40 (16.0%)

$30,000-$49,999	285 (23.2%)	239	(83.9%)	46	(16.1%)
$50,000-$74,999	214 (17.5%)	173	(80.8%)	41	(19.2%)
$75,000 or more	183 (14.9%)	159	(86.9%)	24	(13.1%)
Missing	12 (1.0%)	9	(75.0%)	3	(25.0%)
Education					
High school graduate or GED and below	176 (14.4%)	132	(75.0%)	44	(25.0%)
Some college, Associate, or Technical Degree	393 (32.1%)	315	(80.2%)	78	(19.8%)
Bachelor's/College Degree	377 (30.8%)	320	(84.9%)	57	(15.1%)
Any post-graduate studies	277 (22.6%)	244	(88.1%)	33	(11.9%)
Missing	3 (0.2%)	2	(66.7%)	1	(33.3%)
Site					
Atlanta	478 (39.0%)	393	(82.2%)	85	(17.8%)
Detroit	334 (27.2%)	260	(77.8%)	74	(22.2%)
New York	414 (33.8%)	360	(87.0%)	54	(13.0%)
Employment					
Employed full-time	696 (56.8%)	582	(83.6%)	114	(16.4%)
Employed part-time	233 (19.0%)	193	(82.8%)	40	(17.2%)
Unemployed, unable to work, and other	286 (23.3%)	230	(80.4%)	56	(19.6%)
Missing	11 (0.9%)	8	(72.7%)	3	(27.3%)
Insurance					
No	187 (15.3%)	152	(81.3%)	35	(18.7%)
Yes	1037 (84.6%)	859	(82.8%)	178	(17.2%)
Missing	2 (0.2%)	2	(100.0%)	0	(0.0%)
HIV Status					
Negative	838 (68.4%)	684	(81.6%)	154	(18.4%)

Positive	388 (31.6%)	329	(84.8%)	59	(15.2%)
Hepatitis Vaccination					
No	251 (20.5%)	196	(78.1%)	55	(21.9%)
Yes	794 (64.8%)	667	(84.0%)	127	(16.0%)
Don't Know	179 (14.6%)	148	(82.7%)	31	(17.3%)
Missing	2 (0.2%)	2	(100.0%)	0	(0.0%)
HPV Vaccination					
No	736 (60.0%)	608	(82.6%)	128	(17.4%)
Yes	291 (23.7%)	241	(82.8%)	50	(17.2%)
Don't Know	199 (16.2%)	164	(82.4%)	35	(17.6%)
Group-Based Medical Mistrust Scale					
Low Medical Mistrust	949 (77.4%)	786	(82.8%)	163	(17.2%)
Moderate to High Medical Mistrust	242 (19.7%)	204	(84.3%)	38	(15.7%)
Missing	35 (2.9%)	23	(65.7%)	12	(34.3%)
Concern about HIV transmission/acquisition					
Very concerned	160 (13.1%)	130	(81.3%)	30	(18.8%)
Some concern	180 (14.7%)	149	(82.8%)	31	(17.2%)
Neither	144 (11.7%)	122	(84.7%)	22	(15.3%)
Little concern	409 (33.4%)	339	(82.9%)	70	(17.1%)
No concern at all	328 (26.8%)	269	(82.0%)	59	(18.0%)
Missing	5 (0.4%)	4	(80.0%)	1	(20.0%)
Perceived protection of HIV/STI Testing					
Low (0-50)	275 (22.4%)	226	(82.2%)	49	(17.8%)
Moderate (51-95)	299 (24.4%)	248	(82.9%)	51	(17.1%)

High (96-100)	180 (14.7%)	139	(77.2%)	41	(22.8%)
Missing	472 (38.5%)	400	(84.7%)	72	(15.3%)
Likelihood of using condoms during anal sex in next 3 months					
Definitely not likely	280 (22.8%)	233	(83.2%)	47	(16.8%)
Probably not likely	218 (17.8%)	191	(87.6%)	27	(12.4%)
Somewhat likely	203 (16.6%)	158	(77.8%)	45	(22.2%)
Probably likely	216 (17.6%)	173	(80.1%)	43	(19.9%)
Definitely likely	294 (24.0%)	246	(83.7%)	48	(16.3%)
Doesn’t apply to me	12 (1.0%)	9	(75.0%)	3	(25.0%)
Missing	3 (0.2%)	3	(100.0%)	0	(0.0%)
Likelihood of getting tested for STDs in next 3 months					
Definitely not likely	41 (3.3%)	36	(87.8%)	5	(12.2%)
Probably not likely	104 (8.5%)	94	(90.4%)	10	(9.6%)
Somewhat likely	152 (12.4%)	127	(83.6%)	25	(16.4%)
Probably likely	196 (16.0%)	162	(82.7%)	34	(17.3%)
Definitely likely	712 (58.1%)	577	(81.0%)	135	(19.0%)
Doesn’t apply to me	14 (1.1%)	12	(85.7%)	2	(14.3%)
Missing	7 (0.6%)	5	(71.4%)	2	(28.6%)
Internet use in past 3 months					
Less than 2 hours per day	153 (12.5%)	118	(77.1%)	35	(22.9%)
2-3 hours per day	148 (12.1%)	128	(86.5%)	20	(13.5%)
3-4 hours per day	198 (16.2%)	162	(81.8%)	36	(18.2%)
More than 4 hours per day	713 (58.2%)	596	(83.6%)	117	(16.4%)
Missing	14 (1.1%)	9	(64.3%)	5	(35.7%)
Average time spent on phone					
Less than 2 hours per day	238 (19.4%)	195	(81.9%)	43	(18.1%)

2-3 hours per day	248 (20.2%)	206	(83.1%)	42	(16.9%)
3-4 hours per day	270 (22.0%)	215	(79.6%)	55	(20.4%)
More than 4 hours per day	457 (37.3%)	385	(84.2%)	72	(15.8%)
Missing	13 (1.1%)	12	(92.3%)	1	(7.7%)
Number of sexual partners in past 3 months					
1	312 (25.4%)	267	(85.6%)	45	(14.4%)
2-3	331 (27.0%)	272	(82.2%)	59	(17.8%)
4 or more	506 (41.3%)	415	(82.0%)	91	(18.0%)
Missing	77 (6.3%)	59	(76.6%)	18	(23.4%)
Ever tested for HIV					
No	54 (4.4%)	45	(83.3%)	9	(16.7%)
Yes	1162 (94.8%)	961	(82.7%)	201	(17.3%)
Don’t Know	9 (0.7%)	6	(66.7%)	3	(33.3%)
Missing	1 (0.1%)	1	(100.0%)	0	(0.0%)
Tested for HIV in past 12 months					
No	459 (37.4%)	385	(83.9%)	74	(16.1%)
Yes	767 (62.6%)	628	(81.9%)	139	(18.1%)
Tested for HIV in past 3 months					
No	738 (60.2%)	611	(82.8%)	127	(17.2%)
Yes	488 (39.8%)	402	(82.4%)	86	(17.6%)
Tested for STIs in past 3 months					
No	559 (45.6%)	462	(82.6%)	97	(17.4%)
Yes	665 (54.2%)	549	(82.6%)	116	(17.4%)
Missing	2 (0.2%)	2	(100.0%)	0	(0.0%)
Currently taking PrEP/ART					
No	613 (50.0%)	492	(80.3%)	121	(19.7%)

