Does Time Matter? Mhealth Program Enrollment Duration Effects on Healthy Behaviors among Key Populations in Lomé

Introduction

Despite progress in containing the spread of the human immunodeficiency virus (HIV) in sub-Saharan Africa, West Africa still experiences high rates of HIV infection among certain vulnerable subpopulations (1). Togo has a mixed HIV epidemic, with a countrywide HIV prevalence of 2.5% and higher prevalence estimates of 13.0% among men who have sex with men (MSM) and 11.7% among female sex workers (FSW) (2). Improved HIV prevention, treatment and care (PTC) of these key populations (KP) is essential to achieving the 2020 UNAIDS 90/90/90 goal: 90% of HIV positive individuals aware of their status, 90% of those positive being on sustained anti-retroviral therapy (ART), and 90% of those in care being virally suppressed by the year 2020 (3). Accomplishing these goals depends on engaging KP at each step along the PTC cascade.

Various short-messaging system (SMS) and social media campaigns have been implemented in low- and middle-income settings in an effort to connect with individuals living with or at-risk for HIV infection (4). These interventions include using mobile health (mHealth) approaches, short-message service (SMS) or text messaging and online channels such as social media, to link at-risk populations with HIV PTC services (5). In the context of HIV treatment, mHealth programs have demonstrated success in improving health outcomes by promoting medication adherence (6); evidence suggests that mHealth programs can improve viral suppression with SMS reminders to take antiretroviral therapy (ART) and attend scheduled appointments (7). This evidence indicates high feasibility and potential for adoption of mHealth activities in the context of HIV programs (8,9).

The five year USAID-funded PACTE-VIH implemented by FHI360 in West Africa initiated information communication technology (ICT) activities targeting KP, with mHealth and social media approaches employed to achieve a greater reach online network-based forums (5,10). The SMS program served as an alert system to effect behavior change and improve adherence to ART by: reminding people living with HIV to take ARVs as prescribed; reminding KP to systematically use condoms and lubricants anytime they have sexual intercourse; inviting KP to utilize PTC services and seek early treatment for STIs; and reminding KP to check their HIV status every 3 months. The overall goal of the program was to improve HIV outcomes for KP by intervening on both HIV treatment and prevention, as well as to provide data on the effectiveness of these types of behavior change programs.

A systematic review by Gurman et al. highlights the dearth of evaluation research in mHealth, specifically in the context of developing countries (4). Many of these previous mHealth interventions have prioritized HIV treatment, and few have evaluated outcomes relating to prevention behavior, including HIV testing and consistent condom use (10). Furthermore, the mechanisms behind how mHealth programs might work have not been thoroughly explored

(11). Prior HIV mHealth studies have suggested investigating longer-term interventions, since short-term ones may not yield definitive results (12). One mHealth study on alcohol use examined how receiving more SMS reminders over time led to reduced reports of alcohol consumption (13), but to date, there are no studies examining time exposure to HIV-related mHealth messages and related HIV behavioral outcomes.

The data from the PACTE-VIH program provide a unique opportunity to examine various components of an HIV mHealth program and explore which components may lead to desirable behavioral outcomes. In this study, we examined the association between the duration of enrollment in the PACTE-VIH program with the adoption of prevention behavior. Understanding the potential effects of enrollment duration on HIV prevention behavior outcomes can help programs make effective use of their resources and tailor their interventions to be more efficient.

The purpose of this analysis was to assess whether there was a dose-response relationship between duration of time enrolled in an mHealth HIV program and adoption of prevention behavior.

Data Methods

Data Collection

Data for this analysis come from an operations research conducted in Lomé, Togo, in 2016. The aim of the operations research was to assess the role of mHealth in improving HIV knowledge, outreach, and linkage to prevention and care services among KP. PACTE-VIH targeted MSM and FSW to receive SMS messages containing information described above. SMS were sent out twice weekly with a different message in each instance. One example message is as follows: "Protect yourself and your partner. Always use a condom and lubricant anytime you have sexual intercourse."

