The mChoice app: usability evaluation of a patient tool for PrEP adherence monitoring and sexual behaviors

Fabiana Cristina Dos Santos, Maeve Brin, Mary R Tanner, Carla A Galindo, Rebecca Schnall

Submitted to: JMIR Human Factors
on: May 16, 2024

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Abstract

Background: Mobile health (mHealth) applications (apps) provide easy and quick access for users to monitor their health-related activities. Features such as medication reminders help users adhere to their medication schedules and automatically record these actions, thereby helping track their overall health management. Due to insufficient mHealth tools tailored to Human Immunodeficiency Virus (HIV) preventive care for young men who have sex with men (MSM), our study evaluated the usability of the mChoice app, a tool designed to enhance pre-exposure prophylaxis (PrEP) adherence and promote sexual health (e.g., encouraging the use of condoms and being aware of the partner's HIV status and PrEP use).

Objective: To apply systematic usability evaluations to test the mChoice app and to refine the visualizations to better capture and display patient-reported health information.

Methods: Usability testing involved heuristic evaluations conducted with five experts in informatics and user testing with twenty young MSM who were taking or eligible to take PrEP.

Results: Participants demonstrated satisfaction with the appearance of the mChoice app, reporting that the app has an intuitive interface to track PrEP adherence. However, participants highlighted areas needing improvement, including chart titles and the inclusion of 'undo' and 'edit' buttons to improve user control when recording PrEP use.

Conclusions: Usability evaluations should be considered in the app's development to ensure the effectiveness of the app's future iterations.

(JMIR Preprints 16/05/2024:59780)
DOI: https://doi.org/10.2196/preprints.59780

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health management. Due to insufficient mHealth tools tailored to Human Immunodeficiency Virus (HIV) preventive care for young men who have sex with men (MSM), our study evaluated the usability of the mChoice app, a tool designed to enhance pre-exposure prophylaxis (PrEP) adherence and promote sexual health (e.g., encouraging the use of condoms and being aware of the partner's HIV status and PrEP use).
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Keywords: HIV prevention; data visualization; patient-reported health information; mHealth; digital health; usability.

Introduction

Human Immunodeficiency Virus (HIV) incidence, although having declined modestly overall in the United States, remains a significant public health problem for men who have sex with men (MSM) [1,2]. Notably, young MSM aged 13 to 34 represent 58% of estimated HIV infections in 2021, indicating a pressing need for targeted intervention in this group [2]. Pre-exposure prophylaxis (PrEP) is the most effective biomedical prevention strategy to reduce HIV incidence and curb the HIV epidemic [3–9]. PrEP, when taken daily or consistently (at least 4 times per week), effectively reduces HIV transmission by 99% among MSM [7–12]. While awareness of PrEP has increased among MSM [13,14], those that are most disproportionately affected have been found to be less aware of PrEP [14], and overall, widespread uptake among those with the greatest indications for PrEP remains low [13–16].
To overcome this clinical and public health challenge, technological interventions, such as mobile health (mHealth) applications (apps), have emerged to support public healthcare initiatives. However, despite the potential of mHealth for delivering sexual health and HIV prevention awareness, mHealth is underutilized for supporting PrEP adherence [17,18]. In response, our study team developed mChoice, an innovative PrEP adherence monitoring app integrated with a CleverCap smart pill bottle. The app was created by Compliance Meds Technology and has been used in prior studies among persons living with HIV [19–23]. It was adapted for the mChoice study. The app's key functionalities include monitoring PrEP adherence, visualizing data trends, and documenting sexual behavior, particularly among young MSM from diverse backgrounds.
A notable issue in the proliferation of mHealth apps is the development of this technology with minimal input from end-users, leading to poor design, inadequate consideration of user needs, and, ultimately, poor usability [24]. Poorly designed apps, lacking in usability, are prone to misuse, underutilization, and failure to achieve their intended objectives.
To ensure the best utilization of mHealth apps, it is essential to understand their usability, keeping in mind target end-users (e.g., young MSM), tasks (e.g., PrEP medication management, HIV information), and cultural contexts (e.g., language, beliefs). Therefore, in this study, we sought to apply systematic usability evaluations to test the mChoice app and to refine the visualizations to better capture and display patient-reported health information.