Yes	613 (50.0%)	521	(85.0%)	92	(15.0%)
Unprotected anal intercourse in the past 3 months					
No	159 (13.0%)	130	(81.8%)	29	(18.2%)
Yes	610 (49.8%)	516	(84.6%)	94	(15.4%)
Don't Know	4 (0.3%)	3	(75.0%)	1	(25.0%)
Missing	453 (36.9%)	364	(80.4%)	89	(19.6%)
HIV status of partner(s)					
All known negative	217 (17.7%)	182	(83.9%)	35	(16.1%)
At least one known positive	275 (22.4%)	227	(82.5%)	48	(17.5%)
At least one unknown and no known positive	134 (10.9%)	110	(82.1%)	24	(17.9%)
Missing	600 (48.9%)	494	(82.3%)	106	(17.7%)
CES-D Mental Health Scale					
Not depressed (<10)	664 (54.2%)	587	(88.4%)	77	(11.6%)
Depressed (>=10)	323 (26.3%)	279	(86.4%)	44	(13.6%)
Missing	239 (19.5%)	147	(61.5%)	92	(38.5%)
Frequency of alcohol consumption					
Never	117 (9.5%)	94	(80.3%)	23	(19.7%)
Monthly or less	258 (21.0%)	211	(81.8%)	47	(18.2%)
2-4 times per month	346 (28.2%)	283	(81.8%)	63	(18.2%)
2-3 times per week	357 (29.1%)	298	(83.5%)	59	(16.5%)
4 or more times per week	145 (11.8%)	125	(86.2%)	20	(13.8%)
Missing	3 (0.2%)	2	(66.7%)	1	(33.3%)
Number of drinks in a typical day of drinking					
1 or 2	506 (41.3%)	428	(84.6%)	78	(15.4%)
3 or 4	446 (36.4%)	370	(83.0%)	76	(17.0%)

5 or more	148 (12.1%)	113	(76.4%)	35	(23.6%)
Missing	126 (10.3%)	102	(81.0%)	24	(19.0%)
Non-prescribed drug use in past 3 months					
No	775 (63.2%)	645	(83.2%)	130	(16.8%)
Yes	451 (36.8%)	368	(81.6%)	83	(18.4%)
Number of drugs used in a typical day of drug use					
1 or 2	461 (37.6%)	379	(82.2%)	82	(17.8%)
3 or more	129 (10.5%)	102	(79.1%)	27	(20.9%)
Missing	636 (51.9%)	532	(83.6%)	104	(16.4%)

† Includes mixed race

Table 2. Baseline and time-dependent hazard ratios (HRs) with 95% confidence intervals (CIs) calculated from bivariate analyses between covariates and LTFU using Cox regression among MSM in a randomized trial of an mHealth intervention in Atlanta, Detroit, and New York City, 2018-2019.

Variable	Baseline HR	95% CI	Time-Dependent HR[§]	95% CI[†]
Randomization				
Control	ref			
Intervention	0.91	(0.70, 1.20)		
Age at Enrollment (years)				
18-25	ref			
26-35	0.88	(0.62, 1.24)		
36-45	0.72	(0.47, 1.13)		
46+	0.62	(0.41, 0.94)		
Race/Ethnicity				
White, non-Hispanic	ref			
Black, non-Hispanic	1.17	(0.85, 1.61)		
Hispanic/Latino	1.25	(0.85, 1.84)		
Asian and Pacific Islander, non-Hispanic	1.11	(0.90, 0.62)		
Other[‡]	1.32	(0.76, 2.33)		
Income				
$0-$14,999	ref			
$15,000-$29,999	0.74	(0.50, 1.11)		
$30,000-$49,999	0.74	(0.50, 1.09)		

$50,000-$74,999	0.9	(0.61, 1.35)		
$75,000 or more	0.61	(0.38, 0.97)		
Education				
High school graduate or GED and below	ref			
Some college, Associate, or Technical Degree	0.78	(0.54, 1.12)		
Bachelor's/College Degree	0.57	(0.39, 0.85)		
Any post-graduate studies	0.45	(0.28, 0.70)		
Site				
Atlanta	ref			
Detroit	1.27	(0.92, 1.73)		
New York	0.72	(0.51, 1.02)		
Employment				
Employed full-time	ref		ref	
Employed part-time	1.08	(0.75, 1.54)	0.99	(0.74, 1.37)
Unemployed, unable to work, and other	1.25	(0.91, 1.72)	1.06	(0.71, 1.25)
Insurance				
No	ref		ref	
Yes	0.91	(0.63, 1.30)	0.87	(0.65, 1.21)
HIV Status				
Negative	ref			
Positive (<150 days)	1.06	(0.70, 1.62)		
Positive (>=150 days)	0.66	(0.43, 1.02)		
Hepatitis Vaccination				
No	ref			
Yes	0.68	(0.50, 0.93)		

HPV Vaccination				
No	ref			
Yes	0.99	(0.71, 1.37)		
Group-Based Medical Mistrust Scale				
Low Medical Mistrust	ref			
Moderate to High Medical Mistrust	0.92	(0.65, 1.31)		
Concern about HIV transmission/acquisition				
Very concerned	ref		ref	
Some concern	0.88	(0.53, 1.46)	1.11	(0.71, 1.73)
Neither	0.82	(0.48, 1.43)	0.94	(0.59, 1.51)
Little concern	0.88	(0.58, 1.40)	1.01	(0.69, 1.47)
No concern at all	0.95	(0.61, 1.47)	1.02	(0.69, 1.52)
Perceived protection of HIV/STI Testing				
Low (0-50)	ref			
Moderate (51-95)	0.96	(0.65, 1.42)		
High (96-100)	1.28	(0.85, 1.94)		
Likelihood of using condoms during anal sex in next 3 months				
Definitely not likely	ref			
Probably not likely	0.73	(0.45, 1.17)		
Somewhat likely	1.39	(0.92, 2.10)		
Probably likely	1.21	(0.80, 1.83)		
Definitely likely	0.98	(0.65, 1.46)		

Likelihood of getting tested for				
STDs in next 3 months				
Definitely not likely	ref			
Probably not likely	0.8	(0.27, 2.34)		
Somewhat likely	1.41	(0.54, 3.69)		
Probably likely	1.52	(0.59, 3.89)		
Definitely likely	1.65	(0.68, 4.01)		
Internet use in past 3 months				
Less than 2 hours per day	ref		ref	
2-3 hours per day	0.55	(0.32, 0.95)	0.94	(0.62, 1.41)
3-4 hours per day	0.75	(0.47, 1.19)	0.79	(0.52, 1.18)
More than 4 hours per day	0.67	(0.46, 0.98)	0.83	(0.61, 1.14)
Average time spent on phone				
Less than 2 hours per day	ref		ref	
2-3 hours per day	0.91	(0.60, 1.40)	1.22	(0.87, 1.71)
3-4 hours per day	1.12	(0.75, 1.68)	1.21	(0.86, 1.71)
More than 4 hours per day	0.84	(0.58, 1.23)	0.88	(0.63, 1.23)
Number of sexual partners in past				
3 months				
1	ref		ref	
2-3	1.27	(0.86, 1.87)	0.91	(0.63, 1.31)
4 or more	1.25	(0.88, 1.79)	1.36	(1.01, 1.86)
Ever tested for HIV				
No	ref			
Yes	1.07	(0.55, 2.08)		
Tested for HIV in past 12 months				
No	ref			
Yes	1.15	(0.87, 1.53)		

Tested for HIV in past 3 months				
No	ref			
Yes	1.04	(0.79, 1.37)		
Tested for STIs in past 3 months				
No	ref			
Yes	1.02	(0.78, 1.33)		
Currently taking PrEP/ART				
No	ref		ref	
Yes	0.75	(0.57, 0.98)	0.71	(0.57, 0.89)
Unprotected anal intercourse in the past 3 months				
No	ref		ref	
Yes	0.82	(0.54, 1.25)	1.12	(0.74, 1.69)
HIV status of partner(s)				
All known negative	ref			
At least one known positive	1.04	(0.70, 1.55)		
At least one unknown and no known positive	1.23	(0.58, 2.60)		
CES-D Mental Health Scale				
Not depressed (<10)	ref		ref	
Depressed (>=10)	1.19	(0.83, 1.73)	0.95	(0.73, 1.23)
Frequency of alcohol consumption				
Never	ref		ref	
Monthly or less	0.91	(0.55, 1.50)	0.99	(0.69, 1.44)
2-4 times per month	0.91	(0.56, 1.47)	0.69	(0.48, 0.99)
2-3 times per week	0.78	(0.48, 1.27)	0.82	(0.57, 1.18)
4 or more times per week	0.67	(0.37, 1.22)	0.59	(0.36, 0.98)

