Original Article

Facilitators and barriers to incorporating digital technologies into HIV care among cisgender female sex workers living with HIV in South Africa

William X. You[1], Carly A. Comins[1], Brooke A. Jarrett[1], Katherine Young[2], Vijayanand Guddera[3], Deliwe R. Phetlhu[4], Ntambue Mulumba[3], Mfezi Mcingana[2], Harry Hausler[2], Stefan Baral[1], Sheree Schwartz[1]

[1]Johns Hopkins Bloomberg School of Public Health, Key Populations Program, Center for Public Health and Human Rights, Department of Epidemiology, Baltimore, USA; [2]TB HIV Care, Cape Town, South Africa; [3]TB HIV Care, Durban, South Africa; [4]University of Western Cape, School of Nursing, Cape Town, South Africa

Contributions: (I) Conception and design: H Hausler, S Baral, S Schwartz, K Young, DR Phetlhu,CA Comins, WX You; (II) Administrative support: H Hausler, S Baral, S Schwartz, K Young, DR Phetlhu, V Guddera, N Mulumba, M Mcingana, CA Comins, WX You; (III) Provision of study materials or patients: V Guddera, N Mulumba, M Mcingana, K Young, CA Comins, WX You; (IV) Collection and assembly of data: V Guddera, N Mulumba, M Mcingana, K Young, DR Phetlhu, CA Comins, WX You; (V) Data analysis and interpretation: BA Jarrett, CA Comins, S Schwartz, WX You; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: William X. You, MSPH. 175 Huguenot St, PH503, New Rochelle, NY 10801, USA. Email: willxt92@gmail.com.

Background: An estimated 44–69% of female sex workers (FSW) in South Africa are living with HIV, among whom 39% are virally suppressed. Digital technologies—increasingly advanced and accessible to marginalized populations—present new opportunities to improve the HIV care continuum. The objective of this study was to explore potential facilitators and barriers to incorporating mobile phones and advanced technologies (e.g., biometric identification methods, mobile phone applications for social media and other uses, and chatbots) to deliver HIV-related interventions to cisgender FSW living with HIV in Durban, South Africa.

Methods: Four semi-structured, focus group discussions (FGDs) were conducted with 22 cisgender FSWs in December 2018. Participants were recruited from the ongoing Siyaphambili trial using maximum variation sampling to optimize diversity in participant age and sex work venue. FGDs were audio recorded in isiZulu, and translated and transcribed into English. Transcripts were inductively coded using thematic analysis and sub-themes were iteratively refined to connect and evaluate the saliency of codes.

Results: Phone ownership was motivated by a desire to remain safe and to connect with family, peers, and clients. When FSW did not have access to a mobile phone, they reported sharing phones with their peers, though sharing only occurred under specific conditions. Still, to integrate mobile phones into HIV care, FSW identified consistent access to mobile phones as a key barrier. Mobile phone turnover due to frequent selling of phones to meet other financial priorities, substance use, and theft were common. To integrate advanced technologies into HIV care, FSW identified convenience, security, and additional opportunities for social support as the main facilitators. For example, FSW described how biometric identification at clinics could eliminate the need to retain a clinic card. FSW also described how chatbots could easily set medication alarms or be available to assist in emergencies. Barriers for advanced technologies included maintaining privacy, potential threats to security, and cost.

Conclusions: FSWs were receptive to digital technologies for HIV care and beyond, but they also described many barriers such as inconsistent phone ownership and threats to privacy. As phone ownership grows and HIV programs increasingly leverage digital tools, strong considerations are needed to ensure the most vulnerable are not systematically excluded.

Keywords: Sex work; telemedicine; biometric identification; South Africa; HIV; continuity of patient care; technology

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Introduction

In 2019, there were 8.3 billion mobile phone subscriptions worldwide—greater than the global population (1). In low and middle income countries, the number of subscribers is growing exponentially, and increasingly accessible mobile technologies offer opportunities to easily connect with a large number of patients to provide individual-level support (2). Sending text messages as treatment reminders, calling patient mobile phones to promote behavior change, and using phone applications (apps) to track test results and appointment details can positively impact individual antiretroviral therapy (ART) adherence (3-14).