Peer educators from PACTE-VIH connected data collectors to randomly chosen MSM and FSW in the urban and peri-urban Lomé region. These peer educators contacted KP enrolled in the PACTE-VIH program to participate in the study, invited them to ask their friends, or accompanied data collectors to "hotspots" where FSW work. KP aged 18 years or older were eligible to participate. Data collection took place over 30 days in July and August of 2016.

The study covered a total of 1,005 KP who responded to a structured questionnaire that asked about cell phone and internet use, HIV knowledge, prevention practices, and opinions on the PACTE-VIH mHealth program. Data collectors were trained to not lead the respondents during the interview, but to record their response options as respondents provided. All respondents gave signed consent, and no personal information or identifying data were obtained as part of the interview. Ethical approval for this study was provided by the Togolese Ethical "Comité de Bioéthique pour la Recherche en Santé" of the Ministry of Health and Social Protection (AVIS N° 19/2015/CBRS) on June 30, 2016. Approval was also provided by the University of California, Berkeley Center for Protection of Human Subjects (CPHS #2016-03-8583). This paper use a subsample, including 312 respondents who ever received the PACTE VIH HIV-related SMS between November 2014 and June 2016.

Variables

In this study, the primary independent variable was time enrolled in the mHealth program, in months. The questionnaire recorded the month and year of respondents' first and last HIV-related SMS received. Therefore, enrollment time was constructed by subtracting date of first SMS from the date of most recent SMS received. Due to a non-normal distribution, we log-transformed the continuous variable for initial analyses (see Figure 2 in Results). The final analysis used a categorical version of enrollment time in order to address the non-normal distribution of the continuous variable, and to examine how adoption of prevention behavior may vary across intervals of several months. The final variable was categorized into four levels: less than 6 months, 6-11 months, 12-23 months, and 24 months or more.

The dependent variable, adoption of prevention behavior, refers to the respondent's reported action after having received the message (reminders to get tested, reminders to use condoms and lubricant). The variable was coded as a binary "yes/no" variable; "yes" indicated the respondent followed through with the action suggested by the SMS, otherwise they were categorized as "no." All the responses were spontaneous, not prompted.

Control variables (covariates) included respondent's age, socioeconomic status, marital status, education, and type of key population (MSM or FSW). Socio-economic status was represented by a socio-economic status index, constructed with principal component analysis (PCA) using variables that described technology ownership (owning a computer or smartphone) and transportation ownership (owning a car, motorcycle, and bicycle), with Cronbach's Alpha reliability coefficients estimated. The final socio-economic status index was divided into three categories (terciles), ranging from lowest to highest.

Use of multiple imputation to address missing values

Out of 1005 KP surveyed, 313 received PACTE VIH HIV-related SMS, of which 123 were unable to recall the length of their exposure period: start date (84.6%), end date (3.3%), or both (12.2%). We used regression-based multiple imputation to account for the missing data in the independent variable, enrollment time. The process of multiple imputation drew values from a distribution of the observed data and assigned them to the 123 missing observations over five iterations (14). Five total datasets were created and analyzed separately in the regression analysis, with the results from each dataset pooled to give one final result.

