

Development and Usability Test of an Ecological Momentary Assessment Smartphone Application for High-Risk HIV Populations in Peru

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Abstract

Background: HIV incidence has continued to increase among men who have sex with men (MSM) in Peru, despite intervention efforts. Addressing stigma, risky behaviors, and low medication adherence is key to reducing incidence rates. Ecological momentary assessment (EMA) allows for collection of discrete, real-time data of stigmatized, risky behaviors while reducing recall bias.

Objective: The aim of this study was to develop and assess the usability of an EMA smartphone app among HIV+ MSM in Peru which tracks daily health risk behaviors to determine ease of use, usefulness, and satisfaction with the app.

Methods: A mixed-method three-phase study was conducted which included a usability test, 10-day field testing, and a debriefing focus group. Quantitative survey data and user analytics allowed for assessments of acceptability and user compliance. Qualitative interview and focus group data were thematically analyzed for in-depth assessments of user satisfaction.

Results: Acceptability of the EMA app was high with a mean usability rating of 6.4/7.0, indicating high user satisfaction, ease of use, and usefulness. 10-day field testing demonstrated a high average compliance rate of 93%, which suggests high feasibility of the app for daily tracking of health risk behaviors among HIV+ MSM. Interview and focus group findings indicated that the app was navigable, time-efficient, and holds promise for long-term use, particularly with the inclusion of daily reminders and incentives for prolonged use.

Conclusions: EMA apps can provide valuable real-time data while protecting users' privacy. This formative work lays the foundation for future larger-scale EMAs of substance use and sexual risk behaviors among high-risk HIV populations, and in developing just-in-time (JIT) interventions to address stigma, improve medication adherence, and reduce risky behaviors. Clinical Trial: NA

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Keywords: ecological momentary assessment; mHealth; usability testing; smartphone; Peru; people with HIV; men who have sex with men; antiretroviral therapy; adherence; feasibility and acceptability

Introduction

The HIV epidemic in Peru – a prototypical middle-income country – is concentrated among men who have sex with men (MSM) [1-3]. HIV prevalence in this group is 10-22% [4 5] compared with less than 1% in the general population [6]. The HIV cascade is similarly concerning, with suboptimal levels of retention in care and antiretroviral therapy (ART), and viral suppression rates of just 12% [2]. This has resulted in Peru being one of the few countries globally, since 2014, where HIV incidence continues to increase and HIV-related mortality has plateaued [7].

Despite a number of evidence-based HIV prevention and treatment strategies implemented by the Peruvian Ministry of Health, intervening with MSM in Peru has been challenging due to high levels of stigma and discrimination [8]. Same-sex behavior and HIV status are both stigmatized in Peruvian social and medical settings, and are associated with psychological distress, risky sex, and suboptimal

adherence to ART [9-12], all of which exacerbate health disparities. High drug and alcohol use in this population [13 14] further undermine adherence to ART [15], and are associated with increased sexual risk-taking [16-18]. This underscores the importance of providing efficacious HIV risk-reduction interventions for MSM that address stigma and substance use challenges.

Despite the many studies that show a significant relationship between substance use and risky sex, this relationship is not uniformly supported [19-22]. The conflicting findings are likely due to methodological limitations of retrospective data collection techniques such as timeline follow-back that are plagued by recall bias, and prospective techniques such as diary entries that have low reliability [23 24]. A review of event-level research on substance use and sexual risk behavior showed that most studies were cross-sectional, employing either timeline follow-back or prospective daily diary entries, both of which are fraught with recall and social desirability bias [25]. There is thus a need for more robust event-level methodologies, such as ecological momentary assessment (EMA), which can capture real-time data on risk behaviors and pertinent contextual factors.

EMA refers to a collection of assessment techniques such as behavioral observations, self-monitoring, and ambulatory physiological monitoring to measure behaviors, activities, or event-level data in real-world contexts and in real-time [26-28]. EMA studies involve recurring assessments albeit with varying degrees of intensity [29 30]. Since EMA occurs in 'real-time' or 'near real-time' and in one's natural environment, recall bias is markedly reduced and ecological validity is strengthened [31]. Substance use behaviors, being discrete and episodic, lend themselves well to event-level assessments [32]. Theories of drug use highlight the importance of internal cues, situational factors, and social context, all of which cannot be replicated in experimental settings and are subject to recall bias in retrospective studies. EMA is therefore ideally placed to examine substance use as data is recorded on an event-level basis using short-term recall [27 33]. This method, however, has not been leveraged with HIV+ MSM to examine concurrent substance use and risky sex in South America.