Number of drinks in a typical day of drinking				
1 or 2	ref		ref	
3 or 4	1.09	(0.80, 1.50)	1.15	(0.87, 1.52)
5 or more	1.53	(1.03, 2.29)	1.38	(0.96, 1.97)
Non-prescribed drug use in past 3 months				
No	ref		ref	
Yes	1.09	(0.83, 1.44)	0.9	(0.70, 1.16)
Number of drugs used in a typical day of drug use				
1 or 2	ref		ref	
3 or more	1.21	(0.79, 1.88)	1.14	(0.77, 1.70)

† Wald CI with a test statistic of z=1.96

‡ Includes mixed race

§ Not all data was collected (or relevant) over time, so some variables do not have a time-dependent HR

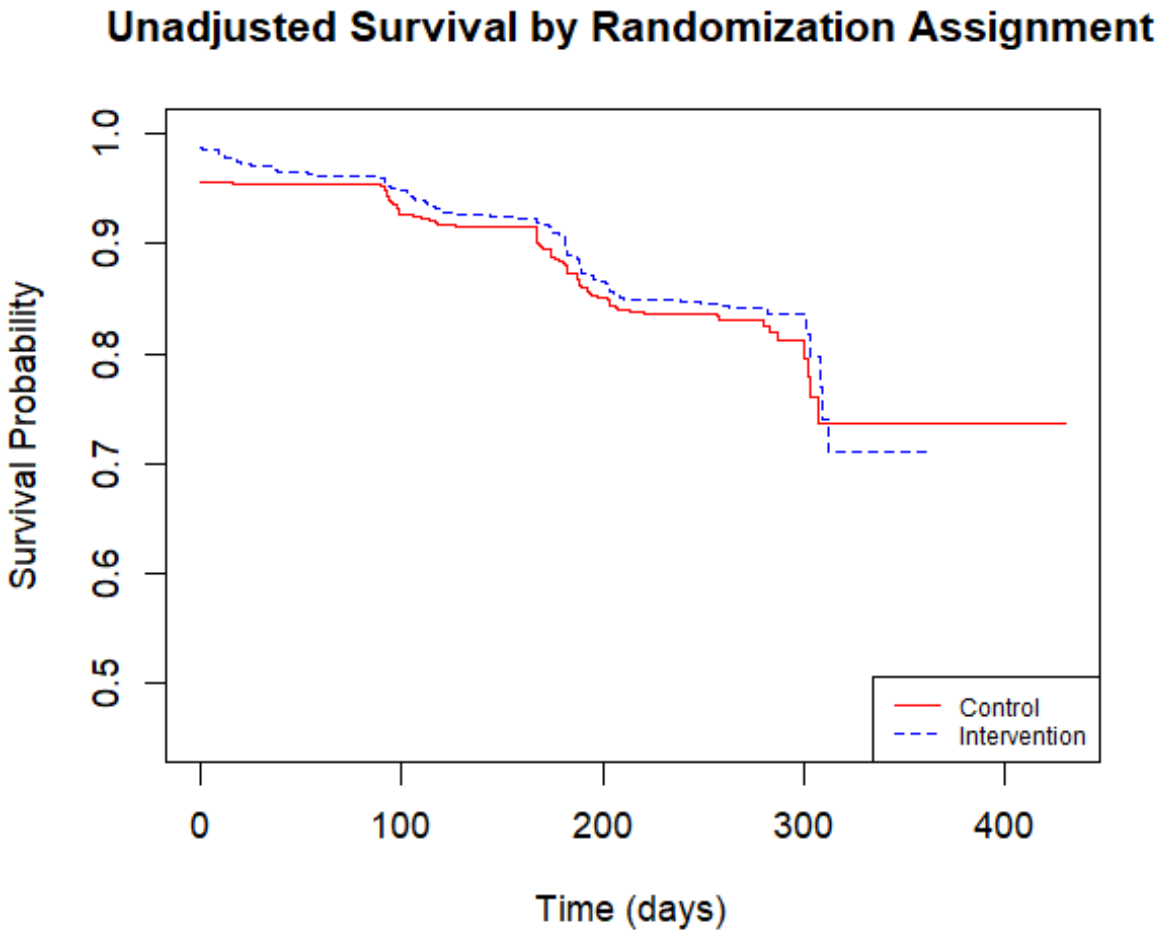

Figure 2. Kaplan-Meier survival curve of the M-cubed trial by randomization assignment of receiving the app at baseline (blue dashed line) or being in the control group (red solid line) in a study of an mHealth app in Atlanta, Detroit, and New York City, 2018-2019. The hazard of being lost to follow-up in the intervention group was 0.91 [95% CI: (0.70, 1.19)] times the hazard of being lost to follow-up in the control group.