Marginalized populations face complex, multi-level barriers to accessing, adhering to, and remaining in HIV care (15,16). As a result, more intensive support and tailored interventions are needed to reach HIV viral suppression (17). Female sex workers (FSW) are one marginalized population who are often difficult to engage in care due to the stigma and criminalization of their work (18). Of the 121,000–167,000 women in South Africa estimated to be engaged in sex work, approximately 60% are living with HIV and an estimated 39% are currently on ART (19-23). Models suggest that approximately 20% of new infections among adults in South Africa are acquired by FSW or their clients (24).

To improve the health and quality of life for FSW and prevent HIV onward transmission, adherence to ART among FSW is needed. Documented determinants of ART non-adherence among FSW include alcohol and substance use, dissatisfaction with healthcare facilities and healthcare workers, depression, discrimination and stigmatization, and limited social support (25). The mediators of poor ART uptake, non-adherence, and retention in HIV treatment programs vary across individuals, highlighting the need for patient-responsive and adaptive intervention strategies (26). Individual-level interventions such as motivational messages, monitoring, and behavior change tools used in tailored face-to-face support can be modified for delivery via mobile devices (2). Furthermore, mobile technologies are accessible across time and space, permitting intervention delivery and interaction to capture attention when it is most relevant (2).

An abundance of literature demonstrates that mHealth interventions may improve ART adherence in adult, reproductive-aged populations (27-30). There are existing programs in South Africa and other sub-Saharan African countries utilizing mHealth strategies to engage FSW in HIV prevention treatment; most of whom use text message as the primary mode of delivering mHealth interventions (31-33). However, the appropriateness of delivering HIV-related interventions to FSW via mobile phone and other advanced digital technologies, has not been well studied to date. Thus, the objective of this qualitative study was to identify potential facilitators and barriers faced by cisgender FSW living with HIV in South Africa in using mobile phone and other advanced digital interventions for HIV care.

Methods

Study setting

This qualitative study was embedded in the Siyaphambili trial in Durban, South Africa (26). Recruitment of FSW participants was led by FSW peers employed at TB HIV Care, a non-governmental organization offering free HIV care and treatment to FSW in the eThekwini (Durban) metropolitan municipality. Participants were recruited at the TB HIV Care drop-in centers and sex work venues. For context, to-date we note that 63.5% (n=395/622) of the participants randomized into the trial reported phone ownership at enrollment.

Study participants

Women were eligible for the qualitative study if they had been randomized into and actively engaged in the Siyaphambili trial. To be eligible for randomization into the trial, cisgender women over 18 years of age had to be living with HIV, diagnosed at least six months prior, be ART-naive or on first line ART initiated at least two months prior, be non-virally suppressed as defined by South African standard of Care (≥50 copies/mL), selling sex as their main source of income, and not pregnant at enrollment (26). Sex work was defined as exchanging sex for money or goods as their main source of income, following TB HIV Care's programmatic definition. We used maximum variation sampling to include FSW of varying age groups, educational levels, income

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levels, operating sites, and current relationship status, with aims to generate findings that are applicable to different FSW groups and individuals (34).

Data collection

Focus group discussions (FGDs) were conducted using a semi-structured interview guide developed in English, translated into isiZulu, and reviewed by FSW peers. The guide was focused on barriers and facilitators to receiving digital health interventions. The guides probed around mobile phone ownership and access as well as mobile phone use generally and for HIV care and treatment support. The guide also explored perceptions on the use of more advanced digital technologies, including biometrics as tools for identification, mobile phone apps, and chatbots. To ensure consistent understanding of chatbots for all participants, the iPhone Siri was demonstrated at each FGD as an example. A female research assistant with >15 years of qualitative experience led the FGDs. The first author (WX You), a behavioral scientist with content knowledge in technological innovations, supported the research assistant with logistics during the FGDs. FGDs occurred in a private space at the TB HIV Care drop-in center, were conducted in isiZulu and audio-recorded. Each FGD ranged from 60–90 minutes. FGDs continued until similar themes about facilitators and barriers around mobile phone use and advanced digital technologies emerged. Four FGDs were ultimately conducted.

All participants provided written informed consent prior to participation. Precautions taken to address participants' anonymity were included in the consent form and risks were communicated with participants during the consenting process. This study was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board and the University of the Western Cape Biomedical Research Ethics Committee. Reimbursement was provided to participants to account for their time and the cost of transportation (100ZAR=$7 USD).

Data analysis

Our analysis is guided by a combination of the Technology Acceptance Model and Theory of Planned Behavior (C-TAM-TMB) (35). This model was chosen due to its flexibility in examining both old and new digital technologies and accommodating both experienced and inexperienced users. Factors that support and hinder the uptake and engagement in digital interventions are explored to shape HIV treatment and care intervention and program development. Further details on our application of this framework can be found in the supplementary materials.

