


Effect of an mHealth intervention on retention in HIV pre-exposure prophylaxis services among female sex workers: Preliminary evidence of the use of the *Jichunge* app in Dar es Salaam, Tanzania

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Abstract

Background: Mobile health (mHealth) applications have been reported to be effective in promoting access and adherence to health services. However, knowledge about their effect on retention in HIV preventive services among at-risk populations in sub-Saharan Africa is limited.

Objective: We aimed to evaluate the effect of the *Jichunge* mHealth application on retention in HIV pre-exposure prophylaxis (PrEP) services among female sex workers in Dar es Salaam, Tanzania.

Methods: We used respondent-driven sampling to recruit female sex workers eligible for PrEP and who owned a smartphone. All study participants were provided with a smartphone application (*Jichunge* app) aiming to promote PrEP use through medication reminders, easy access to PrEP information, online consultations with a doctor and/or peer educator, and online discussions between PrEP users. The effect of optimal use of the *Jichunge* app on retention in PrEP services at 1-month was modelled using log-binomial regression.

Results: A total of 470 female sex workers with a median age of 26 (interquartile range: 22–30) years were recruited. Overall, 27.7% of female sex workers were retained in PrEP services at 1 month. Retention was twice as high among optimal users of the app than among sub-optimal users (adjusted risk ratios = 2.00, 95% confidence interval (CI): 1.41–2.83, $p < 0.001$).

Conclusion: The optimal use of the *Jichunge* mHealth application was significantly associated with higher retention in PrEP services among female sex workers in Dar es Salaam.

Keywords

Mobile health, mHealth, retention, pre-exposure prophylaxis, PrEP, female sex workers, smartphone, Africa

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Introduction

The incidence of HIV has decreased by more than 50% since the late 1990s, but the reduction is far from evenly distributed between populations.^{1,2} Female sex workers are among the groups that still carry a high burden of new HIV infections.^{1,3,4} In Tanzania, a recent bio-behavioral study estimated the HIV prevalence among female sex workers in Dar es Salaam to be 15.3%,⁵ more than twice than among women in general.⁶ HIV interventions targeting female sex workers are therefore called for and could lead to a significant public health impact and contribute to the achievement of the global 2030 goal of ending HIV as a public health challenge.

Pre-exposure prophylaxis (PrEP) is antiretroviral medication taken prophylactically by HIV negative individuals to prevent HIV acquisition. It has been shown to be effective and is recommended for use among people at increased risk of HIV.⁷ However, low retention in PrEP services is a major challenge and negatively affects the effectiveness of PrEP programming.^{8–10} In Tanzania, PrEP roll-out is ongoing,¹¹ but like in many other countries, low retention is expected to become a challenge. PrEP interventions are complex and their implementation associated with a range of barriers at different levels.^{12–15} Finding ways of supporting retention in care could potentially strengthen the impact of PrEP.

Increased access to mobile phones, expansion of mobile networks and innovations in mobile technologies offer an opportunity for leveraging mobile services for public health benefits.¹⁶ Also, the increase in internet use globally represents an opportunity for internet-based interventions that can help mitigate several health challenges.^{17–19} Mobile health (mHealth) applications have increasingly been reported to be useful in promoting the use of different medications.^{19–22}

The effectiveness of text messaging interventions in improving adherence to PrEP and retention in PrEP services has been demonstrated among men who have sex with men in the United States.^{21–24} However, there is limited evidence on the impact of mHealth interventions on PrEP use among people at increased risk of HIV infection in sub-Saharan Africa.¹ Considering this, we aimed to evaluate the effect of a smartphone mHealth application called *Jichunge* (a Swahili word meaning ‘protect yourself’) that was developed with the aim of supporting the use of PrEP among men who have sex with men and female sex workers. In this paper, we present results of the effect of the use of the *Jichunge* app on retention in PrEP services at 1 month among female sex workers in Dar es Salaam, Tanzania.