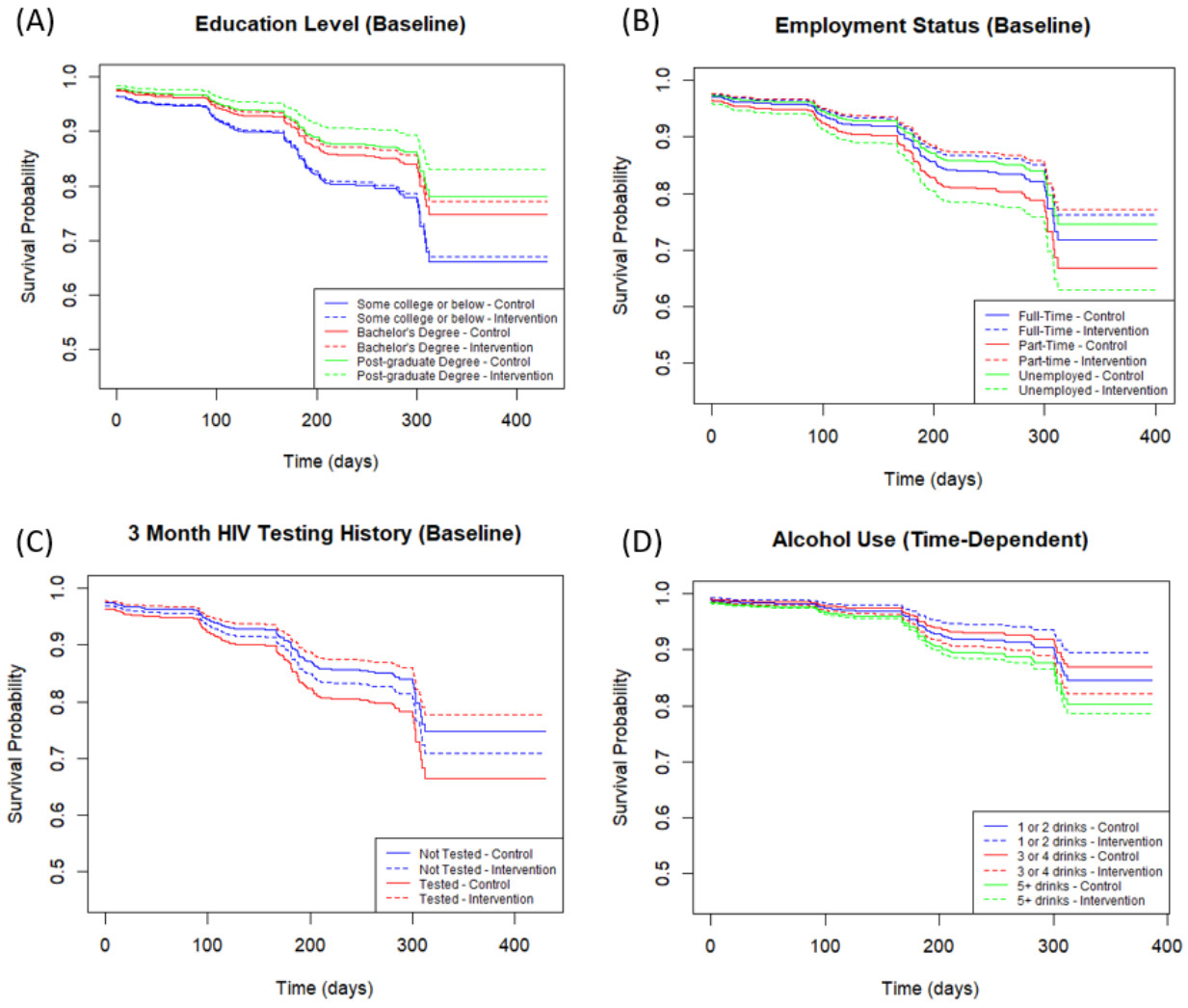

Figure 3. Adjusted survival curves accounting for interaction of the effect of randomization on survival in a study of an mHealth app in Atlanta, Detroit, and New York City, 2018-2019. (A) Effect modification by education level at baseline, showing increasingly higher survival as education level increases and consistently better survival in the intervention arm than the control group. (B) Effect modification by employment status at baseline, showing that participants who were unemployed in the intervention arm had lower survival in the study than participants who were unemployed in the control group. (C) Effect modification by 3-month HIV testing history, showing participants who had not tested in the past 3 months and were assigned to the control

group had higher survival than participants who had not tested in the past 3 months and were assigned to the intervention group. (D) Effect modification by time-varying alcohol use, showing decreasing survival with increasing drinking frequency and that those who typically only had 1-2 drinks in the intervention group had higher survival than those who typically only had 1-2 drinks in the control group.

Table 3. Variables with significant interaction with the effect of randomization on LTFU in a sample of MSM from Atlanta, Detroit, and New York City in the M-Cubed study, 2018-2019.

Effect Modifier		aHR	95% CI[†]
Education (baseline)			
Some college or below	Control	ref	
	Intervention	0.97	(0.68, 1.38)
Bachelor's degree	Control	ref	
	Intervention	0.63	(0.40, 0.99)
Post-grad degree	Control	ref	
	Intervention	0.45	(0.26, 0.79)
Employment (baseline)			
Full-Time	Control	ref	
	Intervention	0.82	(0.56, 1.19)
Part-Time	Control	ref	
	Intervention	0.78	(0.46, 1.33)
Unemployed	Control	ref	
	Intervention	1.40	(0.92, 2.12)
Tested for HIV in past 3 months			
No	Control	ref	
	Intervention	1.18	(0.83, 1.67)
Yes	Control	ref	
	Intervention	0.87	(0.56, 1.33)
Number of drinks in a typical day of drinking (time-dependent)			

1 or 2 drinks	Control	ref	
	Intervention	0.61	(0.41, 0.89)
3 or 4 drinks	Control	ref	
	Intervention	1.02	(0.70, 1.49)
5+ drinks	Control	ref	
	Intervention	1.09	(0.66, 1.81)

† Wald CI with a test statistic of z=1.96

Table 4. Characteristics of gay, bisexual, and other men who have sex with men in Atlanta, Detroit, and New York City who received access to the M-Cubed app at baseline, 2018-2019.

Variable	Total (n=611) N (col %)	Survived (n=509) N (row %)	LTFU (n=102) N (row %)
Survival (days)			
Mean (sd)	253 (63.2)	275 (17.4)	139 (83.9)
Age at Enrollment (years)			
18-25	129 (21.1%)	100 (77.5%)	29 (22.5%)
26-35	232 (38.0%)	193 (83.2%)	39 (16.8%)
36-45	93 (15.2%)	81 (87.1%)	12 (12.9%)
46+	157 (25.7%)	135 (86.0%)	22 (14.0%)
Race/Ethnicity			
White, non-Hispanic	256 (41.9%)	217 (84.8%)	39 (15.2%)
Black, non-Hispanic	198 (32.4%)	162 (81.8%)	36 (18.2%)
Hispanic/Latino	87 (14.2%)	72 (82.8%)	15 (17.2%)
Asian and Pacific Islander, non-Hispanic	33 (5.4%)	27 (81.8%)	6 (18.2%)
Other†	37 (6.1%)	31 (83.8%)	6 (16.2%)
Income			
$0-$14,999	146 (23.9%)	116 (79.5%)	30 (20.5%)
$15,000-$29,999	132 (21.6%)	108 (81.8%)	24 (18.2%)
$30,000-$49,999	126 (20.6%)	108 (85.7%)	18 (14.3%)
$50,000-$74,999	105 (17.2%)	86 (81.9%)	19 (18.1%)

$75,000 or more	100 (16.4%)	89	(89.0%)	11	(11.0%)
Missing	2 (0.3%)	2	(100.0%)	0	(0.0%)
Education					
High school graduate or GED and below	86 (14.1%)	65	(75.6%)	21	(24.4%)
Some college, Associate, or Technical Degree	192 (31.4%)	154	(80.2%)	38	(19.8%)
Bachelor's/College Degree	187 (30.6%)	160	(85.6%)	27	(14.4%)
Any post-graduate studies	145 (23.7%)	130	(89.7%)	15	(10.3%)
Missing	1 (0.2%)	0	(0.0%)	1	(100.0%)
Site					
Atlanta	239 (39.1%)	200	(83.7%)	39	(16.3%)
Detroit	166 (27.2%)	128	(77.1%)	38	(22.9%)
New York	206 (33.7%)	181	(87.9%)	25	(12.1%)
Employment					
Employed full-time	339 (55.5%)	288	(85.0%)	51	(15.0%)
Employed part-time	123 (20.1%)	106	(86.2%)	17	(13.8%)
Unemployed, unable to work, and other	145 (23.7%)	111	(76.6%)	34	(23.4%)
Missing	4 (0.7%)	4	(100.0%)	0	(0.0%)
Insurance					
No	89 (14.6%)	72	(80.9%)	17	(19.1%)
Yes	521 (85.3%)	436	(83.7%)	85	(16.3%)
Missing	1 (0.2%)	1	(100.0%)	0	(0.0%)
HIV Status					
Negative	417 (68.2%)	347	(83.2%)	70	(16.8%)

Positive	194 (31.8%)	162	(83.5%)	32	(16.5%)
Hepatitis Vaccination					
No	122 (20.0%)	92	(75.4%)	30	(24.6%)
Yes	389 (63.7%)	329	(84.6%)	60	(15.4%)
Don't Know	99 (16.2%)	87	(87.9%)	12	(12.1%)
Missing	1 (0.2%)	1	(100.0%)	0	(0.0%)
HPV Vaccination					
No	365 (59.7%)	302	(82.7%)	63	(17.3%)
Yes	153 (25.0%)	125	(81.7%)	28	(18.3%)
Don't Know	93 (15.2%)	82	(88.2%)	11	(11.8%)
Vaccination History					
No vaccination	202 (33.1%)	166	(82.2%)	36	(17.8%)
1 vaccination	274 (44.9%)	230	(83.9%)	44	(16.1%)
2 vaccinations	134 (22.0%)	112	(83.6%)	22	(16.4%)
Group-Based Medical Mistrust Scale					
Low Medical Mistrust	4.03 (3.08)	4.11	(53.4%)	3.58	(46.6%)
Moderate to High Medical Mistrust	4.00 [1.00, 30.0]				
Missing	438 (71.7%)	362	(82.6%)	76	(17.4%)
Concern about HIV transmission/acquisition					
Somewhat or very concerned	237 (38.8%)	198	(83.5%)	39	(16.5%)
Little or no concern	374 (61.2%)	311	(83.2%)	63	(16.8%)
Perceived protection of HIV/STI Testing					
Low (0-50)	139 (22.7%)	117	(84.2%)	22	(15.8%)