Audio-recordings were transcribed verbatim and translated into English. Transcripts were inductively coded using thematic analysis. First, WXY identified emerging themes through iterative, open coding, and developed a codebook based on emergent themes. The codebook was reviewed and updated based on transcript reviews and consensus from WXY, CAC, and BAJ. Repeated reading, discussion, and coding was conducted by WXY and BAJ in Atlas.ti version 8 (36). After independently double-coding all transcripts, WXY and BAJ convened, resolved discrepancies, and agreed upon final coding. Themes presented were consistent across transcripts, and final selection of representative quotations was an iterative process by WXY, BAJ, CAC, and SS.

Results

Twenty-two black FSW participated in the FGDs and varied in their demographics, including age, education, income, ART status and relationship status (*Table 1*). The majority (82%, n=18) of participants owned a mobile phone.

A modified C-TAM-TPB model, adapted to the findings, is presented in *Figure 1*. Primary themes included both facilitators and barriers to incorporating mobile phones into HIV care (*Table 2*), and facilitators and barriers to utilization of other advanced digital technologies within HIV care (*Table 3*). Sub-themes are described in detail below and outlined alongside additional supportive quotes in *Tables 2* and *3*.

Mobile phones for HIV care: facilitators

FSW expressed positive attitudes and a willingness to use mobile phones to engage in HIV care. Patterns of ownership varied and were reflected in participant attitudes toward the utility of mobile phones, behavioral intentions for phone use and perceived ability to retain a mobile phone (*Figure 1*). Mobile phone ownership as well as the type of mobile phone owned (i.e., a smart or feature phone) depended first on participants' individual stability and current life situation and then, preference, and utility. Though some participants indicated using one phone for her family and boyfriend and another phone for her clients, other participants owned a single phone for all uses.

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Table 1 Demographic characteristics of study participants

Demographics	n=22	%
Age (years)		
<30	8	36
30–39	9	41
40–49	3	14
50–59	2	9
Site of operation		
Indoor	11	50
Outdoor	11	50
On ART at baseline		
Yes	18	82
No	4	18
Baseline viral load results		
Between 50–1,000 copies/mL	6	27
>1,000 copies/mL	16	73
Income (ZAR), last 30 days		
<1,000	3	14
1,000–1,999	4	18
2,000–2,999	3	14
3,000–3,999	8	36
4,000–4,999	2	9
≥5,000	2	9
Highest level of education completed		
Some primary school	1	5
Primary school complete	1	5
Some secondary school	15	68
Secondary school complete	5	22
Current relationship status		
Single	12	55
Steady partner (husband/boyfriend)	10	45
Owns mobile phone(s) at time of FGDs		
Yes	18	82
No	4	18

Among participants who did not currently or consistently have a mobile phone, FSW reported sharing mobile phones with their peers, friends, boyfriends, and family members. Some participants indicated that they shared or borrowed a physical phone while others used the phone number of another person, who then passed on messages to the participant. FSW valued reliability as a key characteristic when considering with which person to share a phone.

"*That's why I give people the number of someone that I am certain will always be available to answer.*"

Most participants reported moving frequently between cities and locations within cities (i.e., sex work venues) and highlighted the importance of having a phone to stay connected with friends, family, and clients. Mobile phone ownership and use among FSW also emerged as a desired security measure. When necessary and in reference to troublesome clients or law enforcement, mobile phones provide a tool for FSW to account and look out for one another's safety.

Mobile phones for HIV care: barriers

Lack of continuous mobile phone or phone number retention due to financial instability, substance use, and theft emerged as key barriers to using mobile phones for HIV care among FSW. Collectively, these barriers negatively impacted FSW's perceived behavioral control surrounding mobile phone use (*Figure 1*).

In addition to frequent cycling of a single physical phone, FSW expressed failing to retain the same subscriber identity module (SIM) card over time and hence, phone number.

"*I will not lie*, *most of us [keep our phones for] one week or two weeks.*"

Inconsistent ownership or access was often a product of immediate needs, substance use and theft. FSW reported frequent selling or pawning mobile phones for cash to meet their basic needs. FSW also reported personally selling or trading mobile phones for substances, including alcohol and drugs. Moreover, conducting sex work under the influence emerged as increasing the risk that FSW would lose their phones or have them stolen. FSW also reported having clients or FSW peers steal their phone, even when not under the influence of drugs or alcohol. Participants' perceived risk of losing their mobile phones both influenced FSWs' intentions to own specific types of mobile phones and overall mobile phone use.