With the ubiquity of mobile technology, mobile phones can be used to conduct EMA efficiently [34 35]. They can: 1) increase participants' privacy and enable ease of participation; 2) upload data in real-time via wireless networks, preventing data loss; and 3) provide automatic time-stamping, geocoded data and metadata to monitor participant compliance [36]. Studies have shown that smartphones are feasible for collecting substance use data among HIV+ individuals and MSM [37 38], and that HIV+ Peruvian MSM report high acceptability of technology-based studies to collect health behavior data [39]. To date, however, there is no published research on the development or use of smartphone-based EMA for examining health behaviors among key HIV populations – such as MSM and transgender women – in South America.

Effective interventions, especially just-in-time (JIT) interventions, require rigorous data on concurrency of risk behaviors so that they can be correctly targeted. To achieve this long-term goal, the first step is to develop a smartphone-based EMA application (app) to collect event-level data on substance use and sexual risk behaviors among HIV+ MSM, and conduct usability testing with the target population – this is the scope of the current study. We developed an EMA smartphone app in English and Spanish languages, designed specifically to collect daily data on substance use, sexual risk behaviors, mood, and behavioral intention to engage in future risk behaviors. Feasibility and acceptability of the app were assessed among a representative sample of the target population of

HIV+ MSM using a three-phase protocol: (1) in-person usability test of the app, (2) 10-day field test, and (3) debriefing focus group. This formative work lays the foundation for a larger-scale EMA of substance use and sexual risk behaviors among HIV+ MSM.

Methods

This study involved developing and testing a smartphone app to collect EMA of daily substance use, unprotected sex, medication adherence, mood, and intent to engage in future risky behaviors. The EMA app, labeled PEMAA (Peru Ecological Momentary Assessment App) was developed on CommCare, an open-source app development platform. After alpha testing of the app, PEMAA was tested with the target population of 10 Peruvian HIV+ MSM. The sample size was determined by referring to the usability testing literature that recommends a sample of 3-5 [40] and using the cumulative binomial probability formula to estimate usability test sample size, which estimates 8 to be sufficient to discover usability issues [41]. Taking the upper limit, we supplemented this by 20% to account for dropouts during the 10-day field test, resulting in a sample size of 10.

Testing of PEMAA was conducted in three phases – (1) in-person usability test of the app, (2) 10-day field test, and (3) debriefing focus group. During the in-person usability test, participants were audio-recorded while they downloaded and tested the app in front of the research team, after which they completed a quantitative assessment of app usability. Participants then field-tested the app for 10 days during which daily reminder messages were sent to participants to remind them to enter data on the app. Finally, at the end of field testing, a virtual focus group was convened to assess participants' collective experience of using PEMAA and feedback for app improvement.

App assessment data collected across the three phases were mixed methods in nature. The in-person usability test yielded both qualitative and quantitative data, the field test yielded data on user analytics, and the focus group yielded qualitative data on user experience and feedback. The study team was assisted by two research assistants – RA1 aided in developing and alpha testing PEMAA, and RA2 helped conduct the three phases of the usability testing in Lima, Peru. The study protocol and recruitment materials, including the informed consent forms, were approved by the Clinical Trials Unit at the National University of San Marcos.

Participants

Usability testing of PEMAA was conducted with 10 HIV+ MSM participants, recruited from the clinical site of the Centro de Investigaciones Tecnológicas, Biomédicas y Medioambientales (CITBM) or the Center for Technological, Biomedical and Environmental Research – a non-governmental research organization based in Lima, Peru. CITBM is located on the main campus of the National University of San Marcos and provides health services to approximately 1600 HIV+ MSM. Participants were eligible for this study if they were: (1) 18 years or older; (2) born male; (3) self-reported HIV+ status; (4) self-reported drug/alcohol use and condomless sex in the past 60 days; and (5) currently owned an Android smartphone. At least two participants were selected with substantial alcohol use or drug addiction severity to allow for usability testing with the most impaired participants.

Participants signed an informed consent form prior to the three-phase usability test. They were informed about voluntary participation and could choose to withdraw from the study at any stage. Participants were compensated with 25 Peruvian Soles (\$7) for phase I, 50 Soles (\$14) for phase 2, and 25 Soles (\$7) for the focus group phase. They were also given bus tokens for traveling to the research site.