Moderate (51-95)	151 (24.7%)	128	(84.8%)	23	(15.2%)
High (96-100)	82 (13.4%)	64	(78.0%)	18	(22.0%)
Missing	239 (39.1%)	200	(83.7%)	39	(16.3%)
Likelihood of using condoms during anal sex in next 3 months					
Definitely not likely	129 (21.1%)	108	(83.7%)	21	(16.3%)
Probably not likely	115 (18.8%)	101	(87.8%)	14	(12.2%)
Somewhat likely	105 (17.2%)	80	(76.2%)	25	(23.8%)
Probably likely	104 (17.0%)	84	(80.8%)	20	(19.2%)
Definitely likely	148 (24.2%)	127	(85.8%)	21	(14.2%)
Doesn't apply to me	9 (1.5%)	8	(88.9%)	1	(11.1%)
Missing	1 (0.2%)	1	(100.0%)	0	(0.0%)
Likelihood of getting tested for STDs in next 3 months					
Definitely not likely	21 (3.4%)	17	(81.0%)	4	(19.0%)
Probably not likely	42 (6.9%)	38	(90.5%)	4	(9.5%)
Somewhat likely	80 (13.1%)	66	(82.5%)	14	(17.5%)
Probably likely	101 (16.5%)	84	(83.2%)	17	(16.8%)
Definitely likely	354 (57.9%)	292	(82.5%)	62	(17.5%)
Doesn't apply to me	7 (1.1%)	7	(100.0%)	0	(0.0%)
Missing	6 (1.0%)	5	(83.3%)	1	(16.7%)
Internet use in past 3 months					
Less than 4 hours a day	249 (41.2%)	200	(80.3%)	49	(19.7%)
4 or more hours a day	355 (58.8%)	305	(85.9%)	50	(14.1%)
Average time spent on phone					
Less than 2 hours per day	117 (19.1%)	97	(82.9%)	20	(17.1%)

2-3 hours per day	130 (21.3%)	110	(84.6%)	20	(15.4%)
3-4 hours per day	132 (21.6%)	107	(81.1%)	25	(18.9%)
More than 4 hours per day	226 (37.0%)	190	(84.1%)	36	(15.9%)
Missing	6 (1.0%)	5	(83.3%)	1	(16.7%)
Number of sexual partners in past 3 months					
1	156 (25.5%)	132	(84.6%)	24	(15.4%)
2-3	159 (26.0%)	134	(84.3%)	25	(15.7%)
4 or more	255 (41.7%)	214	(83.9%)	41	(16.1%)
Missing	41 (6.7%)	29	(70.7%)	12	(29.3%)
Ever tested for HIV					
No	32 (5.2%)	29	(90.6%)	3	(9.4%)
Yes	571 (93.5%)	475	(83.2%)	96	(16.8%)
Don't Know	7 (1.1%)	4	(57.1%)	3	(42.9%)
Missing	1 (0.2%)	1	(100.0%)	0	(0.0%)
Tested for HIV in past 12 months					
No	241 (39.4%)	199	(82.6%)	42	(17.4%)
Yes	370 (60.6%)	310	(83.8%)	60	(16.2%)
Tested for HIV in past 3 months					
No	374 (61.2%)	305	(81.6%)	69	(18.4%)
Yes	237 (38.8%)	204	(86.1%)	33	(13.9%)
Tested for STIs in past 3 months					
No	279 (45.7%)	232	(83.2%)	47	(16.8%)
Yes	331 (54.2%)	276	(83.4%)	55	(16.6%)
Missing	1 (0.2%)	1	(100.0%)	0	(0.0%)

Currently taking PrEP/ART					
No	305 (49.9%)	248	(81.3%)	57	(18.7%)
Yes	306 (50.1%)	261	(85.3%)	45	(14.7%)
Unprotected anal intercourse in the past 3 months					
No	79 (12.9%)	66	(83.5%)	13	(16.5%)
Yes	306 (50.1%)	263	(85.9%)	43	(14.1%)
Don't Know	2 (0.3%)	2	(100.0%)	0	(0.0%)
Missing	224 (36.7%)	178	(79.5%)	46	(20.5%)
HIV status of partner(s)					
All known negative	161 (26.4%)	140	(87.0%)	21	(13.0%)
At least one known positive	135 (22.1%)	113	(83.7%)	22	(16.3%)
At least one unknown and no known positive	16 (2.6%)	11	(68.8%)	5	(31.3%)
Missing	299 (48.9%)	245	(81.9%)	54	(18.1%)
CES-D Mental Health Scale					
Not depressed (<10)	347 (56.8%)	312	(89.9%)	35	(10.1%)
Depressed (>=10)	143 (23.4%)	124	(86.7%)	19	(13.3%)
Missing	121 (19.8%)	73	(60.3%)	48	(39.7%)
Frequency of alcohol consumption					
Never	55 (9.0%)	49	(89.1%)	6	(10.9%)
Monthly or less	133 (21.8%)	108	(81.2%)	25	(18.8%)
2-4 times per month	181 (29.6%)	149	(82.3%)	32	(17.7%)
2-3 times per week	169 (27.7%)	139	(82.2%)	30	(17.8%)
4 or more times per week	72 (11.8%)	64	(88.9%)	8	(11.1%)
Missing	1 (0.2%)	0	(0.0%)	1	(100.0%)

Number of drinks in a typical day of drinking					
1 or 2	271 (44.4%)	226	(83.4%)	45	(16.6%)
3 or 4	218 (35.7%)	186	(85.3%)	32	(14.7%)
5 or more	64 (10.5%)	45	(70.3%)	19	(29.7%)
Missing	58 (9.5%)	52	(89.7%)	6	(10.3%)
Non-prescribed drug use in past 3 months					
No	397 (65.0%)	337	(84.9%)	60	(15.1%)
Yes	214 (35.0%)	172	(80.4%)	42	(19.6%)
Number of drugs used in a typical day of drug use					
1 or 2	223 (36.5%)	181	(81.2%)	42	(18.8%)
3 or more	56 (9.2%)	43	(76.8%)	13	(23.2%)
Missing	332 (54.3%)	285	(85.8%)	47	(14.2%)

† Includes mixed race

Table 5. Results from the implementation assessment of the M-cubed app to explore the predictive factor of variables related to the e-commerce acceptance model (EAM) on LTFU.