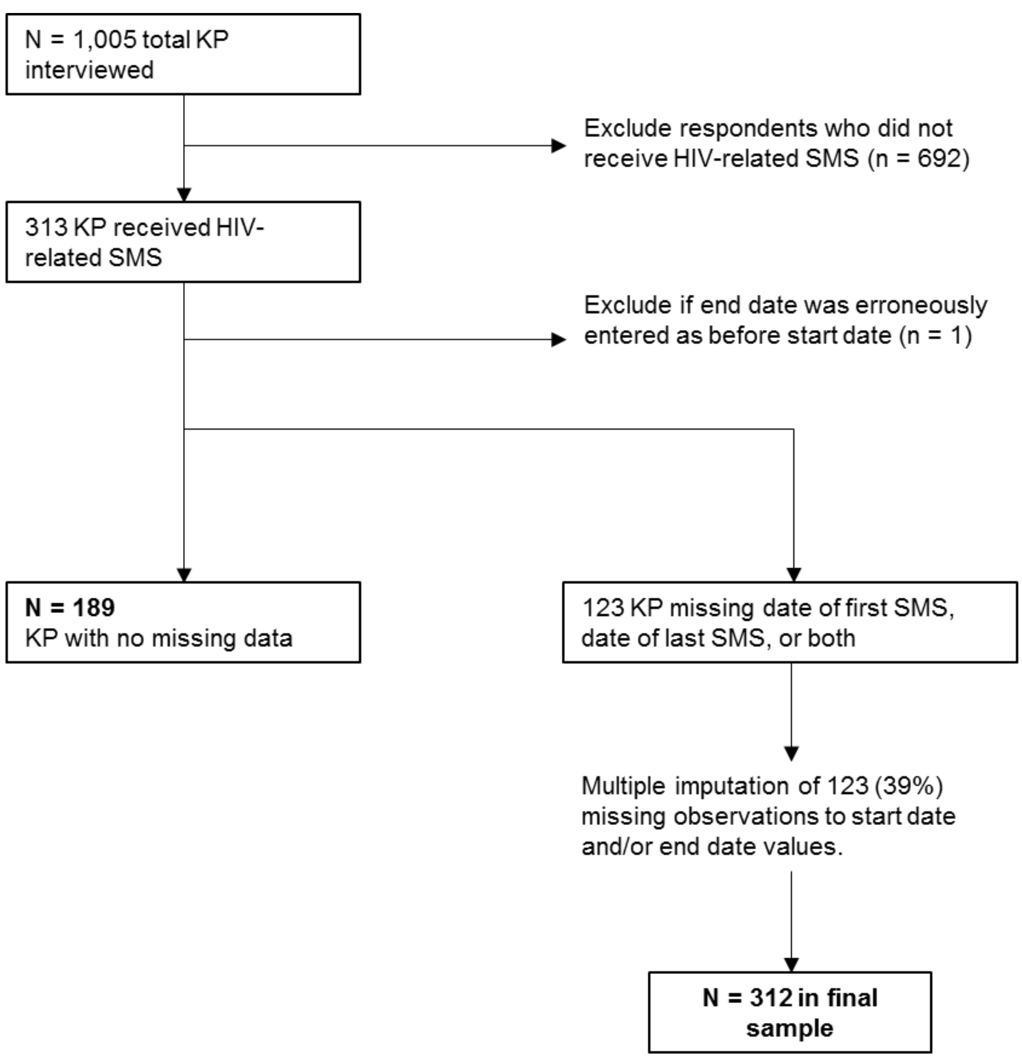
Analysis

Data analyses relied on chi-square test and logistic regression. Chi-square test allowed exploring bivariate relationships between dependent and independent variables of interest. Logistic regression models enabled to assess the relationship between number of months exposed to the mHealth program and adoption of prevention behavior before and after controlling for other covariates. Final models were fully adjusted for all covariates described above. To assess differences in observed and imputed data, we conducted the same analyses with only the observations that had no missing data (N=189). All analyses were performed in Stata 14.2.

