Taking a Human Computer Interaction lens to Person-based design of an interactive digital intervention to support men to test for HIV and link to care in a resource-constrained setting: A case study

Anya Zeitlin, Thulile Mathenjwa, Thembelihle Zuma, Sally Wyke, Philippa Matthews, Nuala McGrath, Janet Seeley, Maryam Shahmanesh, Ann Blandford

Submitted to: JMIR Formative Research
on: August 12, 2024

Table of Contents

Taking a Human Computer Interaction lens to Person-based design of an interactive digital intervention to support men to test for HIV and link to care in a resource-constrained setting: A case study

Anya Zeitlin[1*]; Thulile Mathenjwa[2, 3*] MA; Thembelihle Zuma[2, 4]; Sally Wyke[5]; Philippa Matthews[2]; Nuala McGrath[2, 4, 6]; Janet Seeley[2, 7]; Maryam Shahmanesh[2, 8]; Ann Blandford[1]

[1]UCL Interaction Centre University College London London GB
[2]Africa Health Research Institute Durban ZA
[3]School of Public Health University of Cape Town Cape Town ZA
[4]School of Nursing and Public Health University of KwaZulu Natal Durban ZA
[5]School of Social and Political Sciences University of Glasgow Glasgow GB
[6]Faculty of Medicine and Faculty of Social Sciences University of Southampton Southampton GB
[7]London School of Hygiene & Tropical Medicine London GB
[8]Institute for Global Health University College London London GB
[*]these authors contributed equally

Corresponding Author:
Thulile Mathenjwa MA
Africa Health Research Institute
719 Umbilo Rd, Krith building 3rd floor
Durban
ZA

Abstract

Background: The Person Based Approach is a method to incorporate users' perspectives from the earliest stages of design for interactive digital health interventions (IDHIs). However, it does not explicitly describe the iterative stages of design and evaluation that are essential in moving from early planning to deployment. For this, we draw on methods from Human–Computer Interaction (HCI). Such methods have been developed for a variety of different contexts and drawing on different resources.

Objective: To reflect on the adaptation and synthesis of the Person Based and HCI approaches to developing IDHIs. We describe a case study in which we used both approaches to develop EPIC-HIV1, an IDHI to support men living in a resource-constrained setting, rural KwaZulu-Natal, South Africa. EPIC-HIV was intended to support men to make an informed choice about whether to take an HIV testing and, if necessary, engage in the care process.

Methods: We conducted a retrospective analysis of the documentation generated during the development of EPIC-HIV1 including findings about requirements, design representations and the results of iterative rounds of testing. The analysis sought to construct a narrative on the process, the outcomes, and the strengths and limitations of the design and evaluation methods applied. We also present the design of EPIC-HIV1 and an account of considerations when designing for hard-to-reach people in such settings.

Results: The Person Based Approach was applied to deliver a first prototype. This was effective in identifying key messages to convey and how to manage issues such as user privacy, but the resulting prototype was judged by the team not to be engaging for potential users and there were concerns about whether the design was inclusive of people with low digital or health literacy. We therefore drew on methods from HCI to iteratively refine the app. Working with representatives of the local community, we conducted three cycles of refinement, adapting and retesting EPIC-HIV1 until no further changes were needed. Key changes included making it clearer what the consequences of selecting particular options in the app were and changing wording to minimize misconceptions (e.g., that the app would test for HIV).

Conclusions: Techniques for developing IDHIs need to be situationally appropriate. The Person Based Approach enabled us to establish both empirical data and theory to design the content of EPIC-HIV1 but it did not directly address questions about interaction design that were necessary to make the app usable and effective for the intended users; HCI techniques that were tailored to the setting enabled us to refine the app to be easy for men with little familiarity with digital technologies to use within the constraints of the setting. Iterative testing ensured the app was engaging and that the intended clinical messages were communicated effectively.