Advanced technologies for HIV care: facilitators

Facilitators of using advanced technologies for HIV care included familiarity with the technologies and perceptions

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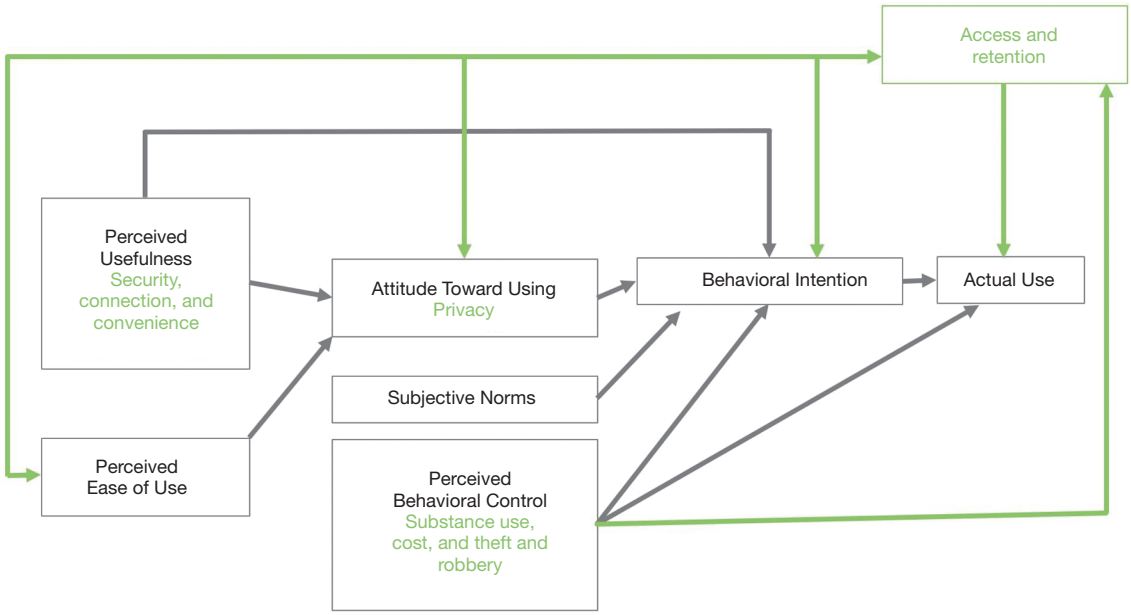

Figure 1 Adapted and applied combined technology acceptance model and theory of planned behavior (C-TAM-TPB). Words in black are the original C-TAM-TPB constructs. Words in green are adapted and applied construct elements.

that these advanced technologies would offer convenience, security, and social support.

Participant familiarity with advanced technologies (e.g., biometrics, social media, messaging apps and chatbots) varied among participants and influenced their perceived ease of using advanced technologies. Participants most commonly expressed knowledge of social media apps and search engines. A few reported utilizing apps like Facebook and WhatsApp tools to support their sex work and expressed greater perceived ease of use (*Figure 1*). No participant had previously used biometrics for identification prior to study participation nor had interacted with a chatbot.

Participants perceived biometric identification tools useful for their convenience and ability to offer security. Specifically, participants imagined a use case where biometric identification was introduced alongside a national electronic medical record system, hence eliminating the need for clinics to ask FSW for clinic cards or other means of identification before dispensing ART. Participants noted that while clinic or identification cards can be lost, inaccessible, manufactured or falsified, biometric identification is more specific and difficult to forge. Participants felt that biometric identification would ensure ART could only be received by the participant herself, preventing fraudulent ART pick-ups.

Preferences and concerns around the types of biometric tools varied. Some participants did not prefer fingerprint scanning due to their long nails. Others worried voice recognition would not consistently work with a voice deepened after drinking.

Social media tools were also cited as back up measures to stay connected within their network, especially if mobile phones are lost, stolen, or sold. After seeing the various capabilities of Siri, participants also imagined scenarios where chatbots might act as a tool to protect themselves in case of an emergency, like kidnapping.