Framework Domain	Variable	Bivariate analysis		Reduced multivariable analysis (each domain assessed separately)				Final Model[§]	
		HR	95% CI[†]	Interaction		aHR	95% CI[†]	aHR	95% CI[†]
Trust	**Medical Mistrust**								
	Low Mistrust	ref		Not depressed	Low Mistrust[‡]	ref		ref	
					Moderate-to-High Mistrust[‡]	0.30	(0.09, 0.95)	0.31	(0.09, 1.02)
	Moderate-to-High Mistrust	0.81	(0.52, 1.26)	Depressed	Low Mistrust[‡]	ref		ref	
					Moderate-to-High Mistrust[‡]	0.86	(0.39, 1.88)	0.53	(0.18, 1.54)
	Vaccination History								
	No vaccination	ref			No vaccination[§]	ref		ref	
	1 vaccination	0.92	(0.63, 1.33)		1 vaccination[§]	0.91	(0.63, 1.31)	0.95	(0.60, 1.55)
	2 vaccinations	0.87	(0.55, 1.36)		2 vaccinations[§]	0.69	(0.43, 1.10)	0.82	(0.45, 1.47)
	Concern about HIV transmission/acquisition							Not included	

Perceived Risk	Somewhat or very concerned	ref			Somewhat or very concerned¶	ref			
	Little or no concern	0.82	(0.58, 1.14)		Little or no concern¶	0.78	(0.51, 1.19)		
Perceived Usefulness	**Perceived protection of HIV/STI Testing**							Not included	
	Low protection	ref			Low protection††	ref			
	Moderate protection	0.86	(0.52, 1.40)		Moderate protection††	0.80	(0.48, 1.32)		
	High protection	1.31	(0.78, 2.19)		High protection††	1.03	(0.60, 1.79)		
Perceived Ease of Use	**Internet use in past 3 months**								
	Less than 4 hours a day	ref		Not depressed	Less than 4 hours a day‡	ref		ref	
					4 or more hours a day‡	0.38	(0.23, 0.64)	0.43	(0.25, 0.72)
	4 or more hours a day	0.71	(0.51, 0.99)	Depressed	Less than 4 hours a day‡	ref		ref	
					4 or more hours a day‡	0.65	(0.37, 1.12)	0.72	(0.39, 1.34)

† Wald CI with a test statistic of z=1.96

‡ Adjusted for age

§ Adjusted for age and race/ethnicity

¶ Adjusted for number of sexual partners, current PrEP/ART use, and education

†† Adjusted for education and employment

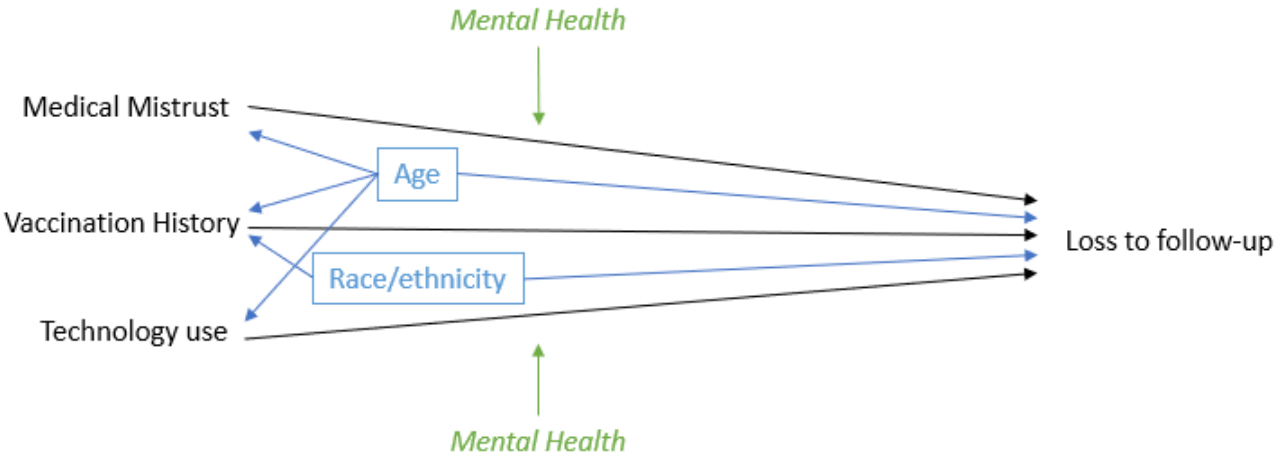

Figure 4. Directed acyclic graph (DAG) showing the final model used in the implementation assessment of the M-Cubed app with predictors (black), confounders (blue), and effect modifiers (green) for the outcome of LTFU.

References

1. Sexually Transmitted Disease Surveillance, 2020 [Internet]. 2022 [cited 2022 Oct 31]. Available from: https://www.cdc.gov/std/statistics/2020/default.htm

2. Sullivan PS, Satcher Johnson A, Pembleton ES, Stephenson R, Justice AC, Althoff KN, et al. Epidemiology of HIV in the USA: epidemic burden, inequities, contexts, and responses. Lancet Lond Engl. 2021 Mar 20;397(10279):1095–106.

3. HIV in the US | HIV Statistics Center | HIV | CDC [Internet]. 2022 [cited 2022 Oct 31]. Available from: https://www.cdc.gov/hiv/statistics/overview/ataglance.html

4. Overview [Internet]. HIV.gov. [cited 2022 Oct 31]. Available from: https://www.hiv.gov/federal-response/ending-the-hiv-epidemic/overview

5. Paz-Bailey G, Mendoza MCB, Finlayson T, Wejnert C, Le B, Rose C, et al. Trends in condom use among MSM in the United States: the role of antiretroviral therapy and seroadaptive strategies. AIDS Lond Engl. 2016 Jul 31;30(12):1985–90.

6. Sanchez TH, Zlotorzynska M, Sineath RC, Kahle E, Tregear S, Sullivan PS. National Trends in Sexual Behavior, Substance Use and HIV Testing Among United States Men Who have Sex with Men Recruited Online, 2013 Through 2017. AIDS Behav. 2018 Aug 1;22(8):2413–25.

7. Zhang Kudon H, Mulatu MS, Song W, Heitgerd J, Rao S. Trends in Condomless Sex Among MSM Who Participated in CDC-Funded HIV Risk-Reduction Interventions in the United States, 2012-2017. J Public Health Manag Pract. 2022 Mar 1;28(2):170–3.

8. de Voux A, Bernstein KT, Kirkcaldy RD, Zlotorzynska M, Sanchez T. Self-Reported Extragenital Chlamydia and Gonorrhea Testing in the Past 12 Months Among Men Who Have Sex with Men in the United States-American Men's Internet Survey, 2017. Sex Transm Dis. 2019 Sep;46(9):563–70.

9. Centers for Disease Control and Prevention. Sexually Transmitted Infections Treatment Guidelines, 2021 [Internet]. 2022 [cited 2023 Mar 7]. Available from: https://www.cdc.gov/std/treatment-guidelines/msm.htm

10. STI Screening Recommendations [Internet]. 2022 [cited 2022 Oct 31]. Available from: https://www.cdc.gov/std/treatment-guidelines/screening-recommendations.htm

11. Weiss KM, Prasad P, Sanchez T, Goodreau SM, Jenness SM. Association between HIV PrEP indications and use in a national sexual network study of US men who have sex with men. J Int AIDS Soc. 2021 Oct;24(10):e25826.

12. Sullivan PS, Jones J, Kishore N, Stephenson R. The Roles of Technology in Primary HIV Prevention for Men Who Have Sex with Men. Curr HIV/AIDS Rep. 2015 Dec 1;12(4):481–8.

13. Mulawa MI, Rosengren AL, Amico KR, Hightow-Weidman LB, Muessig KE. mHealth to reduce HIV-related stigma among youth in the United States: a scoping review. mHealth. 2021;7:35.

14. Sullivan PS, Hightow-Weidman L. Mobile apps for HIV prevention: how do they contribute to our epidemic response for adolescents and young adults? mHealth. 2021 Apr 20;7:36.

15. Nelson KM, Perry NS, Horvath KJ, Smith LR. A systematic review of mHealth interventions for HIV prevention and treatment among gay, bisexual, and other men who have sex with men. Transl Behav Med. 2020 Oct 12;10(5):1211–20.

16. Hsiang E, Offer C, Prescott M, Rodriguez A, Behar E, Matheson T, et al. Bridging the Digital Divide Among Racial and Ethnic Minority Men Who Have Sex With Men to Reduce Substance Use and HIV Risk: Mixed Methods Feasibility Study. JMIR MHealth UHealth. 2020 Apr 29;8(4):e15282.