(JMIR Preprints 12/08/2024:65185)
DOI: https://doi.org/10.2196/preprints.65185

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?
✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.
2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?
✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Taking a Human Computer Interaction lens to Person-Based design of an interactive digital intervention to support men to test for HIV and link to care in a resource-constrained setting: A case study

Anya Zeitlin[1*], Thulile Mathenjwa[2,3*], Thembelihle Zuma[2,6], Sally Wyke[4], Philippa Matthews[2], Nuala McGrath[2,5,6], Janet Seeley[2,7], Maryam Shahmanesh[2,8], Ann Blandford[1]

[1]UCL Interaction Centre, University College London, London, United Kingdom
[2]Africa Health Research Institute, Durban, South Africa
[3]School of Public Health, University of Cape Town, Cape Town, South Africa
[4]School of Social and Political Sciences, University of Glasgow, Glasgow, United Kingdom
[5]Faculty of Medicine and Faculty of Social Sciences, University of Southampton, Southampton, United Kingdom
[6] School of Nursing and Public Health, University of KwaZulu-Natal, Durban, South Africa

[7]London School of Hygiene & Tropical Medicine, London, United Kingdom
[8]Institute for Global Health, University College London, London, United Kingdom
[*]These authors contributed equally

Corresponding author – Thulile Mathenjwa, MA; email address: thulile.mathenjwa@ahri.org

Keywords:

Person Based Approach, HIV, resource-constrained settings, digital intervention, user-centred design, behaviour change techniques, digital health

Abstract (up to 450 words)

Background: The Person Based Approach is a method to incorporate users' perspectives from the earliest stages of design for interactive digital health interventions (IDHIs). However, it does not explicitly describe the iterative stages of design and evaluation that are essential in moving from early planning to deployment. For this, we draw on methods from Human–Computer Interaction (HCI). Such methods have been developed for a variety of different contexts and drawing on different resources.

Objective: To reflect on the adaptation and synthesis of the Person Based and HCI approaches to developing IDHIs. We describe a case study in which we used both approaches to develop EPIC-HIV1, an IDHI to support men living in a resource-constrained setting, rural KwaZulu-Natal, South Africa. EPIC-HIV was intended to support men to make an informed choice about whether to take an HIV testing and, if necessary, engage in the care process.

Methods: We conducted a retrospective analysis of the documentation generated during the development of EPIC-HIV1 including findings about requirements, design representations and the results of iterative rounds of testing. The analysis sought to construct a narrative on the process, the outcomes, and the strengths and limitations of the design and evaluation methods applied. We also present the design of EPIC-HIV1 and an account of considerations when designing for hard-to-reach people in such settings.

Results: The Person Based Approach was applied to deliver a first prototype. This was effective in identifying key messages to convey and how to manage issues such as user privacy, but the resulting prototype was judged by the team not to be engaging for potential users and there were concerns about whether the design was inclusive of people with low digital or health literacy. We therefore drew on methods from HCI to iteratively refine the app. Working with representatives of the local community, we conducted three cycles of refinement, adapting and retesting EPIC-HIV1 until no further changes were needed. Key changes included making it clearer what the consequences of selecting particular options in the app were and changing wording to minimize misconceptions (e.g., that the app would test for HIV).

Conclusions: Techniques for developing IDHIs need to be situationally appropriate. The Person Based Approach enabled us to establish both empirical data and theory to design the content of EPIC-HIV1 but it did not directly address questions about interaction design that were necessary to make the app usable and effective for the intended users; HCI techniques that were tailored to the setting enabled us to refine the app to be easy for men with little familiarity with digital technologies to use within the constraints of the setting. Iterative testing ensured the app was engaging and that the intended clinical messages were communicated effectively.

Introduction

The focus of this paper is on the application of methods for developing usable, effective and engaging interactive digital health interventions (IDHIs), taking as a case study an intervention, EPIC-HIV1, intended to enable men to make an informed choice about testing for HIV and, if necessary, engaging with care. Recent literature shows that men are left behind in the response to HIV [1] as evidenced by the low uptake of HIV testing, prevention and treatment compared to women [2-4].

Challenges of developing interactive digital health interventions

As digital technologies become more affordable, their potential is increasingly leveraged for IDHIs in a broad range of settings including both affluent and resource-constrained communities, in urban, rural and remote settings [5]. There are numerous challenges with implementing IDHIs such as ensuring interventions keep pace with rapidly changing technical systems [6], supporting usability needs [7], ensuring that the intervention is accessible across devices and operating systems [8], and making it culturally appropriate [9]. These challenges are exacerbated in resource-constrained settings where there are variable infrastructural constraints and levels of familiarity with technology within intervention cohorts.