Materials and methods

Study design and settings

This paper is based on the analysis of part of the data emanating from a pragmatic quasi-experimental trial for PrEP

roll-out in Tanzania (PREPTA) described in our previous publication.²⁵ In short, PREPTA is a research project with the overall aim of assessing the effectiveness of an mHealth intervention in promoting retention in PrEP services and adherence to PrEP among female sex workers and men who have sex with men in two cities of Tanzania: Dar es Salaam (intervention arm) and Tanga (control arm). The project is implemented by Muhimbili University of Health and Allied Sciences (MUHAS), Tanzania and University of Oslo (UiO), Norway. This paper focuses on the female sex workers only and utilises baseline data and 1-month follow-up data from Dar es Salaam.

Intervention

The *Jichunge* app is a smartphone-based mHealth application designed to provide support during start-up and use of PrEP. Details about the app development process have been described in our previous publication.²⁶ The app offers user information about PrEP, reminds them to take their daily PrEP pill, provides an opportunity to consult a doctor and/or a peer educator online, and operates an online forum for anonymous discussions between PrEP users. The overall aim of the app is to improve adherence to PrEP and retention in the PrEP programme.

Study population

We included women aged 18 years and above who had sold sex during the past 3 months. Participants were residents of the city of Dar es Salaam (they had an address in the city and had lived there for the past 6 months) who owned a smartphone and were starting PrEP.

Sample size estimation

The sample size was estimated using a formula for cohort studies.²⁷ Since the retention in PrEP services among female sex workers was not known during the design of the study, we assumed that it was between 10% and 90%. Thus, an estimated 50% of retention rate was used in sample calculation because it would provide the optimum sample size.²⁸ A precision of 5% and a design effect of 2 were used in estimating the sample size to achieve the minimum statistical power of 80%. After adjusting for a 20% potential loss to followup, the minimum sample size was estimated to be 423 female sex workers.

Study procedures

Recruitment. Participants were recruited between March and June 2021 using respondent-driven sampling.^{29,30} All participants were screened for PrEP eligibility as per

national guidelines and those who qualified were provided with PrEP pills and thereafter invited to take part in the study. Those who consented to participate received the *Jichunge* app, attended an app onboarding session and thereafter sat for a face-to-face baseline interview with a trained interviewer and thereafter during the 28 days follow-up study visit.

Data collection. Information on socio-demographics and other structural factors at baseline were collected using a questionnaire administered by trained research assistants. Participants were given an appointment to come back to the clinic for PrEP refill 28 days following enrolment, at which time they were interviewed about PrEP experiences and PrEP adherence. From the app, we also continuously collected data on the use of its different functionalities (opening the app, medicine registration, reading editorial contents, accessing online consultations or entering the online discussion forum). Data from the app were collected from all participants regardless of whether they came back to the 1-month follow-up clinic visit or not.

Research ethics and consent. The study was conducted in accordance with the Declaration of Helsinki. Details on how we worked to protect participants' privacy have been described in a previous article.²⁵ Briefly, all questionnaire data were stored and processed on a secure server developed particularly for the handling of sensitive research data ('Services for sensitive data' or TSD³¹) owned by the University of Oslo. The *Jichunge* app does not store, transfer or expose sensitive data. No element in the app makes reference to any information that can identify a participant. The app does not contain any feature to track the location of a participant and does not collect any other information from their smartphones apart from app usage. Written informed consent was obtained from all participants involved in the study. Participants were informed about collection and use of interview and the *Jichunge* app data.

Study variables

Outcome variable. The primary outcome in this study was retention in PrEP services at 1 month after initiating PrEP. The main reason for choosing to use a 1-month retention as an outcome variable was because it marks the first visit to the clinic after initiation of PrEP and hence provides an opportunity among PrEP users to share their first experience of using PrEP with the healthcare provider. Ability to ensure retention during the first month of PrEP use is critical in informing long-term use. As most complications and access challenges experienced early are more likely to have effect in long-term use of PrEP. Thus, understanding an early retention rate and associated factors would inform early and timely positive modification of services. In addition, the PrEP implementation framework in