Results

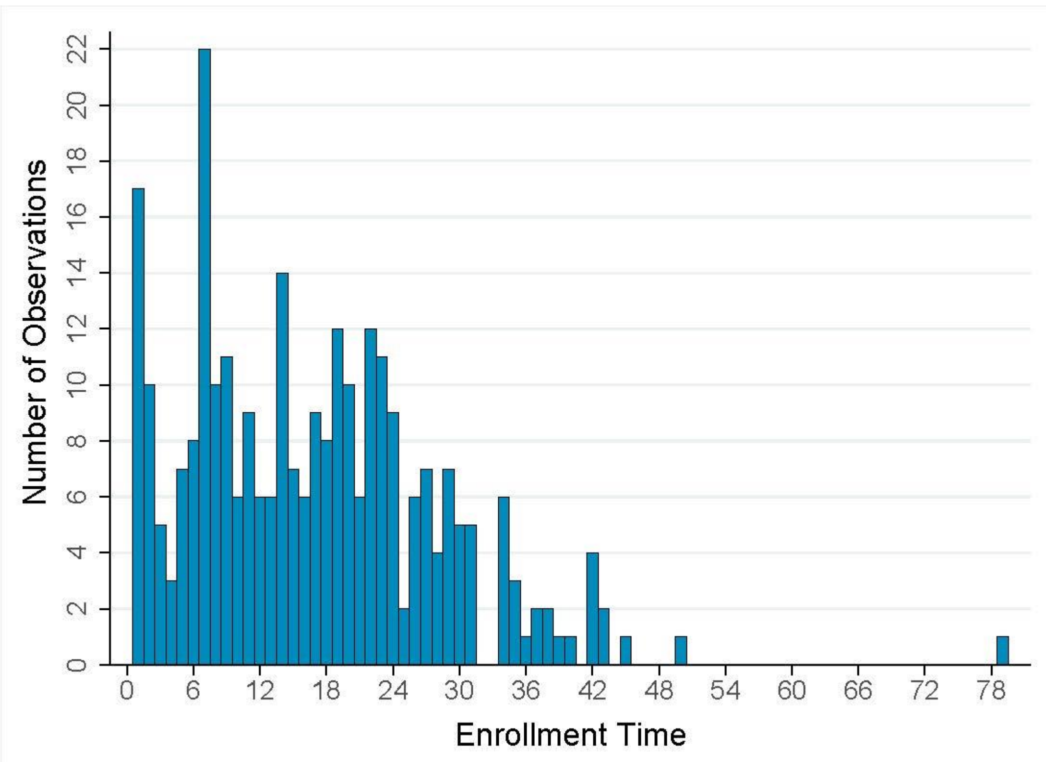
Figure 1 diagrams the observations included in the final analytical sample. Of the 1,005 total KP interviewed in the operations research, 313 KP reported receiving HIV-related SMS. One observation was dropped due to erroneous data entry. The remaining observations were used in the final analyses; 123 missing values were imputed for a final sample of N = 312. The analysis using only respondents with no missing data excluded these 123 observations, for a final analytic sample of n = 189.

Figure 1. Flow chart of exclusion criteria, missing data, and final analytical sample.



Prior to imputing the missing data, we assessed the distribution of respondents by enrollment time among those with no missing data (n = 189). Figure 2 displays the frequency of respondents as a function of enrollment time, by number of months enrolled. The majority of respondents reported an enrollment time of less than 24 months, with the greatest number of respondents reporting an enrollment time of 8 months. The distribution of months enrolled as a continuous variable was skewed slightly right as a result.

Figure 2. Frequency of observations by enrollment time expressed in months, represented as number months enrolled in the PACTE-VIH program.



As previously described, enrollment time was ultimately divided into four categories in order to examine adoption of prevention behavior as a function of time enrolled in the PACTE-VIH program by several month intervals. We first examined proportions and bivariate statistics of study covariates by the primary independent variable, enrollment time, across category of months enrolled (Table 1). These data include only the 189 respondents with no missing data.

Chi-square analysis demonstrated a significant difference in proportions across enrollment time categories for key population and wealth, at a significance value of $p < 0.05$. More FSW (74.19%) were enrolled for less than 6 months than MSM, while MSM accounted for over 80% of KP enrolled for any category at 6 months or more. KP in the lowest socio-economic status tercile accounted for 61.29% of those enrolled in the PACTE-VIH program for less than 6 months, as compared to those in the richest wealth tercile, where 72.34% of KP were enrolled for 24 months or more. The other study covariates, age, marital status, and education, demonstrated a lack of significant difference across the enrollment time categories (p > 0.05).