Methods

Usability testing of the mChoice app included heuristic evaluation conducted with experts in informatics and end-user testing conducted with young MSM. The Columbia University Institutional Review Board reviewed and approved all study activities. Participants signed informed consent prior to participating in usability testing.

Heuristic evaluation

Sample

Five experts were recruited as evaluators in accordance with Nielsen's recommendation to include three to five evaluators in usability testing [25]. Of five evaluators, four had a PhD in Nursing with expertise in human-computer interaction, interface design, and usability testing. Evaluator experience varied between 7 and 23 years, with several impactful publications in the field of informatics.

Procedure

Experts were provided with the mChoice app and asked to complete a session in the app through use case scenarios that represented the main functions of the system and think-aloud methodology [26]. Participants were asked to describe what they were thinking, seeing, and doing as they completed the ten scenarios: 1. Log in to the CleverCap app; 2. Complete a sexual activity log; 3. Mark your PrEP dose for today as 'Taken'; 4. View tomorrow's pending PrEP dose; 5. Edit your sexual activity log; 6. Delete your sexual activity log; 7. View information on PrEP dosing over the past month; 8. Send a chat to the study team; 9. Watch a video about an HIV story, and 10. Find PrEP information (See Figure 1 and Figure 2 illustrating app functions and Figure 3 demonstrating the CleverCap smart pill bottle).
Following their use of the app, experts completed an online Heuristic Evaluation Checklist to assess how a system adheres to Nielsen's ten usability principles [25] using Qualtrics, an online survey software. Each question ranged from 0 (not a usability problem) to 4 (usability catastrophe). Evaluators' comments regarding usability problems were analyzed by a member of the research team to identify areas of usability concern that could be targeted for improvement. Mean usability problem severity scores were calculated for each of the ten usability heuristics.

End-user testing

Sample

Twenty participants were recruited as end-users for the usability testing. Eligibility criteria were young MSM between the ages of 18 and 39 years old, English-speaking, living in New York or Alabama, and taking or eligible to take PrEP. Potential participants were contacted using a research database and were invited to participate in the study.

Procedure

During usability testing, participants were provided with a brief explanation of the mChoice app and its functions. Participants were directed to complete the same ten scenarios completed by experts in the heuristic evaluation. Participants were then asked to speak aloud and describe their thoughts while they worked through the tasks to enable researchers to identify usability concerns. Sessions took place remotely via Zoom meeting, and a member of the team was present during sessions to

provide guidance when a participant was unable to move through a task independently and to take notes. Following their use of the app participants completed a survey using Qualtrics software.
The survey included demographics and two validated measures of usability. The first usability measure was self-reported ease of use measured by the Health Information Technology Usability Evaluation Scale (Health-ITUES) [27,28]. This 20-item tool is designed to support customization at the item level to match the health information technology while retaining standardization at the construct level. It has been demonstrated to be useful for evaluating the usability of mHealth [29]. It is scored on a 5-point Likert scale ranging from 5 (strongly agree) to 1 (strongly disagree), where higher scores indicate a system that is easier to use. The second measure was the short version of the Post Study System Usability Questionnaire (PSSUQ), a 16-item survey that assesses users' perceived satisfaction with a system [30]. Scoring is based on a 7-point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree). Lower scores indicate satisfaction with the system.
Data analysis was done using R statistical software version 4.1.2 (R Foundation) to analyze the usability measures. Mean scores were calculated for each survey domain.