17. Dworkin MS, Lee S, Chakraborty A, Monahan C, Hightow-Weidman L, Garofalo R, et al. Acceptability, Feasibility, and Preliminary Efficacy of a Theory-Based Relational Embodied Conversational Agent Mobile Phone Intervention to Promote HIV Medication Adherence in Young HIV-Positive African American MSM. AIDS Educ Prev Off Publ Int Soc AIDS Educ. 2019 Feb;31(1):17–37.

18. Bauermeister JA, Tingler RC, Demers M, Connochie D, Gillard G, Shaver J, et al. Acceptability and Preliminary Efficacy of an Online HIV Prevention Intervention for Single Young Men Who Have Sex with Men Seeking Partners Online: The myDEx Project. AIDS Behav. 2019 Nov;23(11):3064–77.

19. Hightow-Weidman L, Muessig K, Knudtson K, Srivatsa M, Lawrence E, LeGrand S, et al. A Gamified Smartphone App to Support Engagement in Care and Medication Adherence for HIV-Positive Young Men Who Have Sex With Men (AllyQuest): Development and Pilot Study. JMIR Public Health Surveill. 2018 Apr 30;4(2):e34.

20. Ybarra ML, Prescott TL, Phillips GL, Bull SS, Parsons JT, Mustanski B. Pilot RCT Results of an mHealth HIV Prevention Program for Sexual Minority Male Adolescents. Pediatrics. 2017 Jul;140(1):e20162999.

21. Mitchell JT, LeGrand S, Hightow-Weidman LB, McKellar MS, Kashuba AD, Cottrell M, et al. Smartphone-Based Contingency Management Intervention to Improve Pre-Exposure Prophylaxis Adherence: Pilot Trial. JMIR MHealth UHealth. 2018 Sep 10;6(9):e10456.

22. Sullivan PS, Driggers R, Stekler JD, Siegler A, Goldenberg T, McDougal SJ, et al. Usability and Acceptability of a Mobile Comprehensive HIV Prevention App for Men Who Have Sex With Men: A Pilot Study. JMIR MHealth UHealth. 2017 Mar 9;5(3):e26.

23. Wood BR, Young JD, Abdel-Massih RC, McCurdy L, Vento TJ, Dhanireddy S, et al. Advancing Digital Health Equity: A Policy Paper of the Infectious Diseases Society of America and the HIV Medicine Association. Clin Infect Dis Off Publ Infect Dis Soc Am. 2021 Mar 15;72(6):913–9.

24. Labisi T, Regan N, Davis P, Fadul N. HIV Care Meets Telehealth: a Review of Successes, Disparities, and Unresolved Challenges. Curr HIV/AIDS Rep. 2022 Oct 1;19(5):446–53.

25. Chiasson MA, Hirshfield S, Rietmeijer C. HIV Prevention and Care in the Digital Age. JAIDS J Acquir Immune Defic Syndr. 2010 Dec 15;55:S94.

26. Ioannidis JP, Bassett R, Hughes MD, Volberding PA, Sacks HS, Lau J. Predictors and impact of patients lost to follow-up in a long-term randomized trial of immediate versus deferred

antiretroviral treatment. J Acquir Immune Defic Syndr Hum Retrovirology Off Publ Int Retrovirology Assoc. 1997 Sep 1;16(1):22–30.

27. Johnson MO, Dilworth SE, Neilands TB, Chesney MA, Rotheram-Borus MJ, Remien RH, et al. Predictors of attrition among high risk HIV-infected participants enrolled in a multi-site prevention trial. AIDS Behav. 2008 Nov;12(6):974–7.

28. Kontos E, Blake KD, Chou WYS, Prestin A. Predictors of eHealth usage: insights on the digital divide from the Health Information National Trends Survey 2012. J Med Internet Res. 2014 Jul 16;16(7):e172.

29. Kim YJ, Peragallo N, DeForge B. Predictors of participation in an HIV risk reduction intervention for socially deprived Latino women: a cross sectional cohort study. Int J Nurs Stud. 2006 Jul;43(5):527–34.

30. Kannisto KA, Korhonen J, Adams CE, Koivunen MH, Vahlberg T, Välimäki MA. Factors Associated With Dropout During Recruitment and Follow-Up Periods of a mHealth-Based Randomized Controlled Trial for Mobile.Net to Encourage Treatment Adherence for People With Serious Mental Health Problems. J Med Internet Res. 2017 Feb 21;19(2):e46.

31. de Bruyn G, Hudgens MG, Sullivan PS, Duerr AC. Participant Retention in Clinical Trials of Candidate HIV Vaccines. JAIDS J Acquir Immune Defic Syndr. 2005 Aug 1;39(4):499–501.

32. Newcomb ME, Swann G, Estabrook R, Corden M, Begale M, Ashbeck A, et al. Patterns and Predictors of Compliance in a Prospective Diary Study of Substance Use and Sexual Behavior in a Sample of Young Men Who Have Sex With Men. Assessment. 2018 Jun;25(4):403–14.

33. Geraghty AWA, Torres LD, Leykin Y, Pérez-Stable EJ, Muñoz RF. Understanding attrition from international Internet health interventions: a step towards global eHealth. Health Promot Int. 2013 Sep;28(3):442–52.

34. Siegler AJ, Knox J, Bauermeister JA, Golinkoff J, Hightow-Weidman L, Scott H. Mobile app development in health research: pitfalls and solutions. mHealth. 2021 Apr 20;7:32.

35. Sullivan PS, Zahn RJ, Wiatrek S, Chandler CJ, Hirshfield S, Stephenson R, et al. HIV Prevention Via Mobile Messaging for Men Who Have Sex With Men (M-Cubed): Protocol for a Randomized Controlled Trial. JMIR Res Protoc. 2019 Nov 15;8(11):e16439.

36. Sullivan PS, Stephenson R, Hirshfield S, Mehta CC, Zahn R, Bauermeister JA, et al. Behavioral Efficacy of a Sexual Health Mobile App for Men Who Have Sex With Men: Randomized Controlled Trial of Mobile Messaging for Men. J Med Internet Res. 2022 Feb 2;24(2):e34574.

37. Downing MJ, Wiatrek SE, Zahn RJ, Mansergh G, Olansky E, Gelaude D, et al. Video selection and assessment for an app-based HIV prevention messaging intervention: formative research. mHealth. 2023;9:2.

38. Babor TF, Higgins-Biddle JC, Saunders JB, Monteiro MG. The Alcohol Use Disorders Identification Test: Guidelines for Use in Primary Care. World Health Organ Dep Ment Health Subst Depend

[Internet]. Available from: https://apps.who.int/iris/bitstream/handle/10665/67205/WHO_MSD_?sequence=1

39. Berman AH, Bergman H, Palmstierna T, Schlyter F. Evaluation of the Drug Use Disorders Identification Test (DUDIT) in criminal justice and detoxification settings and in a Swedish population sample. Eur Addict Res. 2005;11(1):22–31.

40. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). Am J Prev Med. 1994;10(2):77–84.

41. Schnall R, Higgins T, Brown W, Carballo-Dieguez A, Bakken S. Trust, Perceived Risk, Perceived Ease of Use and Perceived Usefulness as Factors Related to mHealth Technology Use. Stud Health Technol Inform. 2015;216:467–71.

42. Schnall R, Bakken S. Testing the Technology Acceptance Model: HIV case managers' intention to use a continuity of care record with context-specific links. Inform Health Soc Care. 2011 Sep;36(3):161–72.

43. Paul A. Pavlou. Consumer Acceptance of Electronic Commerce: Integrating Trust and Risk with the Technology Acceptance Model. Int J Electron Commer. 2003 Apr 1;7(3):101–34.

44. Thompson HS, Valdimarsdottir HB, Winkel G, Jandorf L, Redd W. The Group-Based Medical Mistrust Scale: psychometric properties and association with breast cancer screening. Prev Med. 2004 Feb;38(2):209–18.