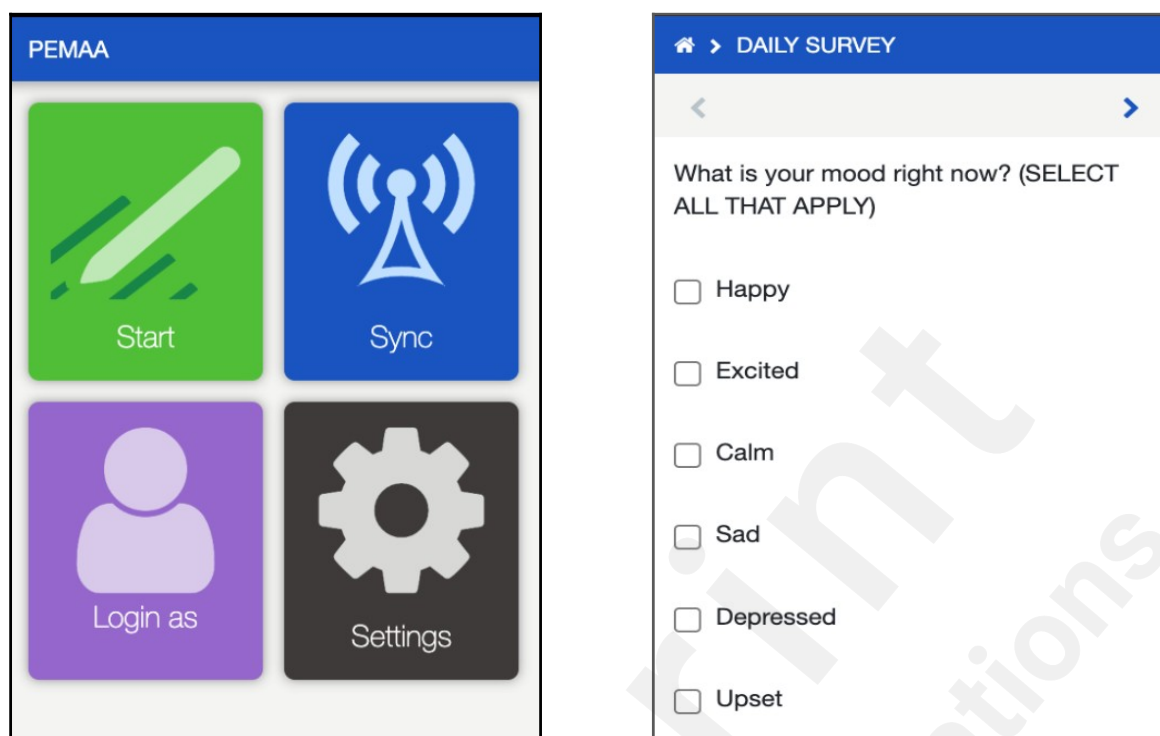
Materials

Ecological Momentary Application

PEMAA was developed on CommCare, an open-source app development platform. CommCare applications can only be downloaded on Android platforms; this is however not considered a limitation since Android is the most popular mobile platform in Peru, with 90.4% of market share [42]. For the purpose of field testing in Peru, we developed a bilingual (English, Spanish) version of PEMAA. Participants could use the app settings to toggle between the two versions depending on their preference. The daily survey contained 13 questions on alcohol and drug use, unprotected sex, ART adherence, mood, and the likelihood of engaging in future risky behaviors (EMA Survey, Multimedia Appendix 1). The survey contained branching logic for specific questions on alcohol, drugs, and unprotected sex. For instance, if a participant responded positively to having consumed alcohol in the past 24 hours, the survey would branch to additional questions on drinking behavior before continuing to the rest of the survey.

As part of the app development process, initial versions of PEMAA were alpha tested by our research team. Alpha testing is an internal acceptance assessment and is a precursor to beta testing and/or field testing [43 44]. The aim is to identify potential technical barriers by checking accuracy, simulating user interaction, and incorporating initial feedback. The app design was kept purposefully simple and streamlined to ensure ease of use; for instance, the home screen had four distinct color-coded buttons (Figure 1). Clicking on the green start button would lead to the survey (Figure 2), with each question laid out in separate pages. After making changes and confirming accuracy of the app, we created the version of PEMAA to be tested by the set of real-world users in Peru.

Figure 1. Screenshot from PEMAA (English Version)



mHealth App Usability Questionnaire (MAUQ)

To quantitatively assess the usability of PEMAA, the mHealth App Usability Questionnaire (MAUQ) [45] was utilized. The MAUQ consists of 14 items scored on a 7-point Likert scale (1 “disagree” to 7 “agree”) and taps into dimensions of user satisfaction, ease of use, and usefulness. It has been utilized in multiple mHealth studies to appraise app usability [46 47]. In the present study, the MAUQ was translated into Spanish and back-translated to establish face validity [48], thus yielding the MAUQ-S scale (Table 1). The MAUQ-S indicated a uni-dimensional scale with acceptable internal consistency (Cronbach’s $\alpha = .81$).