Results

Heuristic Evaluation

Overall, severity scores ranged from 0.8 to 2.2 on the ten items on the heuristic checklist, where scores closest to 0 indicate a more usable system. Mean severity scores for each of the heuristic items are presented in Table 1. The area identified as the most in need of improvement was *user control and freedom*, where evaluators identified that the app did not have an 'undo' button or 'edit' button for the PrEP medication entry.
The next most identified area for improvement was the *visibility of system status*, for which evaluators identified the lack of one 'add' button to add a new sexual event. To improve the *visibility of system status*, the experts suggested we provide one 'edit' button for modifying recorded sexual encounters and incorporate a separate 'add' button for logging new encounters, especially in instances of multiple events. Additionally, *consistency and standards* was an area of concern with difficult terminology in charts. *Error prevention* was another concern, and evaluators highlighted the importance of one 'edit' button to edit medication time as an issue that might impede system usability. Experts provided favorable feedback on the app's user experience. One participant (R2) reported, "the app is very simple and intuitive interface…and it's nice that the button changes color with pleasant colors."

End-user testing

The end-user group for evaluating the mChoice app's usability consisted entirely of males, with the majority identifying as homosexual (70%). The average age was 28 years (SD = 3.4). Half of the participants were White, and 75% were non-Hispanic/Latino. Educationally, 50% had a college degree. Two specific measures were employed for the usability assessment: the Health-ITUES and the PSSUQ, as detailed in Table 2.
The Health-ITUES scale, where a higher score indicates better usability, showed that *perceived ease of use* scored the highest with a mean of 4.6 (SD = 0.5), suggesting a favorable user assessment. However, *user control* received the lowest score in this category, with a mean of 3.8 (SD = 0.9), corroborating the heuristic evaluator's ratings.
Conversely, the PSSUQ, where a lower score indicates better usability, reflected different aspects of mChoice performance. *System quality* scored the lowest at 1.7 (SD = 1.2), while *interface quality* was the highest score with a mean of 3.0 (SD = 1.8). These results suggested a positive user experience with notable ease of use and system quality strengths. However, there are areas for

improvement, particularly in enhancing user control and interface quality.

Discussion

Principal Results

Our study evaluated the mChoice app's usability in enhancing PrEP adherence for young MSM. Overall, heuristic evaluators and end-users demonstrated satisfaction with the mChoice app, reporting that the app is a simple and intuitive interface to track PrEP adherence.

Graphs, charts, and icons are the main features of mHealth apps that help users track their goals, habits, and achievements [31,32]. The mChoice app combines iconography (e.g., face images) and color-coded charts to provide clear and immediate feedback on PrEP adherence. These diverse visualizations allow end-users to interpret their personal data in different formats. Aligned with the findings from our study, a review of 32 mood-tracking apps found that data visualization needed to be varied to match multiple individuals' preferences [31]. In our study, faces with varying expressions and colors (e.g., green for high adherence, red for missed doses, and yellow for off-schedule doses) intuitively communicate the user's adherence status. This aligns with previous research indicating that color-coded visual cues can aid in quick decision-making and interpretation of health data [33–36]. In addition, graphs showed the trend of PrEP medication adherence over time, including evidence-based information on the percentage of missed, off-schedule, and on-time doses.

Our findings suggest that the visual elements available in the mChoice app offer a positive user experience and function accessibility that could assist in timely medication intake and monitor adherence, thereby supporting HIV prevention strategies. However, it is important to note that despite user satisfaction with these visual aids, our heuristic evaluation highlighted areas needing improvement, particularly in the need for clearer chart titles and more labels to exemplify each component (e.g., Clever score), underscoring the importance of refinement of the mChoice design for optimized user experiences.

The accuracy of the information collected through the mChoice app was another area of attention that both heuristic evaluators and end-users raised concerns, particularly highlighting the absence of 'undo,' 'edit,' and 'add' buttons. These limitations restricted user control, potentially affecting the accuracy of patients' health information input. For instance, the absence of 'undo' and 'edit' buttons could lead to inaccuracies if users mistakenly enter the time of their PrEP dose intake. Additionally, the lack of an 'add' button for recording multiple sexual events was seen as an important barrier, restricting users from documenting their sexual event entries accurately. These findings underscore the need for enhanced app capabilities to ensure accurate and comprehensive user input and customizations. Similarly, other studies[37,38] reported concerns about user experiences and data accuracy in mobile apps, reinforcing the findings of our study.

The actionable finding from this study is to reevaluate the functions of the mChoice app after integrating end-user feedback and addressing heuristic violations. Iterative usability evaluations should be considered as a best practice in the app development process to ensure the effectiveness of the app's future iterations.