***Table 1. Characteristics of the study population by enrollment time categories, among observations with no missing data*.**

	Enrollment Time										
	Less than 6 months		**6-11 months**		**12-23 months**		**24 or more months**		**Total**		
	N = 31	%	N = 47	%	N = 64	%	N = 47	%	N = 189	%	p-value
Age											0.661
Less than 25	15	48.39	21	44.68	23	35.94	16	34.04	75	39.68	
25-29	7	22.58	11	23.4	16	25	19	40.43	53	28.04	
30-34	5	16.13	8	17.02	13	20.31	7	14.89	33	17.46	
35+	4	12.9	7	14.89	12	18.75	5	10.64	28	14.81	
Key Population											< 0.001
FSW	23	74.19	7	14.89	7	10.94	1	2.13	38	20.11	
MSM	8	25.81	40	85.11	57	89.06	46	97.87	151	79.89	
Wealth											< 0.001
1 (poorest)	19	61.29	9	19.15	10	15.63	2	4.26	40	21.16	
2	9	29.03	24	51.06	24	37.5	11	23.4	68	35.98	
3 (richest)	3	9.68	14	29.79	30	46.88	34	72.34	81	42.86	
Marital Status											0.088
Never married	23	74.19	43	91.49	58	90.63	42	89.36	166	87.83	
Ever married	8	25.81	4	8.51	6	9.38	5	10.64	23	12.17	
Education Level											0.070
No education / Primary	9	29.03	4	8.51	6	9.38	4	8.51	23	12.17	
Secondary	15	48.39	35	74.47	45	70.31	31	65.96	126	66.67	
Higher education	7	22.58	8	17.02	13	20.31	12	25.53	40	21.16	

Analysis of preventive behavior by the length of exposure excluding individuals with missing values (Table 2) shows that slightly over half of respondents (52.91%) reported adopting prevention behavior after receiving HIV-related SMS messages. Forty-seven respondents (24.87%) were enrolled in the mHealth program for 24 months or more, while the largest proportion of participants were enrolled for a period of 12-23 months (33.86%). Chi-square tests demonstrated a significant difference between two or more categories of enrollment duration and adoption of prevention behavior at the 0.05 significance cutoff (p = 0.029).

When examining the study covariates, we found that about two-thirds (67.72%) of respondents in the complete case dataset were aged less than 30 years, and nearly 80% were MSM. Slightly less than half of all respondents (42.86%) were in the highest wealth category. Most respondents (87.83%) had never been married, and only 21.16% reported receiving a higher education. Based on chi-square tests, there were significant differences at p < 0.05 between adoption of prevention behavior and one or more categories of KP, wealth, and marital status. All study covariates displayed in Table 2 were included in the final adjusted regression models.

Table 2. Enrollment time and characteristics of the study population according to adoption of prevention behavior, among observations with no missing data.

	Adopted Prevention Behavior						
	No		Yes		Total		p-value
	N = 89	%	N = 100	%	N = 189	%	
Enrollment Time							0.029
Less than 6 months	22	24.72	9	9.00	31	16.40	
6-11 months	20	22.47	27	27.00	47	24.87	
12-23 months	29	32.58	35	35.00	64	33.86	
24 months or more	18	20.22	29	29.00	47	24.87	
Age							0.940
Less than 25	36	40.45	39	39.00	75	39.68	
25-29	26	29.21	27	27.00	53	28.04	
30-34	14	15.73	19	19.00	33	17.46	
35+	13	14.61	15	15.00	28	14.81	
Key Population							< 0.001
FSW	29	32.58	9	9.00	38	20.11	
MSM	60	67.42	91	91.00	151	79.89	
Wealth							< 0.001
1 (poorest)	32	35.96	8	8.00	40	21.16	
2	28	31.46	40	40.00	68	35.98	
3 (richest)	29	32.58	52	52.00	81	42.86	
Marital Status							0.021
Never married	73	82.02	93	93.00	166	87.83	
Ever married	16	17.98	7	7.00	23	12.17	
Education Level							0.178
No education / Primary	15	16.85	8	8.00	23	12.17	
Secondary	56	62.92	70	70.00	126	66.67	
Higher education	18	20.22	22	22.00	40	21.16	