"*WXY*: "*[Siri] is a voice communication system. Siri, where am I right now?*"

Siri: "*You are at [address].*"

PARTICIPANT: "*Wow, I am lost for words.*"

INTERVIEWER: "*How would Siri be of assistance to you?*"

PARTICIPANT: "*[Siri] could help if a client kidnapped me, blindfolded me, and I am in an unknown area. If I manage to free myself and do not know where I am, I would check my location [with Siri] and let them know where to find me.*"

Participants also imagined that chatbots like Siri could provide various types of social support. For instance, participants imagined chatbots providing informational social support and improving ART adherence by providing reminders about clinic appointments and daily medication reminders. Additionally, participants imagined Siri as being useful as an emotional social support tool, highlighting the

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Table 2 Facilitators and barriers to using mobile phones

Primary themes	Sub-themes	Quotes
Facilitators	Access	
	Ownership	*"INTERVIEWER: Those girls who have phones, how many phones do they have? PARTICIPANT: Most ladies have two phones. INTERVIEWER: Two phones for what? PARTICIPANT D: She will tell you this is for clients, it's my working phone. This is my family phone and my boyfriend. When she is with her boyfriend, she will switch off the working phone. She will be able to talk freely when she is home and with her boyfriend."*
	Sharing with family, partners, or peers	*"I do share a phone with my friend. She does not have a problem. We share it whenever I need something. She does not have a problem."*
	Motivation to own a phone	
	Safety	*"Most of us do have cell phones. They do help a lot because we had a problem at [sex work venue]. We had problems with the police. I stand next to Spar (supermarket). I would call one lady to tell her that they should run. That person will then tell others and disappear like that."*
	Connection with family, peers, and clients	*"Since I don't stay at home [with my family] and I am renting [away from them], it is easy for [my family] to call me when something happens at home. I am also able to call them easily. Clients can easily access me. A case manager [from this study] can easily call me. They can remind me of my dates for treatment, and they would check on you, even when there are meetings. They can easily get to you. So the phone is so important to me."*
Barriers	Continuous retention	
	Phone	*"Some [FSW] do have phones, and some do not because they cannot keep them."*
	Phone number	*"I do not even do a SIM [card] swap because I would just tell myself that I did not have any important contacts on that number. I would just notify my family that I am using a different number."*
	Threats to retention	
	Financial instability	*"I pawn my phones. Sometimes I might be injured or my family needs money for electricity. I would not have any other option but to pawn it for around two hundred rand to buy electricity. I would then tell myself that I would buy a better one."*
	Substance use	*"No, I pawn [my phone] for rock (cocaine). So if you want one piece, it's one hundred rands. You have to take out your phone or something. Because, no one can just give you e-e-h something for — give you something for hundred rands for free! No! Or fifty rands for free. If you want two pieces, take out your phone. Maybe they will see that okay this phone is perfect — can give you maybe ten pieces with it. That means you are sorted [handled]."*
	Loss	*"I would like to have a phone but I lose them… I usually drink; sometimes I give it to someone to keep it for me, then I drink, and I hear that it is ringing but now no one answers it." "[Stealing from other FSW] happens, because … you can see this: I'm smoking, you are not smoking. You see now that I'm too high. I'm too high. I have a phone. I have everything. I have money. Hey, what are you going to do? You are going to steal my phone and go and sell it somewhere."*
	Theft	*"I leave a smartphone in my room and bring the cheap phone with me [to work] because we sometimes — we get robbed by clients. They would steal from our bags, steal our money. So, you then leave a smartphone at home and bring the cheap phone with you."*

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Table 3 Facilitators and barriers to using advanced digital technologies