Limitations

A limitation of our study was the convenience sample, recruited from a database that included participants who had participated in past research and expressed interest in future studies. Despite this limitation, we identified areas of improvement to refine the mChoice app. In addition, this study enriched the body of research on mHealth usability evaluation in HIV prevention contexts. This was achieved by employing end-users and heuristic evaluators to assess this innovative app designed for

PrEP adherence and HIV prevention.

Conclusions

Our usability study of the mChoice app involved rigorous evaluations through interactive heuristic evaluations and end-user testing. The results demonstrated the app's simplicity and user-friendly interface, showcasing its potential in monitoring health-related activities such as PrEP adherence. End-users particularly appreciated the app's visual features, such as iconography and color-coded charts, which may make information easily understandable and culturally appropriate. Further research could explore how these usability enhancements might influence user engagement and behavior change to support HIV prevention efforts.

Acknowledgments

Research reported in this study was funded by the Centers for Disease Control and Prevention through grant # U01PS005229. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Competing Interests

None declared.

Abbreviations

Apps: Applications
Health-ITUES: Health information technology usability evaluation scale
HIV: Human immunodeficiency virus
mHealth: Mobile health
MSM: Men who have sex with men
PrEP: Pre-exposure prophylaxis
PSSUQ: Post study system usability questionnaire

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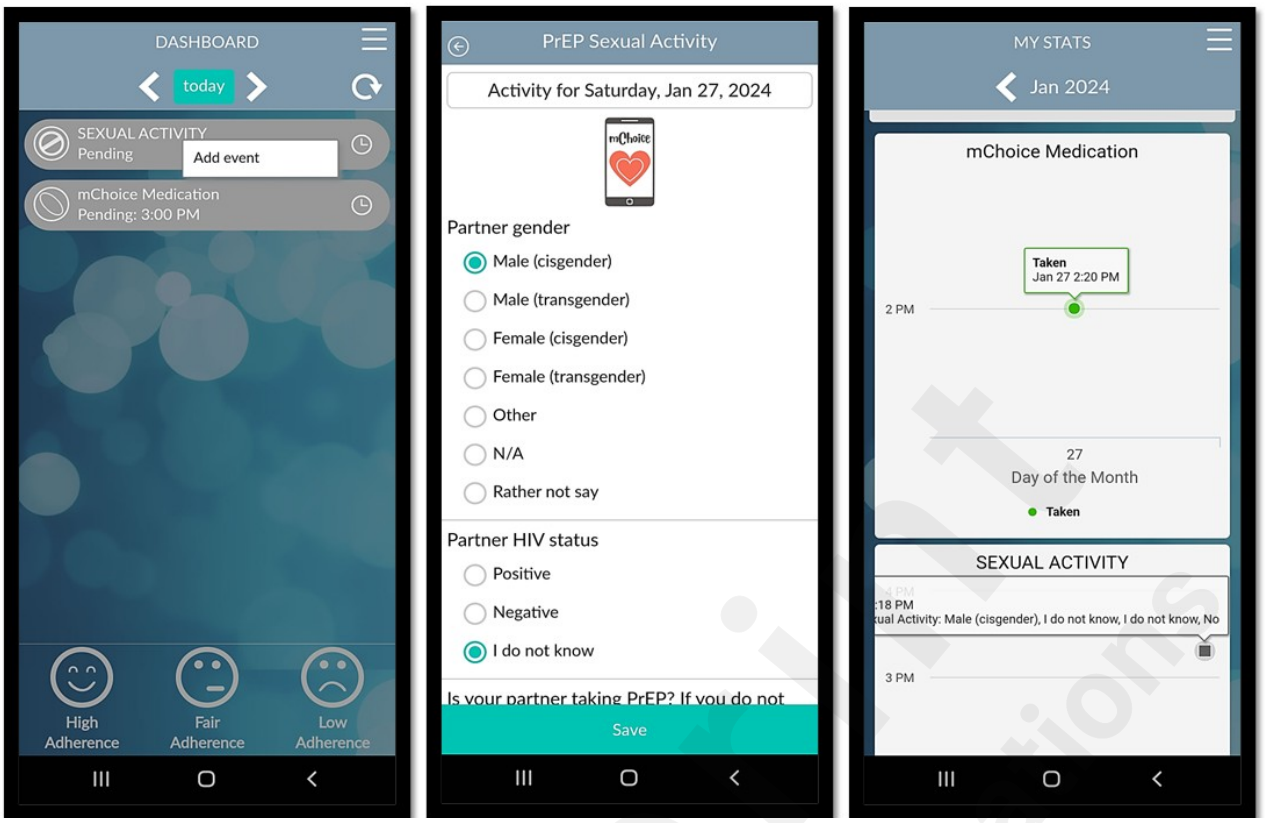