Tanzania requires that HIV rapid test should be repeated during the first visit to confirm eligibility for PrEP treatment.³² Hence, retention at 1 month was considered one of the meaningful targets in PrEP programming and is likely to affect the long-term cascade of PrEP.³³ Participants were considered to have been retained to services if they visited the clinic within 4 weeks (28 days) after the scheduled date of their follow-up appointment. This definition was informed by Goodman et al.³⁴ who defined retention at 3-month as a visit after 3 months \pm 30 days, and by Hovaguimian et al.³⁵ who defined PrEP programme uptake as 'the proportion of participants attending first follow-up visit as scheduled \pm 4 weeks'.^{34,35}

Exposure variables. The exposure variable was what we refer to as 'optimal use' of the *Jichunge* app, defined as opening the app and use it at least three out of the four main app functionalities during the first 30 days after enrolment. Access and use of any three of the app functionalities exposed the user to substantial information about PrEP which were sufficient to promote service engagement. The functionalities albeit different, they conveyed similar detailed message about PrEP use to the user. Moreover, we refer to these users as optimal because after installation and introduction to the app, they did not only choose to open the app on their own, but also explored the majority of the app's functionalities. The four functionalities are medicine registration, PrEP editorial contents, the online consultation services and the online discussion forum.

Confounder variables. These were socio-demographics, sex work characteristics and other socio-structural factors which were collected at baseline and considered to potentially have an association with both the outcome and exposure variables. They include the age of the respondent, marital status, education level, social support, awareness of PrEP, PrEP stigma, sex work stigma, self-perceived HIV risk, income from sex work, steady partners and condom use. The measurement of scale variables also described in our previous publication²⁵ is provided below:

Social support was measured using an 8-item Likert scale that was adapted from the Duke-UNC Functional Social Support Questionnaire (FSSQ).³⁶ Participants were asked to respond to one of the five responses (1 = Much less than I would like; 2 = Less than I would like; 3 = Some, but would like more; 4 = Almost as much as I like and 5 = As much as I like). We computed the total score for all items and a total score below 32 was considered as 'inadequate social support'. The scale gave a Cronbach's alpha of 0.88.

Sex work stigma and perceived PrEP stigma were measured using 13 and 10 scale items, respectively, each with five response options (1 = Strongly disagree, 2 = Disagree, 3 = Neither disagree nor agree, 4 = Agree and 5 = Strongly agree), and gave a Cronbach alpha of 0.84 and 0.88, respectively; signifying high reliability. Sex work

Table 1. Distributions of socio-demographics characteristics and Jichunge app use by retention in PrEP services.

Variable	N (%)	Not retained: n (%)	Retained: n (%)	p-Value
<i>Jichunge</i> app use				<0.001
Optimal users	247 (52.6)	154 (62.3)	93 (37.7)	
Non-optimal users	223 (47.4)	186 (83.4)	37 (16.6)	
Age (years)				0.012 ^b
18–24	199 (42.3)	153 (76.9)	46 (23.1)	
25–34	226 (48.1)	161 (71.2)	65 (28.8)	
35+	45 (9.6)	26 (57.8)	19 (42.2)	
Marital status				0.094
Never married	361 (76.8)	268 (74.2)	93 (25.8)	
Married or previously married	109 (23.2)	72 (66.1)	37 (33.9)	
Education level				0.086
No formal	28 (6.0)	25 (89.3)	3 (10.7)	
Primary	165 (35.1)	114 (69.1)	51 (30.9)	
Secondary+	277 (58.9)	201 (72.6)	76 (27.4)	
Social support ^a				0.108
Inadequate	283 (60.2)	213 (75.3)	70 (24.7)	
Adequate	184 (39.1)	126 (68.5)	58 (31.5)	
PrEP awareness				0.026
Low	238 (50.6)	183 (76.9)	55 (23.1)	
High	232 (49.4)	157 (67.7)	75 (32.3)	
Sex work stigma score ^a				0.032 ^b
Low	27 (5.7)	16 (59.3)	11 (40.7)	
Moderate	398 (84.7)	288 (72.4)	110 (27.6)	
High	32 (6.8)	27 (84.4)	5 (15.6)	
Self-perceived HIV risk ^a				0.640
High	334 (71.1)	239 (71.6)	95 (28.4)	
Medium	41 (8.7)	28 (68.3)	13 (31.7)	
Low/none	60 (12.8)	46 (76.7)	14 (23.3)	

(continued)

Table 1. Continued.