Primary themes	Sub-themes	Quotes
Facilitators	Perceived ease of use	
	Familiarity	*"PARTICIPANT: Most of the time I use it to get clients. Like on Facebook, you can search for clients there. INTERVIEWER: You search for clients? PARTICIPANT: Yes, you can post that you work as a sex worker and you are looking for clients around Pinetown or around Durban if you are in Durban. That is what I do when I am at home and I do not feel like going to stand to the streets."*
	Perceived usefulness	
	Convenience	*"I will be fine with [biometrics], because sometimes you may find that your card for collecting pills get stolen and you end up struggling to collect your treatment, but the thumb is with you all the time and everywhere you go." "The thumb [fingerprint scanning] is good as she has mentioned that if maybe I have travelled far away from Durban, I will use my thumb to get my treatment."*
	Security	*"So, as we go all over the place, the use of fingerprints will help so that we don't have to carry the card. This will also help protect our information. It can protect us from fraud; these days people can use other people's information for fraudulent activities. There is no one that can commit a crime using your details [with your thumb], as you have the thumb. You know that wherever you are, your thumb is with you."*
	Social support	*"[Siri] will remind me when it is time to take my medication. This means that I will be able to adhere to my treatment." "I would be able to share secrets with Siri. I would say 'Siri, yesterday someone took me and left me stranded. He did this and that to me. I am stranded on the side of the road'. Siri would give me time, and I would continue and regain my strength because of Siri."*
Barriers	Privacy	*"I thought it [iris scan] is for criminal records. Maybe if you're guilty, it is the way they want to catch you."*
	Security	*"People die because of WhatsApp and such platforms. A man would invite you [over Whatsapp]. You meet somewhere, and he takes you to a hotel. How many women have been found lying dead somewhere in a hotel room because of these men they meet through their phones? I am against all of this."*
	Cost/internet access	*"PARTICIPANT: Does she need data in order to work? INTERVIEWER: Yes, it is on data. PARTICIPANT: But now your Siri is expensive." "If you say it is only on smartphones, not all of us can afford smartphones. I use a cheap phone I bought from Pep [general store] for one hundred and thirty-nine Rands. [Siri] cannot remind me, because this programme only works with smartphones."*

possibility of Siri listening and offering a feeling of being understood.

"*When I leave the clinic and I am told that my next visit will be on a certain day, I could easily just ask Siri to remind me. We want Siri. If that's how this program works, then it is really good.*"

Advanced technologies for HIV care: barriers

Initial concerns about privacy emerged regarding fingerprint and iris scanning, because these are also used by the police to track people who commit crimes. However, after explaining the system linkages needed to connect the medical and criminal justice databases, participants expressed less apprehension. Other privacy concerns emerged based on participants' personal experiences, the experiences of other FSW, and fearing potentially negative outcomes. One participant specifically expressed that a Google Maps location image included her standing outside of the sex work venue.

"*Yes. When you browse [street name] on Google Maps, it shows you the car parked there. I would appear standing there*

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as well. The lounge [sex work venue] as it is, and it will even reveal you sitting there on the side of the road with your legs wide open. [Google Maps] will show you in whatever clothes you are wearing."

Security and cost emerged as other salient concerns around advanced technology use. For example, using messaging apps like WhatsApp to find clients was perceived as potentially dangerous. Furthermore, many advanced technologies require smartphones and internet access, which have associated costs and access issues that were identified as a barrier.

Discussion

This study explored the perceived usefulness, perceived ease of use, attitudes towards and control over digital health technologies for engagement in HIV treatment support. While most FSW are motivated to own or have access to a mobile phone, nearly all FSW expressed difficulty retaining phones and phone numbers as a result of financial instability, substance use, and theft. When discussing advanced technologies such as biometrics, apps, and chatbots, FSW showed interest because of their potential to provide convenience, security, and social support. However, FSW also expressed that privacy and cost would be barriers to use. Given that preferences and opinions of technology varied by individual, integrating technology into HIV care will require more patient-centered, tailored approaches for FSW.

FSW described currently using mobile phones frequently to remain safe and connected; future interventions should leverage perceived utility of the technology to offer social and clinical support to FSW via phone. Given the highly stigmatized nature of sex work and that digital interactions can be anonymous, immediate, and tailored, mHealth interventions may effectively supplement in-person healthcare venues for FSW (37-40). Previous research demonstrates that people may even be more willing to disclose personal information via phone than in-person (41). mHealth tools have also made it possible for researchers to engage previously unreachable members of marginalized populations by easing the burden of participating, as in the LITE study with the transgender community (42). Providing data via a mobile phone may also be more acceptable than clinician-led, in-person interviews, since some key populations living with HIV often face discrimination from physicians and nurses in South Africa (40).

Despite these opportunities, FSW described difficulties consistently retaining their mobile phone and phone number, which will require creative solutions for FSW to benefit from digital HIV care. FSW know how to perform SIM swaps to maintain their phone number while changing phones, but were unmotivated to do so. Given that SIM cards are relatively inexpensive, FSW could be provided multiple SIM cards or new SIM cards, as needed, at in-person clinical or research visits. Alternately, phone numbers could be collected anew from engaged FSW at each in-person visit. FSW stated that they notified certain people when getting a new phone number; researchers and clinicians could also request and provide incentives to be notified whenever FSW change their contact information. However, this would need to be balanced against motivating FSW to provide false change in contacts to acquire incentives such as airtime credit. Additionally, many FSW described at least one key peer who was "reliable" and consistently maintained a single phone number over time. In lieu of delivering tailored messaging to each FSW, future mHealth interventions could deliver generic health information to key, consenting FSW peer champions who could then share that information with her peers (43). Future research should explore whether social media or other accounts (e.g., Facebook, WhatsApp) independent of a phone number would be an acceptable way to maintain contact with FSW as their phone numbers change.