Figure 1. Sexual activity log. A confidential and secure feature for users to record their sexual activities, such as gender of partner, whether a condom was used, and the HIV status of their partner. Users of the on-demand/intermittent (2-1-1) PrEP regimen can use this feature to trigger subsequent PrEP dose reminders following sexual activity (i.e., one pill 24 hours and one pill 48 hours after sexual activity).

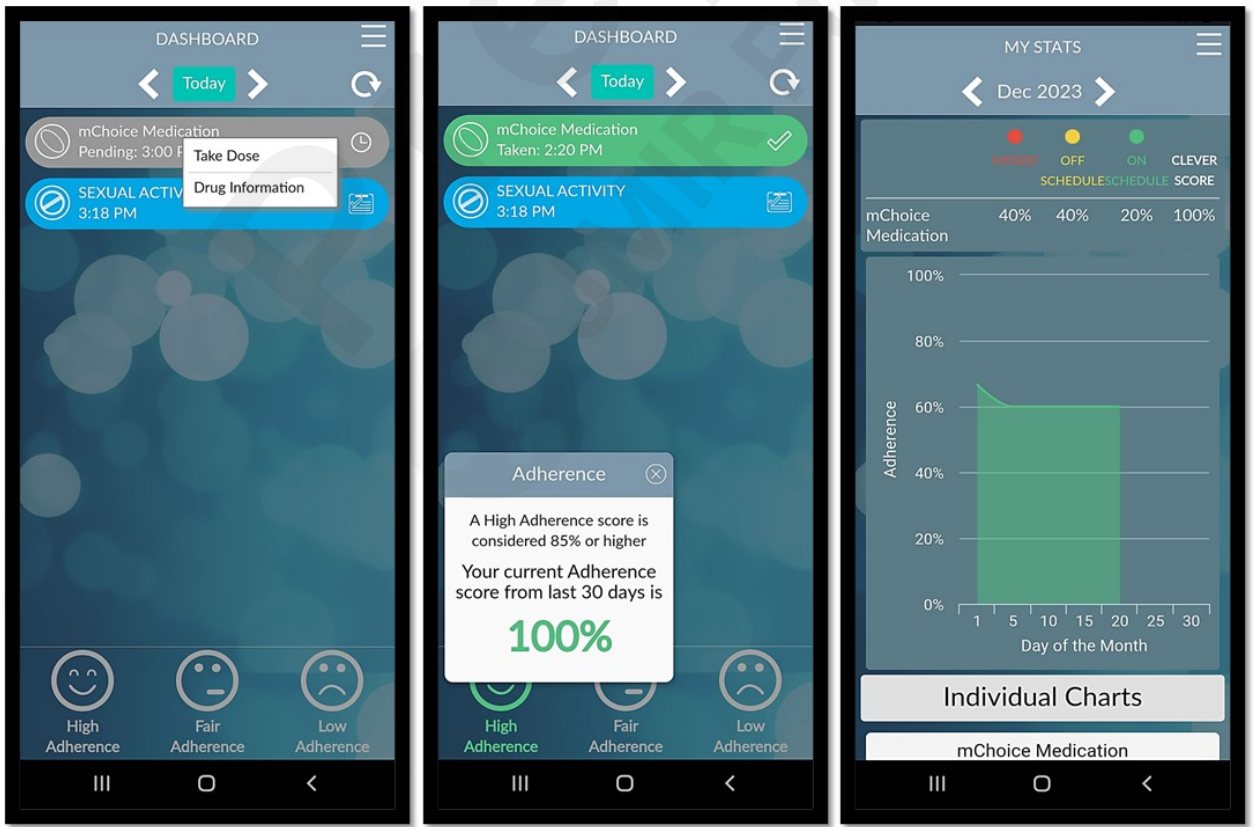


Figure 2. PrEP adherence tracking. A simple interface for users to track PrEP intake, facilitating adherence

monitoring over time. This feature is linked with the CleverCap device, a smart pill bottle that tracks when users take their medication. PrEP tracking is also customizable for users on different PrEP regimens (i.e., 2-1-1, injectable, or daily oral dose) to ensure timely intake of PrEP medication. For instance, users on injectable PrEP will be alerted of their upcoming appointment or need for their PrEP injection.

Figure 3. CleverCap device. A smart pill bottle linked with mChoice app to track PrEP medication.

Table 1. Heuristic Evaluation Mean Severity Scores

Heuristic principles	Mean (SD)	Reviewer comments to identify areas of usability concerns
User control and freedom	2.2 (1.3)	"No undo or edit for the medication entry. This is a big problem." R5
Visibility of system status	1.6 (1.1)	"…When adding a sexual encounter record, it is not clear whether it edits or adds a new one, so there should be two buttons, one for edit and one to add a new one. The screen when you use edit also shows the old entry, which implies you are editing it, not starting a new one, but actually it is starting a new one. That is confusing." R3