Variable	N (%)	Not retained: n (%)	Retained: n (%)	p-Value
Don't know	33 (7.0)	26 (78.8)	7 (21.2)	
Perceived PrEP stigma ^a				0.532
Low	355 (75.5)	254 (71.6)	101 (28.4)	
High	114 (24.3)	85 (74.6)	29 (25.4)	
Reported monthly earnings from sex work (TZS)				0.291 ^b
≤150,000	116 (24.7)	83 (71.6)	33 (28.4)	
150,001–299,999	108 (23.0)	83 (76.9)	25 (23.1)	
300,000–444,999	144 (30.6)	106 (73.6)	38 (26.4)	
≥450,000	90 (19.1)	58 (64.4)	32 (35.6)	
Having a steady partner				0.346
Yes	305 (64.9)	225 (73.8)	80 (26.2)	
No	165 (35.1)	115 (69.7)	50 (30.3)	
Used condom during last sex with paying partner ^a				0.154
Yes	215 (45.7)	149 (69.3)	66 (30.7)	
No	254 (54.0)	191 (75.2)	63 (24.8)	
Accepting condom-less sex for more pay ^a				0.216
Yes	249 (53.0)	174 (69.9)	75 (30.1)	
No	220 (46.8)	165 (75.0)	55 (25.0)	

^aN is < 470 due to missing observations (3 for social support, 13 for sex work stigma, 2 for self-perceived HIV risk, 1 for condom use and condom-less sex variables).

^bThe p-value based on the Chi-square trend test.

PrEP: pre-exposure prophylaxis; TZS: Tanzanian Shillings.

stigma was thereafter categorised into three groups ('low' for scores ≤26, 'moderate' for scores between 27 and 38, and 'high' for scores ≥39). For PrEP stigma, a score above 30 was considered 'high'.

PrEP awareness was measured using eight true or false questions about PrEP. Participants who answered more than six questions correctly were categorised as being highly aware of PrEP.

Statistical analyses

Using the Chi-square test, we assessed the association between retention in PrEP services at 1 month by the *Jichunge* app use, socio-demographics, sex work characteristics and other socio-

structural factors. Variables with p-values <0.25 in the bivariate analysis were included in the regression modelling. Since the outcome variable was binary and common ($p=27.7\%$), we used generalised linear model with a log link and binomial distribution (log-binomial regression)³⁷ to model the effect of optimal use of the *Jichunge* app on retention in PrEP services at 1 month. Log-binomial regression was chosen because it estimates the risk ratios (RR) directly as opposed to logistic regression which gives odds ratios that can overestimate the association if the outcome variable is common ($p>10\%$).³⁸ We present crude RR and adjusted RR (aRR) with their corresponding 95% confidence intervals. All analyses were performed using STATA version 17 and a p-value <5% was considered statistically significant.

Table 2. Log-binomial regression analysis of independent effect of Jichunge app on retention in PrEP services.