Table 1. mHealth App Usability Questionnaire in English (MAUQ) and Spanish (MAUQ-S)

MAUQ Items	MAUQ-S Items
The app was easy to use.	La aplicación fue fácil de usar.
It was easy for me to learn to use the app.	Me fue fácil aprender a usar la aplicación.
The navigation was consistent when moving between screens.	La navegación fue consistente al navegar de una pantalla a otra.
The interface of the app allowed me to use all the functions (such as entering information and viewing information) offered by the app.	La interfaz de la aplicación me permitió usar todas las funciones de la aplicación (por ejemplo, ingresar información o ver información).

Whenever I made a mistake using the app, I could recover easily.	Al cometer algún error en la aplicación, me fue fácil corregirlo.
I like the interface of the app.	Me gusta la interfaz de la aplicación.
The information in the app was well organized, so I could easily find the information I needed.	La información en la aplicación está bien organizada, permitiéndome encontrar la información que necesito con facilidad.
The app adequately acknowledged and provided information to let me know the progress of my action.	La aplicación registró y me mostró adecuadamente progreso el de mi actividad.
I feel comfortable using this app in social settings.	Me siento cómodo al utilizar la aplicación en un lugar publico.
The amount of time involved in using this app has been convenient for me.	La cantidad de tiempo requerida para usar esta aplicación me ha sido conveniente.
I would use this app again.	Usaría esta aplicación de nuevo.
Overall, I am satisfied with this app.	En general estoy satisfecho/a/e con la aplicación.
The app would be useful for my health and well-being.	Esta aplicación me sería útil con mi salud y bienestar.
I could use the app even when the Internet connection was poor or not available.	Pude usar la aplicación aún cuando la conexión de internet estaba débil o no disponible

Procedure

Upon recruitment, participants were provided with a paper copy of the informed consent form and additionally were read the instructions to by RA2. Post informed consent, participants were instructed to download PEMAA on their smartphones. A tutorial video (Multimedia Appendix 2) was created to help navigate participants through downloading and installing PEMAA. To protect privacy and confidentiality, participants were instructed to enter false data while they were observed interacting with the app, both during the in-person usability test and 10-day field test. All informed consent forms and information materials were written in both English and Spanish, although the Spanish version was primarily utilized on site in Peru.

Phase I: Usability Testing

The usability test involved observing each participant using the app, which included various actions such as logging into the app with their assigned user credentials, initiating the EMA survey, reading and responding to each of the questions, and navigating the app. Participants were instructed to verbalize their actions and responses while interacting with the app and entering data. After each participant had tested the app, they were asked questions about the app, specifically its ease of use, navigability, design, suitability of content, and their motivation to use the app. They were also asked for their feedback towards the EMA survey items. The verbalized usability test and the

responses to interviewer questions were recorded using a digital audio recorder. The audio files were later transcribed and translated into English before being analyzed to assess the user experience of PEMAA. At the end of this phase, participants completed the 14-item MAUQ-S. Finally, they were given instructions to field test PEMAA for 10 days.

Phase II: Field Testing

To test the EMA app in real-world settings, each participant was instructed to fill out the survey on PEMAA and enter false data for a period of 10 days. False data was preferred because the purpose of the study was to test the functionality of PEMAA and acceptability of the EMA survey items, and not to collect any personally identifiable health and behavioral data at this stage. However, every single participant indicated their willingness to enter real data and did do so; this was confirmed in the debriefing focus group. Participants indicated their individual preference for when to receive daily reminders to enter data on PEMAA; this was programmed accordingly for each participant.

Phase III: Debriefing Focus Group

In the final phase, a focus group discussion was conducted on Zoom to debrief participants and discuss their experience using PEMAA such as ease of use, ability to enter data, intrusiveness of the EMA survey items, and overall satisfaction with the app and EMA survey. Other topics discussed in the focus group included privacy concerns and suggestions to improve the app, along with feedback on the sensitive nature of the survey items related to substance use and sexual risk behaviors. Finally, participants were asked to provide input on including stigma questions in the daily EMA survey. The focus group was conducted in the presence of a moderator and a note-taker, and was guided by a discussion protocol. The session started with the moderator noting that the proceedings would be recorded, and encouraged participants to switch off their cameras and change the names on their profiles, so as to maintain a degree of anonymity. The discussion was audio-recorded, transcribed, and translated into English prior to being analyzed.