Consistency and standards	1.6 (1.1)	"Not clear if the clever score is just adherence or if it means something else." R4 "…I think in the menu it says stats. Rather than stats, it'd be adherence stats or adherence tracking over time. You know something that makes it really clear what people are clicking on." R2
Error prevention	1.6 (1.1)	"When entering the time of a medication, it might be easy to miss the AM/PM change. I don't think there's any design change to be made for this, but rather the user needs to be able to edit their entry if they forget to adjust this." R4
Match between system and the real world	1.4 (1.3)	"Would like to see one section specific to Prep information." R5
Recognition rather than recall	1.4 (0.9)	"Some of the main features can be moved to more obvious places." R1 "Organization for videos could be improved, especially if you plan to add more content." R4
Help and documentation	1.4 (1.3)	"Information buttons and an introduction to the app would be helpful." R1
Help users recognize, diagnose, and recover from errors	1.2 (1.1)	"When the dose was missed, no way to edit if it was a mistype." R5
Aesthetic and minimalist design	1.2 (1.1)	"Graphs need clearer tiles and more labels." R1

		"Need more medication information or guidance if adherence is low." R5
Flexibility and efficiency of use	0.8 (1.1)	"…Search function for videos. Tags for topics would be good, too." R4

Rating score from 0 = best to 4 = worst. No usability problem (0), cosmetic problem only (1), minor usability problem (2), major usability problem (3), usability catastrophe (4). R1 – R5. Reviewers.