For the regression analyses, our final study sample included 312 observations. We used the enrollment time variable whose 123 missing observations imputed. We initially ran logistic regressions on unadjusted models of enrollment time on adoption of prevention behavior, with enrollment time as a log-transformed continuous variable and as a 4-level categorical variable. Table 3 displays the unadjusted odds ratios of these regressions. As a continuous variable, there was no significant difference in odds of adopting of prevention behavior with each month increase in enrollment time (OR: 1.02; 95% CI: 0.99-1.04). After assessing the same model with enrollment time as a categorical variable, we found the same results; there was no significant difference in odds of adopting prevention behavior with each category increase.

Table 3. Unadjusted odds ratios of adoption of prevention behavior by enrollment time, continuous and categorical.

Adoption of Prevention Behavior	Unadjusted OR		
	Odds Ratio	95% CI	p-value
Enrollment Time	1.02	0.99 - 1.04	0.227
Enrollment Time			
Less than 6 months	1 (ref)	-	-
6-11 months	1.94	0.79-4.77	0.145
12-23 months	1.74	0.78-3.86	0.172
24 months or more	1.82	0.77-4.28	0.166

Despite a lack of significance in the primary relationship between enrollment time and adoption of prevention behavior, we ran logistic regressions with models adjusted for all study covariates in order to observe the potential influences of these factors on the primary relationship. Multivariate regression results for categorical enrollment time on adoption of prevention behavior are shown in Table 4. Consistent with the unadjusted findings, we found that none of the enrollment duration categories had significantly different odds of adopting prevention behavior as compared to those who were enrolled for less than 6 months.

When observing the relationships between study covariates and adoption of prevention behavior, we found that respondents in the 35 or older age group had 3.23 times the odds of adopting prevention behavior as compared to those aged less than 25 ($p = 0.005$). Being in a higher wealth tercile also indicated higher odds of adopting prevention behavior (OR > 2, $p < 0.05$), while having ever been married was again associated with lower odds of the outcome (OR: 0.24; 95% CI 0.10-0.58).

Table 4. Adjusted odds ratio of adopting prevention behavior given enrollment time.

Adoption of Prevention Behavior	Multiple Imputation		
	Odds Ratio	95% CI	p-value
Enrollment Time			
Less than 6 months	1 (ref)	-	-
6-11 months	0.91	0.34-2.41	0.850
12-23 months	0.69	0.29-1.64	0.403
24 months or more	0.63	0.19-2.09	0.443
Age			
Less than 25	1 (ref)	-	-
25-29	1.25	0.69-2.23	0.460
30-34	1.70	0.81-3.55	0.161
35+	3.23	1.42-7.36	0.005
Key Population			
FSW	1 (ref)	-	-
MSM	2.11	0.95-4.69	0.066
Wealth			
1 (poorest)	1 (ref)	-	-
2	2.21	1.09-4.47	0.027
3 (richest)	2.45	1.11-5.41	0.026
Marital Status			
Never married	1 (ref)	-	-
Ever married	0.24	0.10-0.58	0.001
Education Level			
No education / Primary	1 (ref)	-	-
Secondary	1.05	0.47-2.35	0.911
Higher education	1.25	0.49-3.22	0.637

In addition to running multivariate regressions with the imputed data of the enrollment time variable, we performed the same analyses with only observations with no missing data (n = 189) to compare findings. The results from the unadjusted model indicated a significant association between enrollment time and adoption of prevention behavior. The odds of adopting prevention behavior were higher with each additional month enrolled in the program (OR: 1.62; 95% CI: 1.19-2.20). When assessing enrollment time as a categorical variable, the unadjusted results demonstrated that all three enrollment categories had significantly higher odds of adopting prevention behavior, as compared to individuals enrolled for less than 6 months ($p < 0.05$).