Data Analysis

Quantitative Data

Quantitative data were generated via two ways: (1) the mHealth App Usability Questionnaire-Spanish (MAUQ-S) scale completed by participants during the in-person usability test of PEMAA, and (2) user analytic data generated during the 10-day field test of PEMAA which included date, time, and duration of app use, along with the quantitative assessments of the survey items for each of the 10 days. The MAUQ-S and 10-day micro-longitudinal data were consolidated and analyzed using SPSS version 28.0 [49]. Despite participants' disclosure of real data during the 10-day field test, we chose not to present those results for two reasons – (1) IRB approval was obtained primarily for the usability test and user experience of participants with PEMAA and did not cover

behavioral health data; and (2) analysis of micro-longitudinal health behavior data is not meaningful for a small sample.

Qualitative Analysis

The usability testing interviews and focus group discussion were transcribed using a professional transcription service, and then translated into English using DeepL Translator – a neural machine translation software, and Google Translate. Both sets of translations were consolidated and reviewed, and discrepancies reconciled by a native Spanish speaker. The qualitative data were coded using NVivo Version 1.7 [50], and analyzed using thematic analysis which is a method for identifying and analyzing patterns or themes [51].

Two coders conducted multiple readings of the transcript files to generate codes. After independently creating themes and sub-themes, they reviewed and refined themes and sub-themes until they reached consensus. With qualitative data, reliability is associated with consistency. A margin of variability in results is accepted, given the method and epistemological logistics consistently generate ontologically similar data but may differ in richness and quality within similar dimensions [52]. It is important to note that although the same individuals participated in the usability testing and focus group, we cannot attribute the same identification number to participants.

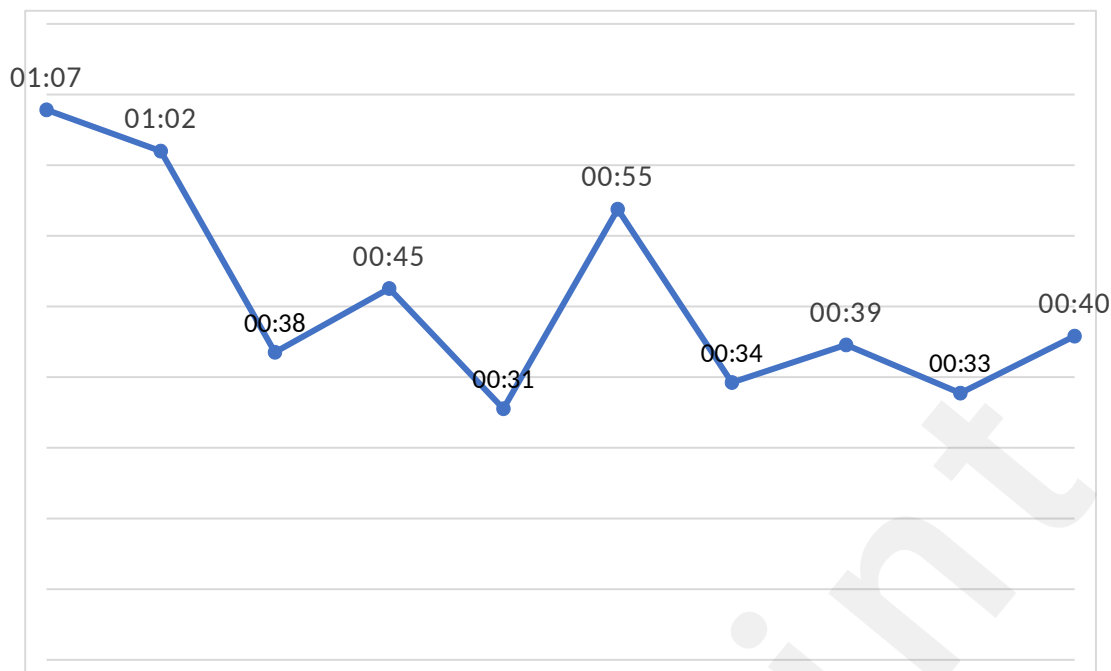
Results

User Analytics, Engagement and App Acceptability

With respect to user perceptions of PEMAA, results showed high acceptability ($M = 6.4/7.0$, $SD = 0.62$) on the MAUQ-S scale. The MAUQ-S score ranged from 4.93 to 7.0 across participants and from 5.5 to 6.8 across all 14 items, thus indicating high user satisfaction, ease of use, and usefulness of the app. When considering user analytic data from the 10-day field test, average compliance was high at 93% despite participant burden to enter sensitive health data on a daily basis. Half of the participants completed 100% of the daily surveys while two participants had the lowest compliance at 80%.