Variable	Crude estimates		Adjusted estimates	
	RR (95% CI)	p-Value	aRR (95% CI)	p-Value
<i>Jichunge</i> app use				
Optimal users	2.27 (1.62–3.17)	<0.001	2.00 (1.41–2.83)	<0.001
Sub-optimal users	1	Ref.	1	Ref.
Age (years)				
18–24	1	Ref.	1	Ref.
25–34	1.24 (0.90–1.72)	0.189	0.93 (0.65–1.32)	0.685
35+	1.83 (1.19–2.79)	0.006	1.17 (0.72–1.88)	0.531
Marital status				
Married or previously married	1	Ref.	1	Ref.
Never married	0.76 (0.55–1.04)	0.086	0.86 (0.62–1.20)	0.377
Education level				
No formal education	1	Ref.	1	Ref.
Primary	2.88 (0.97–8.61)	0.058	2.30 (0.77–6.89)	0.137
Secondary+	2.56 (0.86–7.59)	0.09	2.07 (0.70–6.14)	0.191
Social support				
Adequate	1.27 (0.95–1.71)	0.106	1.27 (0.95–1.70)	0.105
Inadequate	1	Ref.	1	Ref.
PrEP awareness				
High	1.40 (1.04–1.88)	0.027	1.15 (0.86–1.54)	0.350
Low	1	Ref.	1	Ref.
Sex work stigma				
Low	2.61 (1.03–6.57)	0.042	2.66 (1.10–6.45)	0.030
Moderate	1.77 (0.78–4.02)	0.173	1.66 (0.74–3.71)	0.218
High	1	Ref.	1	Ref.
Used condom during last sex with paying partner				
Yes	1.23 (0.92–1.66)	0.155	1.38 (1.01–1.91)	0.046

(continued)

Table 2. Continued.

Variable	Crude estimates		Adjusted estimates	
	RR (95% CI)	p-Value	aRR (95% CI)	p-Value
No	1	Ref.	1	Ref.
Accepting condom-less sex for more pay				
Yes	1.20 (0.90–1.62)	0.219	1.34 (0.98–1.83)	0.069
No	1	Ref.	1	Ref.

aRR: adjusted risk ratios; CI: Confidence interval; Ref: reference; PrEP: pre-exposure prophylaxis; RR: risk ratios.

Results

Socio-demographic characteristics at baseline

A total of 470 female sex workers with a median age of 26 (interquartile range: 22–30) years were recruited. Three-quarters (75.5%) of the participants reported to have never been married, and more than half (58.9%) had at least some secondary education.

Optimal use of the *Jichunge* app

User statistics retrieved from the app administration portal indicated that about half (52.6%) of study participants were optimal users of the app (i.e., they had used at least three app functionalities during the first 30 days after having the app installed on their phones).

Retention in PrEP services

Overall, about one-quarter (27.7%) of the study participants were retained in PrEP services at 1 month following PrEP initiation. Retention was significantly higher among optimal users of the *Jichunge* app than among sub-optimal users (37.7% for optimal users versus 16.6% for non-optimal users; $p < 0.001$). Retention increased significantly and linearly with age (23.1%, 28.8% and 42.2%, for those aged 18–24, 25–34 and above 35, respectively; $p = 0.012$). Retention was high (40.7%) among those reporting low sex work stigma and decreased significantly among those reporting moderate stigma (27.6%) and high stigma (15.6%). Furthermore, there was a significant association between PrEP awareness and retention in PrEP services (32.3% vs. 23.1%; $p = 0.026$) (Table 1).

Independent effect of the use of the *Jichunge* app on retention in PrEP services

The results of log-binomial regression on the effect of the use of the *Jichunge* app on retention in the PrEP service

at 1 month are presented in Table 2. Retention in PrEP services were two times higher for optimal app users when compared to sub-optimal users (aRR = 2.00, 95% CI: 1.41–2.83, $p < 0.001$). Other variables that were significantly associated with higher retention in the multivariable model were low sex work stigma (aRR = 2.66, 95% CI: 1.10–6.45, $p = 0.030$) and having used a condom during last sex with a paying client (aRR = 1.38, 95% CI: 1.01–1.91, $p = 0.046$).

Discussion

Evidence shows that some mHealth applications are effective in promoting the use of different health services. In this study, we aimed to determine the effect of a smartphone mHealth application on early retention in PrEP services (1-month retention) among female sex workers in Dar es Salaam, Tanzania. The findings from this study have the potential to inform different national and global strategies to reduce new HIV infections.