The results were attenuated and lost significance after adjusting for common confounders. The fully adjusted regression model showed that there was no significant increase in odds of adopting prevention behavior, as compared to an enrollment time of less than 6 months. These results are displayed in the supplementary tables (Tables A and B) in the appendix.

Discussion

The aim of this study was to determine whether enrollment time was associated with differences in adoption of prevention behavior. Understanding if length of time enrolled in a study influences behavioral outcomes could inform program interventions to send mHealth reminders in a manner that results in positive behavior change without overusing limited resources.

The results from our study demonstrated that participants who received HIV-related SMS for a longer period of time displayed no significant difference in adopting prevention behavior as compared to those who received SMS for less than 6 months. The regression results from the observations with no missing data corroborated our findings from the primary analysis that used multiple imputation to account for the missing values; fully adjusted models in both sets of analyses demonstrated no significant difference in adoption of prevention behavior with increased number of months enrolled. These findings indicated that KP who were enrolled in the PACTE-VIH program for any period of time greater than 6 months were just as likely to adopt prevention behavior as KP enrolled for less than 6 months.

The results from our study differed from a prior mHealth study that explored number of SMS received as a primary exposure (13). The text4baby mHealth trial on alcohol consumption found a significant decrease in odds of self-reported postpartum alcohol consumption with exposure to a greater number of SMS messages, as compared to fewer messages (13). The results from this dose-response study contrasted ours; while Evans et al. found that receiving SMS more frequently resulted in desirable behavior change, our study demonstrated a similar level of adoption of prevention behavior across varying enrollment times. Further research is needed to understand by what specific processes and in which contexts mHealth programs can improve HIV prevention behavior, and if maintaining enrollment for more than six months to a year would be a beneficial use of resources.

Though longer time enrolled in the PACTE-VIH mHealth program may not have resulted in differences in adopting prevention behavior in our study sample, older, wealthier, or ever married KP were more likely to adopt prevention behavior as compared to their younger, less wealthy, and never married counterparts. These trends are common among HIV prevention programs; a meta-analysis by Albarracin et al., 2009, demonstrated that certain socio-demographic factors, such as age, can determine how likely program participants are to engage with behavioral interventions (15). Accounting for these differences within KP subpopulations by targeting especially vulnerable groups, who may not be as likely to engage with mHealth, could also potentially improve the effectiveness of such programs (16).

Receiving SMS reminders in HIV mHealth programs is known to improve health treatment outcomes (7), and internal studies demonstrated that the act of receiving SMS messages through the PACTE-VIH mHealth program improved HIV testing behaviors and treatment adherence among KP. Prior studies have found that participants who receive SMS reminders had significantly higher adherence to HIV treatment and subsequent viral suppression, as compared to those who received no SMS reminders (7,17,18). These programs may have been effective because of the rapport established between participants and health providers (11), rather than as a result of participants receiving repeated SMS reminders. In the PACTE-VIH program, the role of the peer educators was instrumental in engaging KP with the program and encouraging participants to come in for face-to-face appointments. Behavior change is most likely to occur when subjects are presented with interactive and personalized resources (19). Therefore, sending participants HIV-related SMS over an indefinite period of time may not serve its intended purpose of improving HIV prevention behavior. Instead, HIV programs in developing countries may have more success with behavior change outcomes by involving peer educators to engage with hard-to-reach, at-risk populations (20).