Considering usage data for EMA survey completion for each of the 10 days of field testing, participants completed the assessment in an average of 44 seconds ($SD = 16$ seconds). Seven participants completed the EMA survey in less than a minute each day of the 10-day testing period. Overall, average time to completion was higher in the first two days (Figure 2) and decreased over the remaining days, indicating an experiential effect among study participants.

Figure 2. Screenshot from PEMAA (English Version)



Qualitative Findings

Theme 1: Usability

The literature defines usability as the extent to which users can use a product or system to achieve required goals with effectiveness, efficiency, and satisfaction in a specified context [53]. Users will find the product useful if it takes less time to complete a specific task, is easy to understand, and meets their expectations [54]. Participants described PEMAA to be convenient with respect to usage and time. As part of the usability theme, we uncovered two sub-themes – ‘Ease of Use’ and ‘EMA Survey Completion Time’ – leading users to use the app effectively to answer sensitive behavioral health questions.

Most participants reported that they found the app simple and easy to navigate. Some participants appreciated the intuitive design of the app as it was easy to operate and made their experience seamless.

For my part, it has also been easy to use, I haven't seen any complications. [Participant 2, FG]

Yes, it's intuitive. it guides you by itself with every option you take. You don't necessarily have to do it on every button because the very use of it, the colors, maybe, or the actions you take makes you automatically understand what it's for. Yeah, I'm fine with that. Easy to use. [Participant 8, UT]

Participants also appreciated that accessing the app to complete the EMA survey was time-efficient. They reported that it did not take much time to answer questions and they could easily take the survey anywhere.

The time it takes to answer the questions, all good. It doesn't even take five minutes.
[Participant 7, FG]

Yes, I could do it because it's quite simple. In fact, it doesn't take any time at all. You can do it when you are in the car or when you are having breakfast, watching something or other, or when you are taking, especially the medication. That same time you can do the survey.
[Participant 3, UT]

Theme 2: EMA Survey Questions

Participants commented that the survey questions were clear and concise, and several agreed that the questions were direct and easy to answer. For example, one participant mentioned that he found the questions to be short and realistic.

They are not invasive questions; they are very direct and very easy to answer. Yes, the only thing I think is that the questions are well formulated, they are understood quite quickly.
[Participant 3, UT]

Furthermore, participants found the flow of questions logical as it first assessed the individuals' mood and then their substance use and risky sexual behavior. This seemed to mitigate discomfort with some of the more pointed questions.

To me at least, I found it interesting that, first, it tries to address the mood of the person who is going to answer the questions before answering the directed questions themselves, because it asks you if you are happy, angry, how do you feel now, and then come the questions that are directed. [Participant 1, FG]

Theme 3: User Interface

Many participants commented on the user interface, stating that it is "attractive," "interactive," and "user-friendly." The user interface is defined as what the user sees when interacting with the technology [55]. The appearance of smartphone apps has been found to impact the degree of user engagement and app use, with more appealing designs facilitating greater use [56]. An interface that is easily understood by users has also been suggested to impact mobile app usability by decreasing the cognitive effort required when using the app [57].

Easy. The interface is very user friendly. It's easy to understand and connect. [Participant 7, UT]

Although some participants reported finding the design to be attractive, others suggested that the design of the application could be more appealing. They suggested adding graphics or images

would make the interface more “eye-catching,” and one participant suggested the addition of characters or avatars. Although most participants reported finding PEMAA easy to use, some issues were raised related to navigability. One participant suggested that enlarging the font and changing the color might make the app more navigable. Comments were also made that progression through the survey questions should be automatic rather than prompted by the user. Additionally, while the app was programmed to toggle between English and Spanish languages, the language option did not apply to the log-on page which was in English by default; participants recommended this option be made available.

I see that you have the option to change the language, which is important. Everything is in English in the settings, but I can change the language. Only the language changes for the questions, not for the information in the application. [Participant 9, FG]

Theme 4: Willingness to Use the Application

One area which is under-researched in mHealth usability studies is the duration individuals would be willing to participate in EMA studies and interventions [58]. When questioned about this, one participant noted that it would depend on the amount of time each individual has. This was reflected in other participants' responses, as some indicated they would use the app continuously, while another stated approximately two weeks would be the maximum amount of time they would adhere to utilizing the app. Another participant said they would use the app on their own for a maximum of 30 days but would use it for a longer period with reminders to complete the surveys. Several participants agreed that reminders would be essential for prolonged use.