Table 2. Usability Measures

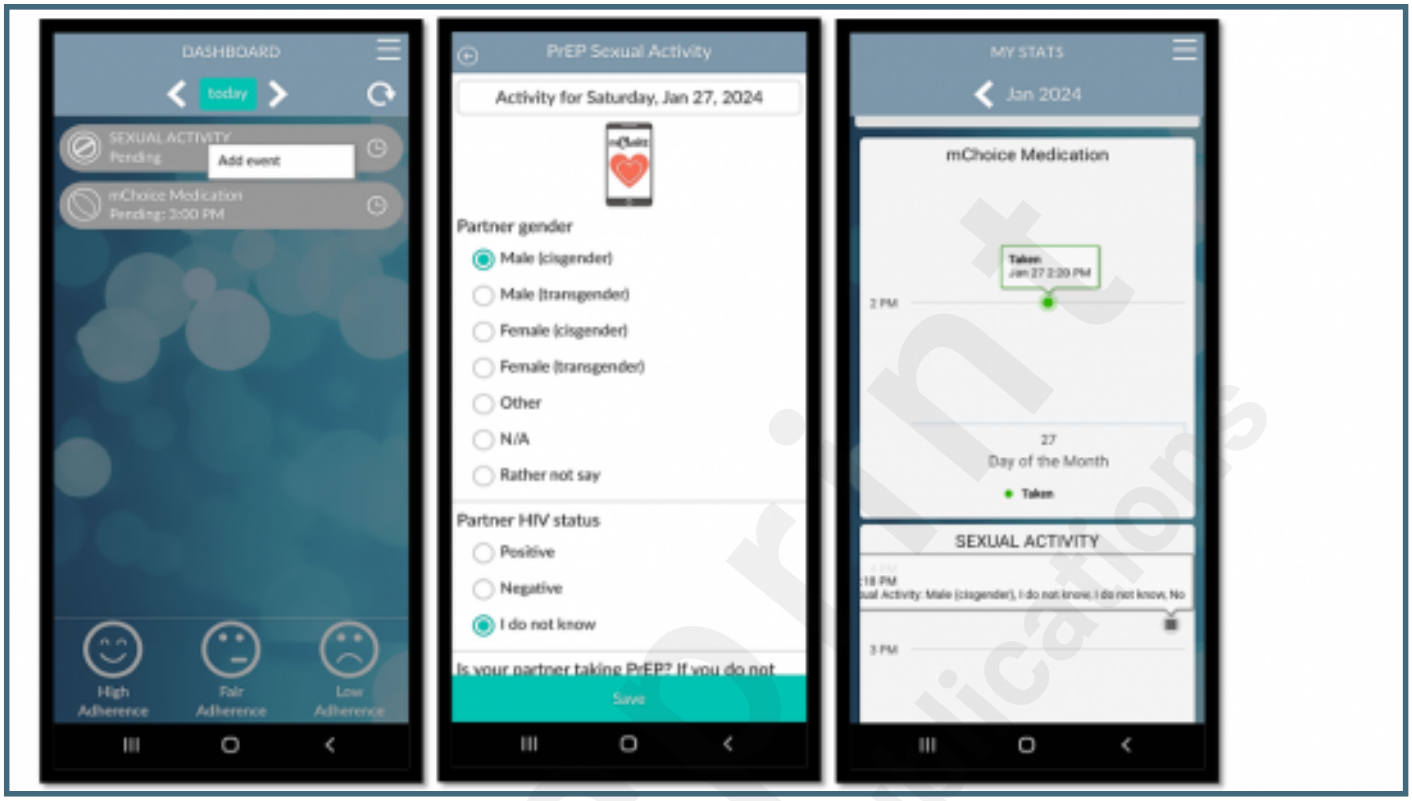
Measures	Mean (SD)
Health Information Technology Usability Evaluation Scale (Health-ITUES)[a]	
Perceived ease of use	4.6 (0.5)
Impact	4.1 (0.8)
Perceived usefulness	4.0 (0.8)
User control	3.8 (0.9)
Overall Health-ITUES score	4.2 (0.4)
Post Study System Usability Questionnaire (PSSUQ)[b]	
System Quality	1.7 (1.2)
Information Quality	2.4 (1.3)
Interface Quality	3.0 (1.8)
Overall PSSUQ score	2.3 (0.6)

a. Health-ITUES: Rating score from 5 = best to 1 = worst score.
b. PSSUQ: Rating score from 1 = best to 7 = worst score.