Participants described other FSW-specific HIV care use cases for advanced technologies like biometric identification, social media, and chatbots. To aid in addressing FSW mobility and the impact on treatment interruptions (44,45), replacing clinic cards with biometric identification at least within sex work-supported services would better accommodate FSW, who may have their cards stolen and are highly mobile while traveling between clients. It should be noted, however, that a national electronic medical record system would be necessary for biometric identification tools to work across clinics. Beyond biometrics, FSW described how social media connected them with other FSW and clients beyond text messaging. In one study with FSWs in Zimbabwe, a messaging app successfully supplemented in-person group therapy (46). Finally, FSW described how chatbots may offer adherence support and emotional support by "listening" to FSW. Chatbots are increasingly being used to address adherence and mental health issues (47), including preliminary research around the use of chatbots for HIV and mental health in low and middle income countries (29,48). Chatbots are particularly promising for FSW and other stigmatized populations because of their focus on users, nonjudgment, and ability to

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help users cognitively reappraise negative experiences (49).

FSW heavily emphasized potential risks about privacy when receiving digital interventions. FSW are criminalized globally, and thus, privacy in many ways equals safety (50-53). Many FSW in this and other studies compartmentalize their work from their personal lives by using separate phones for each; others only share their phones with trusted friends and family members (54). To avoid undesired disclosures about their work or HIV status, future interventions via mobile phone, social media, or chatbots may need to use coded language or have password protection to access certain apps or sections of apps, in line with other successfully implemented HIV strategies (55-57). There may also be unintended consequences such as inadvertent disclosure or poor intervention uptake among those sharing a phone. Clear messaging around the purpose of the technology will be necessary before engaging FSW in digital interventions.

Despite the promise of digital interventions, these data suggest that, at this stage, digital support for HIV care alone will be insufficient for many FSW, and multi-component interventions including in-person strategies are likely to be the most effective. Until phones and other technologies are affordable and retainable for most FSW, HIV programmatic and research activities implemented digitally are likely to underrepresent those most vulnerable.

Technology should complement but not replace personalized, in-person care. For FSW specifically, formative research from the Siyaphambili trial demonstrated that knowing and visiting FSW at their place of work were perceived as critical for long-term engagement (58). FSW also reported that clinic and research staff should know their technology usage preferences (e.g., text vs. call, timing, type of staff member) to best leverage phones as part of HIV care (58).

Several limitations should be considered when evaluating the results of this study. This qualitative study was conducted prior to the holiday seasons, where large numbers of people migrate within the country. This movement of populations may have potentially affected the overall diversity of participants and reduced the overall numbers of women who engaged in the FGDs. Moreover, although the findings apply to FSW in Durban, they are not expected to be generalizable across settings. Generalizability is, however, rarely the intention of qualitative data collection. Participants benefited from being familiar with iris scanning biometrics through the Siyaphambili trial, but discussion around other biometric data collection tools, social media platforms or artificial intelligence technologies would likely have been hypothetical for some participants as not all participants had experience engaging with each of these digital technologies.

Conclusions

FSWs were receptive to digital technologies for HIV care and beyond, but they also described many barriers. Future work must strongly consider digital privacy and ensure that the most vulnerable are not systematically excluded from programming and research requiring technology. There is an inherent tension between the benefits of anonymous, general messages that enhance privacy should phones be shared or seen by clients or family, and personalized efforts to foster greater social support. At this point, digital tools such as mobile phones, biometric identification, mobile apps, and chatbots should only supplement but not replace in-person HIV research and care for FSW in South Africa. While there is extraordinary potential for healthcare interventions leveraging technology among FSW, substantial barriers remain and the views, opinions, and participation of FSW must be primary throughout the design and implementation.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures were approved by the University of the Western Cape Biomedical Research Ethics Committee and the JHSPH institutional review board.