With respect to filling out the questions, it depends on one's time per se, because you have to take into account that some people also study or work, in my case. You also have to take into account the issue of reminders. For my part, it was difficult for me to fill them out, if it were not for the reminder sent to me by WhatsApp. Yes, I filled them out by myself, because I was resting or something, but if they wanted, for example, to fill it out for constant months, they would have to add the reminder through the same application [Participant 7, FG]

Participants had been instructed to enter false data for the purpose of field-testing the app but all ultimately admitted to entering real data. In response to their decision to input real data, participants explained that they were comfortable using real data as personally identifying information would not be collected. This finding is significant, as privacy and security have been found to be particularly important to users of health-related mobile apps [59] and may be of further importance to users with often-stigmatized conditions such as HIV. The quotes below show how participants were able to compartmentalize this issue and felt comfortable entering sensitive health data.

They're not asking me for personal data, whether it's names or exact identity. So there wouldn't be any discomfort. [Participant 2, UT]

If it's for a health study or whatever, there's no problem. [Participant 6, UT]

Theme 5: Recommendations

Participants volunteered multiple recommendations along with feedback, which formed this overarching theme. Many of the recommendations were uncovered in the focus group as by then, participants had 10 days of use experience with PEMAA. The three sub-themes – incentives to use the app, content of questions, daily reminders – indicated how participants visualized higher compliance and better engagement in using the app on a daily basis.

When asked what might motivate regular use of PEMAA to enter health data, participants suggested incentives such as discounts to local restaurants or saunas. Another participant pointed out that vouchers might be more motivating. One participant explained that an incentive could be offered after a certain number of days of survey completion.

For a number of days. If you complete a number of days you get a discount on a hamburger, Bembos, something like that. A Burger King, a KFC or a discount. [Participant 1, FG]

The EMA questions were phrased in a detailed way to avoid confusion; however, participants suggested that they could be shortened for efficiency, which has been suggested to be a key component in promoting usability (Zapata et al., 2015). Additionally, although participants reported that questions were easy to answer, responding to the same questions every day can get monotonous, suggesting that questions be paraphrased to read differently but collect the same information.

The surveys were very interesting, but what I would have liked is that the questions would have changed every day during the 10-day journey, each day would have been asked certain questions, but they were interesting and easy to answer. [participant 6, FG]

One participant even suggested that additional questions could be included to collect more information, such as the frequency of drug and alcohol use or the reason for using drugs and alcohol.

Maybe you can have some more information. There may be something else, not intrusive, but maybe more information can be gathered. It could be perhaps caregiving, sexual relations. Even, the type of drugs that are used or how often alcohol or drugs are used, for what reasons, or it could be maybe for fun or maybe for addiction. I don't know if they're relevant, but it might be a little more informative. [Participant 7, UT]

The key to compliance was attributed to the daily reminders participants received, prompting them to open PEMAA and complete the EMA. Many participants stated that daily reminders were important especially if they are expected to fill out the survey for a longer period. Without a reminder, one participant said 30 days would be the maximum amount of time they would be willing to use the app. Several participants expressed that they would prefer receiving push notifications from the app rather than through WhatsApp.

The reminder, that the application gives you the option to remind you, because it gave us reminders, I think, by a WhatsApp bot, but the ideal thing would be for the application itself to allow you to remember it, to send you an alert, "You have to fill it out". [Participant 1, FG]

Table 2. Summary of Themes and Sub-Themes

<i>Themes</i>	<i>Sub-themes</i>
Usability	Ease of Use
	EMA Survey Completion Time
EMA Survey Questions	
User Interface	
Willingness to Use the Application	
Recommendations	Incentives to Use App
	Content of Questions
	Daily Reminders

Discussion

This was the first culturally-specific EMA app designed to collect sensitive daily risk behavior data from HIV+ MSM in Peru. Usability tests indicated high acceptability of the app, yielding a high score of 6.4 out of 7.0 on the MAUQ-S scale. Most importantly, despite participant burden to enter sensitive health data on a daily basis, compliance was 93%, with some participants having 100% compliance. The simplicity of PEMAA and ease of use in entering data likely influenced compliance. Feedback from the debriefing focus group reinforced these findings, indicating that participants perceived the app as simple, intuitive, and easy to navigate. They also highlighted that the survey questions were concise and direct, allowing for ease of completion. The logical flow of questions, beginning with mood assessments and then progressing to inquiries about substance use and sexual behaviors, appeared to reduce discomfort with more sensitive items. From a methodological point of view, while the antecedent of mood questions to risk behaviors was to explore causation effects, this structure may have encouraged more truthful responses while positively influencing compliance.