Overall, about a quarter of study participants were retained in the PrEP programme at 1 month. This retention level resembles that found in a recent study in neighbouring Kenya where 24% of female sex workers were retained in PrEP and other HIV prevention services after 3 months.³⁹ However, the proportion differs significantly from that reported by a study in Senegal, where more than three-quarters of female sex workers were retained in PrEP services after 6 months.⁴⁰ One reason for the difference could be that sex work is legal and regulated by policy in Senegal (as opposed to the situation in Tanzania and Kenya),⁴¹ and this could have positive implications for the will to seek and remain in health services. Our findings underscore the considerable challenge of poor retention in PrEP services that has been reported elsewhere^{42,43} and calls for more and better strategies to support retention in PrEP services.

mHealth interventions like the *Jichunge* app can be one such promising innovation. Clearly, however, the impact of mobile phone apps depends on how actively they are used.

In this study, objective user statistics demonstrated that half of the participants were optimal users of the app (defined as persons who had used at least three functionalities of the *Jichunge* app during the first 30 days after enrolment). We interpret this as a sign that the app was quite well received. A similar study that assessed the use of a youth-tailored mobile health intervention (“PrEPmate”) aiming to support PrEP retention and adherence among young people at high risk of HIV in Chicago, Illinois reported use of different app services ranging from 58% (the proportion that accessed PrEP information) to 35% (the proportion that had engaged in discussion with other PrEP users).²³ However, more persuasively designed mobile phone applications are needed to attract more users and maximise the benefit of the intervention.

In the bivariate analysis, we observed a significant higher retention in the PrEP service among women who were optimal users of the *Jichunge* app. In multivariable regression analysis (after adjusting for potential confounders), optimal use of the *Jichunge* app independently predicted retention in PrEP services among female sex workers. The retention in the PrEP programme was twice as high among optimal users than among non-optimal users.

The findings from this study provide the preliminary evidence on the effect of the *Jichunge* mHealth intervention in improving retention in PrEP services. These findings compare with a study by Pitye et al.⁴⁴ which found that two-way text messages improved the return to the first PrEP follow-up visit among women initiating PrEP treatment in Kenya. Our findings are also in line with studies into the effect of mHealth on PrEP use that have been conducted elsewhere in other populations at HIV increased risk, such as men who have sex with men.^{21,23,24}

While well-designed mHealth applications may be effective in promoting PrEP use, they may not be equally effective in all settings and populations. For example, Colson et al.⁴⁵ found that an enhanced mHealth application to support PrEP adherence did not improve adherence among men who have sex with men and transgender women in New York in the United States. Also, Songtaweessin et al.⁴⁶ found that mobile phone applications did not provide additional PrEP adherence benefits over youth friendly services. Furthermore, the effect of mHealth interventions on PrEP use is likely to differ between individuals, by age, and by other socio-economic characteristics.²⁵ This underlines the need for designers and implementers of mHealth interventions to closely consider the local context and population specific factors.

One potential limitation of this study is that the findings are based on comparisons within a population (all participants received the app). As no standard control group (group not receiving the app) was used in this analysis, it is difficult to claim that the effect of the *Jichunge* app observed represent actual intervention effectiveness measure. Future comparisons between intervention and

control groups are recommended for effectiveness results. The current study provides evidence only on short term retention in PrEP services, and we propose further studies on the effect of mHealth and long-term retention. The strength of this analysis is the use of actual app usage data which are free of desirability bias and we recommend future analysis of the impact of long-term use of the app.

Conclusion

While only a quarter of the participants were retained in the PrEP service at 1 month, the proportion of retained participants was significantly higher among optimal users of the *Jichunge* app than among non-optimal app users. Retention in PrEP services was two times higher for the *Jichunge* app optimal users when compared to non-optimal users. Our findings suggest that smartphone apps that offer services such as online consultations, pill-taking reminders, information about PrEP and discussion between PrEP users hold a potential to promote retention in PrEP services among HIV at-risk populations in East Africa and beyond. Innovative mHealth applications could therefore contribute to the achievement of the global goal of ending HIV by 2030.

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Availability of data: The data for this analysis will be available from the principal investigator (PI) of the PREPTA project upon reasonable request.

Contributorship: CHM conceptualised, designed the study, analyzed the data and drafted the manuscript. EJM and MRK conceptualised, designed the study, interpreted the findings and revised the manuscript. HOL, KM, MTL and EM conceptualised and revised the manuscript. All authors read and approved the final version of the manuscript.


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