45. Lenhart A, Duggan M, Perrin, Andrew, Stepler, Renee, Rainie, Lee, Parker, Kim. Teens, Social Media, and Technology Overview: Smartphones facilitate shifts in communication landscape for teens.

46. Hernán MA, Hernández-Díaz S, Robins JM. A Structural Approach to Selection Bias: Epidemiology. 2004 Sep;15(5):615–25.

47. Manson JE, Shufelt CL, Robins JM. The Potential for Postrandomization Confounding in Randomized Clinical Trials. JAMA. 2016 Jun 7;315(21):2273–4.

48. Siddiqi AEA, Sikorskii A, Given CW, Given B. Early participant attrition from clinical trials: role of trial design and logistics. Clin Trials Lond Engl. 2008;5(4):328–35.

49. Goldberg SB, Bolt DM, Davidson RJ. Data Missing Not at Random in Mobile Health Research: Assessment of the Problem and a Case for Sensitivity Analyses. J Med Internet Res. 2021 Jun 15;23(6):e26749.

50. Oster AM, Wolitski MDR, Miles PDIW, Le SDBC, DiNenno MDEA, Wiegand PDRE, et al. HIV Testing Among Men Who Have Sex With Men -- 21 Cities, United States, 2008. Morb Mortal Wkly Rep. 2011 Jun 3;60(21):694–9.

51. Smith A, Le B, Finlayson T, Oster A, DiNenno E. Prevalence and awareness of HIV infection among men who have sex with men - 21 cities, United States, 2008. Morb Mortal Wkly Rep. 2010;59(37):1201–7.

52. Millett GA, Peterson JL, Flores SA, Hart TA, Jeffries WL, Wilson PA, 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. The Lancet. 2012 Jul 28;380(9839):341–8.

53. Prati G, Zani B, Pietrantoni L, Scudiero D, Perone P, Cosmaro L, et al. PEP and TasP Awareness among Italian MSM, PLWHA, and High-Risk Heterosexuals and Demographic, Behavioral, and Social Correlates. PLOS ONE. 2016 Jun 13;11(6):e0157339.

54. Kahler CW, Wray TB, Pantalone DW, Kruis RD, Mastroleo NR, Monti PM, et al. Daily Associations Between Alcohol Use and Unprotected Anal Sex Among Heavy Drinking HIV-Positive Men Who Have Sex with Men. AIDS Behav. 2015 Mar 1;19(3):422–30.

55. Allen VC, Myers HF, Ray L. The Association Between Alcohol Consumption and Condom Use: Considering Correlates of HIV Risk Among Black Men Who Have Sex with Men. AIDS Behav. 2015 Sep 1;19(9):1689–700.

56. Postel MG, de Haan HA, ter Huurne ED, van der Palen J, Becker ES, de Jong CAJ. Attrition in web-based treatment for problem drinkers. J Med Internet Res. 2011 Dec 27;13(4):e117.

57. Eubanks A, Coulibaly B, Keita BD, Anoma C, Dah TTE, Mensah E, et al. Loss to Follow-Up from HIV Pre-Exposure Prophylaxis Care in Men Who Have Sex with Men in West Africa. Viruses. 2022 Nov;14(11):2380.

58. Aral SO, Adimora AA, Fenton KA. Understanding and responding to disparities in HIV and other sexually transmitted infections in African Americans. The Lancet. 2008 Jul 26;372(9635):337–40.

59. Viner RM, Ozer EM, Denny S, Marmot M, Resnick M, Fatusi A, et al. Adolescence and the social determinants of health. The Lancet. 2012 Apr 28;379(9826):1641–52.

60. Mills E, Wilson K, Rachlis B, Griffith L, Wu P, Guyatt G, et al. Barriers to participation in HIV drug trials: a systematic review. Lancet Infect Dis. 2006 Jan 1;6(1):32–8.

61. Briel M, Speich B, von Elm E, Gloy V. Comparison of randomized controlled trials discontinued or revised for poor recruitment and completed trials with the same research question: a matched qualitative study. Trials. 2019 Dec 30;20(1):800.

62. Neuner B, Fleming M, Born R, Weiss-Gerlach E, Neumann T, Rettig J, et al. Predictors of loss to follow-up in young patients with minor trauma after screening and written intervention for alcohol in an urban emergency department. J Stud Alcohol Drugs. 2007 Jan;68(1):133–40.

63. Van der Mispel C, Poppe L, Crombez G, Verloigne M, De Bourdeaudhuij I. A Self-Regulation-Based eHealth Intervention to Promote a Healthy Lifestyle: Investigating User and Website Characteristics Related to Attrition. J Med Internet Res. 2017 Jul 11;19(7):e241.

64. Gasslander N, Alfonsson S, Jackalin A, Tengberg C, Håkansson J, Huotari L, et al. Predictors of adherence to an internet-based cognitive behavioral therapy program for individuals with chronic pain and comorbid psychological distress. BMC Psychol. 2021 Oct 12;9(1):156.

65. Cahill S, Taylor SW, Elsesser SA, Mena L, Hickson D, Mayer KH. Stigma, medical mistrust, and perceived racism may affect PrEP awareness and uptake in black compared to white gay and bisexual men in Jackson, Mississippi and Boston, Massachusetts. AIDS Care. 2017 Nov 2;29(11):1351–8.

66. Eaton LA, Driffin DD, Kegler C, Smith H, Conway-Washington C, White D, et al. The Role of Stigma and Medical Mistrust in the Routine Health Care Engagement of Black Men Who Have Sex With Men. Am J Public Health. 2015 Feb;105(2):e75–82.

67. Eaton LA, Driffin DD, Smith H, Conway-Washington C, White D, Cherry C, et al. Psychosocial factors related to willingness to use pre-exposure prophylaxis for HIV prevention among Black men who have sex with men attending a community event. Sex Health. 2014 Jul 8;11(3):244–51.

68. García M, Harris AL. PrEP awareness and decision-making for Latino MSM in San Antonio, Texas. PLOS ONE. 2017 Sep 27;12(9):e0184014.

69. Frye V, Nandi V, Paige MQ, McCrossin J, Lucy D, Gwadz M, et al. TRUST: Assessing the Efficacy of an Intervention to Increase HIV Self-Testing Among Young Black Men Who have Sex with Men (MSM) and Transwomen. AIDS Behav. 2021 Apr 1;25(4):1219–35.

70. den Daas C, Geerken MBR, Bal M, de Wit J, Spijker R, Op de Coul ELM. Reducing health disparities: key factors for successful implementation of social network testing with HIV self-tests among men who have sex with men with a non-western migration background in the Netherlands. AIDS Care. 2020 Jan 2;32(1):50–6.

71. Volk JE, Lippman SA, Grinsztejn B, Lama JR, Fernandes NM, Gonzales P, et al. Acceptability and feasibility of HIV self-testing among men who have sex with men in Peru and Brazil. Int J STD AIDS. 2016 Jun 1;27(7):531–6.

72. Figueroa C, Johnson C, Verster A, Baggaley R. Attitudes and Acceptability on HIV Self-testing Among Key Populations: A Literature Review. AIDS Behav. 2015 Nov 1;19(11):1949–65.

73. Potdar R, Thomas A, DiMeglio M, Mohiuddin K, Djibo DA, Laudanski K, et al. Access to internet, smartphone usage, and acceptability of mobile health technology among cancer patients. Support Care Cancer. 2020 Nov 1;28(11):5455–61.

74. Feroz AS, Ali NA, Khoja A, Asad A, Saleem S. Using mobile phones to improve young people sexual and reproductive health in low and middle-income countries: a systematic review to identify barriers, facilitators, and range of mHealth solutions. Reprod Health. 2021 Jan 16;18(1):9.