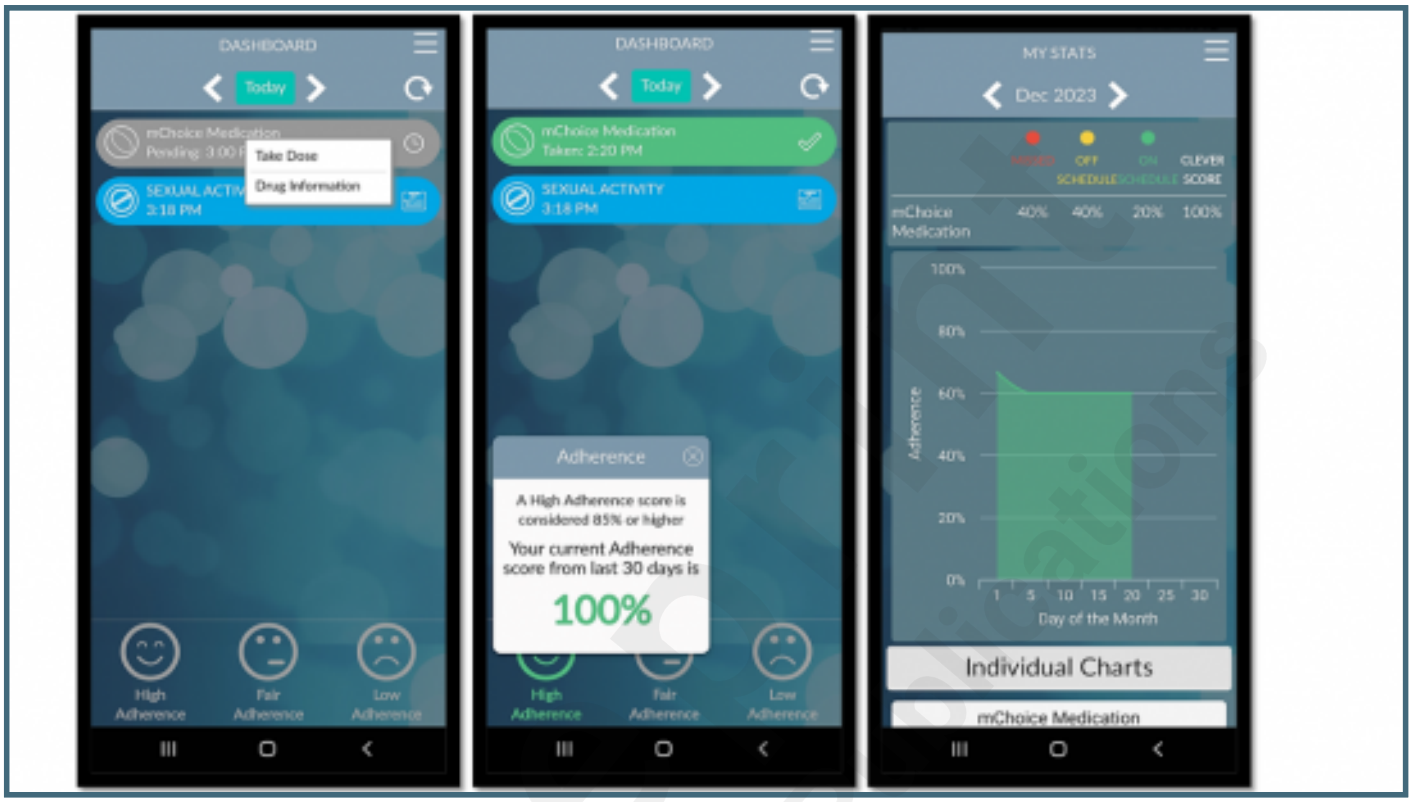
Supplementary Files

Figures

Sexual activity log. A confidential and secure feature for users to record their sexual activities, such as gender of partner, whether a condom was used, and the HIV status of their partner. Users of the on-demand/intermittent (2-1-1) PrEP regimen can use this feature to trigger subsequent PrEP dose reminders following sexual activity (i.e., one pill 24 hours and one pill 48 hours after sexual activity).



PrEP adherence tracking. A simple interface for users to track PrEP intake, facilitating adherence monitoring over time. This feature is linked with the CleverCap device, a smart pill bottle that tracks when users take their medication. PrEP tracking is also customizable for users on different PrEP regimens (i.e., 2-1-1, injectable, or daily oral dose) to ensure timely intake of PrEP medication. For instance, users on injectable PrEP will be alerted of their upcoming appointment or need for their PrEP injection.



CleverCap device. A smart pill bottle linked with mChoice app to track PrEP medication.