One major limitation of this study was the large number of missing values in the primary independent variable. However, the theory-based method of multiple imputation accounted for any bias that may have otherwise occurred in an analysis that excluded all observations with any missing data. Another limitation from the data collection process was the self-reporting of the outcome variable, adoption of prevention behavior. Due to the cross-sectional design of the study, data collectors were not able to verify whether participants did indeed follow the suggested prevention behaviors after receiving the HIV-related SMS message. This could lead to over-reporting of the outcome as a form of social desirability bias. However, the lack of significant results in the final models indicates the outcome was likely not over-reported in our sample.

This analysis provided important insight into how enrollment time in an mHealth program may, or may not, influence prevention behavior outcomes. Engaging peer educators to provide a more collaborative experience could improve KP adherence to HIV PTC interventions, particularly if mHealth harnesses technology to encourage hard-to-reach KP, such as youth or those of lower socioeconomic status, to participate in these programs. Programs that integrate these aspects into their interventions may be more effective than repeated SMS messaging over a long period of time. However, there need to be more high-quality evaluations assessing the effect of mHealth on HIV behavioral outcomes before we can make definitive programmatic recommendations on the ideal enrollment periods of HIV mHealth interventions (4,15). Based on the results of this study, it seems like participants may only need 6 months to gain the HIV knowledge they needed to make decisions about prevention behaviors. Hammering the message home in the first 6 months may work, and further exploration is needed to ascertain in what conditions this finding. Ideally, participants could be segmented and tracked on how they proceed. Not everybody is expected to act on the SMS messages they receive immediately, and among those that do we should expect a distribution similar to the diffusion of innovation curve with early adopters, early majority, late majority and laggards.

Given that mobile technology is becoming more common in behavior health interventions, future studies must aim to provide a greater evidence base for the implementation of mHealth programs to ensure benefits are maximized. Longitudinal studies would be able to maintain better records of exact dates of enrollment and censorship of study participants, and specific outcomes such as testing frequency and self-reported condom use could be measured more accurately. Ultimately, having more data on effectiveness on enrollment time will allow programs to tailor their efforts to allocate their resources efficiently and scale-up to reach vulnerable populations most at-risk of HIV infection.

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Appendix

Table A. Unadjusted odds ratios of adoption of prevention behavior given enrollment time, continuous and categorical, among observations with no missing data.

Adoption of Prevention Behavior	Unadjusted OR		
	Odds Ratio	95% CI	p-value
Enrollment Time	1.62	1.19 - 2.20	0.002
Enrollment Time			
Less than 6 months	1 (ref)	-	-
6-11 months	3.30	1.25-8.68	0.016
12-23 months	2.95	1.18-7.39	0.021
24 months or more	3.94	1.49-10.42	0.006

Table B. Adjusted odds ratio of adoption of prevention behavior given enrollment time, among observations with no missing data.

Adoption of Prevention Behavior	Adjusted OR		
	Odds Ratio	95% CI	p-value
Enrollment Time			
Less than 6 months	1 (ref)	-	-
6-11 months	1.01	0.30-3.45	0.988
12-23 months	0.78	0.23-2.64	0.687
24 months or more	0.86	0.23-3.26	0.827
Age			
Less than 25	1 (ref)	-	-
25-29	1.01	0.46-2.22	0.971
30-34	1.56	0.60-4.03	0.361
35+	1.57	0.55-4.50	0.401
Key Population			
FSW	1 (ref)	-	-
MSM	2.82	0.96-8.32	0.060
Wealth			
1 (poorest)	1 (ref)	-	-
2	4.01	1.48-10.88	0.006
3 (richest)	4.86	1.64-14.37	0.004
Marital Status			
Never married	1 (ref)	-	-
Ever married	0.35	0.12-1.06	0.064
Education Level			
No education / Primary	1 (ref)	-	-
Secondary	1.04	0.34-3.16	0.949
Higher education	0.78	0.22-2.80	0.705