Compliance is a significant issue in EMA studies due to significant participant burden in entering event-level data; this is particularly stark involving substance users. A recent meta-analysis showed that EMA compliance in studies with substance users had a pooled compliance rate of 75% across all studies, regardless of frequency or duration of assessments; this is lower than the recommended 80% compliance rate [60 61]. Low compliance is associated with missing data which has a detrimental effect on statistical power and can skew inferences made on the basis of systematic bias [62]. While this study tested PEMAA for only 10 days and the compliance rates should be considered within this context, qualitative feedback from participants indicates that they are willing to use the EMA app for longer durations, albeit with daily reminders and potential financial incentives. The potential long-term application of PEMAA in this population of HIV+ MSM sets the stage for a larger-scale EMA of substance use and sexual risk behaviors.

Amidst the acceptability of PEMAA, valuable feedback was obtained regarding app design and navigability. The app was designed to be purposely simple with intuitive navigation; however, recommendations were made on enhancing the appearance of the app via images, graphics, and color to avoid monotony. Although participants reported feeling comfortable answering sensitive questions, it was noted that some individuals might be embarrassed and therefore, the ability to skip questions should be included. Recommendations were also suggested to make progression faster by automatically progressing to subsequent pages upon response selection. Our team made this design decision to enable thoughtful selection of responses and to allow participants to change their answer before progressing. All of the above recommended changes can be easily made on the CommCare platform; however, one limitation of the platform is the inability to modify standardized options, such as changing language options on the app installation and log-on pages. Thus, although PEMAA is supported both in English and Spanish, and can potentially be adapted to multiple languages, the use of English on the log-on page by default, likely poses a usability issue.

Most notable in this study was that despite being instructed to input false data during field testing, every single respondent acknowledged entering genuine, real-world data. This behavior underscores the degree of trust participants placed in the smartphone app as well as their comfort in providing sensitive health information. Participants affirmed that perceived data security and anonymity fostered their willingness to provide sensitive health information. This finding is significant, as privacy and security have been found to be particularly important to users of health-related mobile apps [59] and may be of further importance to those experiencing stigma such as HIV+ MSM and other marginalized communities.

Limitations

Within the context and value provided by this formative research, we must also address some limitations. While the sample size was justified for usability testing, the duration of the testing period was relatively short, meaning that long-term feasibility and sustained compliance were not evaluated. Furthermore, although participants reported comfortable providing sensitive health information, social desirability bias cannot be ruled out. Finally, despite having the ability to modify PEMAA based on participants' recommendations, some technical recommendations such as applying language options to the app log-on interface, are reliant on the CommCare development platform.

Future Work

Having shown feasibility and acceptability of PEMAA in the target audience of substance-using high-risk HIV population in Peru, the next step is to conduct a larger-scale EMA to (1) assess compliance over an extended period of time, and (2) establish a temporal link between contextual factors like mood and stigma, and substance use, sexual risk-taking, and medication adherence. In the focus group, we gauged feasibility of adding stigma questions in the daily EMA; this was strongly supported by the study participants. Expanding the app to include questions on stigma and discrimination will provide explanatory power to the complex interactions between substance use, sexual risk, and health behaviors. The long-term goal seeks to develop JIT interventions to improve ART adherence and reducing concurrent substance use and risky sex among HIV+ MSM.

Conclusion

This formative work demonstrates the usability and acceptability of a culture-specific smartphone-based EMA app to collect recurring event-level data on substance use and sexual risk behaviors among HIV+ MSM. The findings show that trust, simplicity, and logical survey design contribute to app compliance and satisfaction. While certain design limitations must be addressed, the results lay an important foundation for scaling EMA use in behavioral health research especially for marginalized and stigmatized populations. Ultimately, this work represents a critical step towards the development of JIT interventions designed to reduce risk behaviors and improve health outcomes in high-risk HIV populations.

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Conflict of Interest

None declared.

Abbreviations

ART: antiretroviral therapy
EMA: ecological momentary assessment
mHealth: mobile health
MSM: men who have sex with men
PWH: people with HIV
SUD: substance use disorder

Multimedia Appendix 1

EMA survey instrument in English and Spanish.

Multimedia Appendix 2

App installation video tutorial for users in Spanish.

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Supplementary Files

Multimedia Appendixes

EMA survey instrument in English and Spanish.

URL: <http://asset.jmir.pub/assets/faeb5812af514552e23adbbb42900d5d.pdf>

App installation video tutorial for users in Spanish.

URL: <http://asset.jmir.pub/assets/410a5013cfc7938e4e3163a93cd15ef1.mp4>