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Conceptual model combined technology acceptance model and theory of planned behavior model (C-TAM-TPB)

One aim of the Siyaphambili study is to explore opportunities in using digital health technologies to improve HIV treatment adherence and retention in care for FSW. To scale up utilization of digital health interventions, there is need for user-centered evaluation to understand the usage behaviors. Specific to this study, what makes FSW use or not use digital health technologies.

Theory of reasoned action (TRA), proposed by Fishbein and Ajzen, posits attitudes toward behavior and subjective norms affect one's behavioral intention (59). It gained widespread acceptance in technology acceptance research; many studies have demonstrated this theory to be useful in predicting and explaining behaviors of technology use (60,61). Theory of planned behavior (TPB) (*Figure S1*), as an extension of TRA, introduced perceived behavior control as the third construct that affects one's behavioral intention (62). Perceived behavior control is determined by the availability of skills, resources, and opportunities, as well as the perceived importance of those skills, resources, and opportunities (63). When the barriers to using digital health seem too high, the user's intention to use it may reduce, hence decreasing the chance of actually using digital health.

The technology acceptance model (TAM) (*Figure S2*) is a model researchers have been using to predict acceptance and use of a new system. TAM suggests that perceived usefulness and perceived ease of use are the determinants of users' behavioral intention to use technology, with the intention to use serving as a mediator of actual usage (61). Similar approaches can be used to evaluate acceptance and use of novel digital health in low-resource settings (64).

This qualitative sub-study drew heavily from the C-TAM-TPB model (*Figure S3*), shown below, which is a combined model of the Technology Acceptance Model and Theory of Planned Behavior (35). While some FSW may have more experience with digital health technologies and familiar with their functionalities and usefulness, others may have little exposure to digital health. This model was chosen due to its flexibility in examining both old and new digital health technologies, and also because it accommodates both experienced and inexperienced users. The C-TAM-TPB was used to inform the analysis and interpretation of the results.

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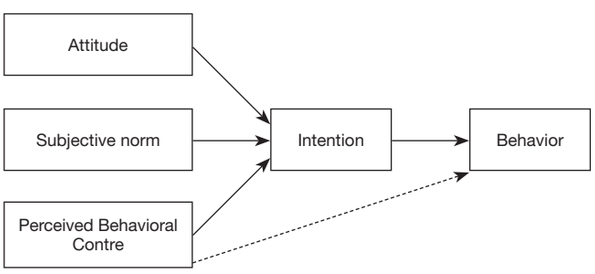

Figure S1 Theory of planned behavior (TPB) (62).

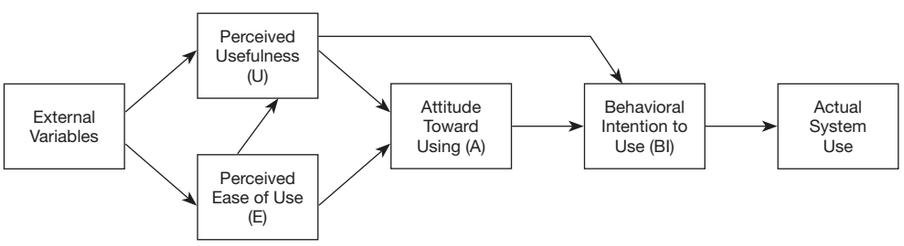

Figure S2 Technology acceptance model (TAM) (61).

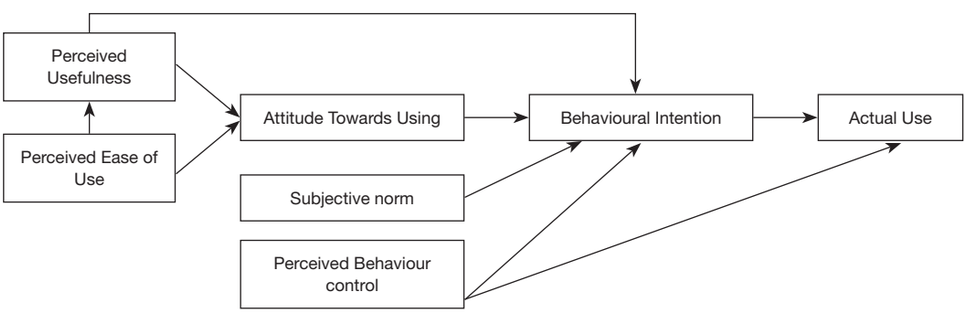

Figure S3 Combined technology acceptance model and theory of planned behavior model (C-TAM-TPB) (35).