There are few accounts of how to develop usable, engaging and effective digital health interventions. One of the most widely cited is the Person Based Approach (PBA) to intervention development [10]. Although this approach describes the need to iteratively test prototypes with end users, it omits detailed discussion of interaction design and how to integrate this into the intervention development process. Conversely, the Human Computer Interaction (HCI) literature rarely addresses issues that matter to population health researchers such as content design, clinical effectiveness, scalability and sustainability [11]. The aim of the work reported here was to reflect on the integration of PBA and HCI methods taking as a case study the design and deployment of an app called EPIC-HIV1 (Empowering people through Informed Choices for HIV). EPIC-HIV1 aimed to encourage men in rural South Africa to test for HIV and understand the value of engaging with HIV care early as well as primary prevention [12]. We developed EPIC-HIV 2 to support engagement in care for those who did not link. However, this paper focuses on the EPIC-HIV 1 the application which supports HIV testing in men.

EPIC-HIV1 description and rationale

EPIC-HIV1 is one of two interventions in the Home-based Intervention to Test and Start (HITS) trial that sought to increase HIV testing and linkage to care among men in rural South Africa using micro incentives and male-targeted decision support [4, 13]. The trial was implemented in a rural setting in uMkhanyakude district in northern KwaZulu-Natal, South Africa using the Africa Health Research Institute (AHRI) HIV surveillance platform [14]. Fieldworkers from AHRI conduct an annual cycle of visits to households in the community.

The decision support was operationalized into a tablet-based app called EPIC-HIV. Digital interventions such as apps are particularly suited for stigmatized health conditions like HIV because they provide users with privacy and anonymity [15, 16]. Additionally, they offer interventionists the ability to deliver uniform messages, free from embarrassment which affects people’s ability to communicate consistent and accurate information [16]. Several studies have used digital technology to increase uptake of HIV testing and medication adherence [17, 18]. These studies found that both mobile and tablet-based HIV interventions are feasible, acceptable and effective methods to engage hard to reach populations [19]. However, the studies do not discuss how the interventions were designed or developed.

EPIC-HIV comprises two apps: EPIC-HIV1 was offered at the point of HIV testing and EPIC-HIV2 was offered to men who had tested HIV positive but had not yet linked to care. The main objective of EPIC-HIV1 was to encourage men to test for HIV. The secondary objective was to introduce the value of linking to care early and adhering to antiretroviral therapy (ART). For this case study, we focus on the development of EPIC-HIV1. EPIC-HIV2 is described elsewhere [12]. Both apps were developed drawing on self-determination theory (SDT) [20] to support three basic psychological needs (autonomy, competence and relatedness) and increase men’s internal motivation to test for HIV and link to care where necessary. We also drew on the Behaviour Change Taxonomy (BCTv1) proposed by Michie et al.[21]. They list 93 techniques that can be applied in behaviour change interventions, clustered into 16 groups (e.g., goals and planning; feedback and monitoring; social support, providing a credible source of information and advice). Many of these are potentially relevant to the design of digital interventions: for example, goal setting, providing instructions on how to perform a behaviour, or providing a credible source.

EPIC-HIV1 was designed to be delivered by fieldworkers during their annual household visits during the AHRI health and demographic surveillance setting for an individual behaviour and health related survey and dry blood spots for HIV antibody testing as well as the offer of point of care HIV tests and linkage to care [14]. The concept was that the app would be implemented on the fieldworker tablet and offered to men prior to the HIV test offer. The fieldwork visits are carried out in a systematic cycle where they are allocated a number of households to cover in a week. Due to this time constraint, user interaction with EPIC-HIV1 was allocated 10 minutes.

Interdisciplinary approaches to developing IDHIs

The World Health Organization advocates the application of user-centred design to develop IDHIs to ensure that they are effective, accessible, acceptable, and user-friendly [22]. This often requires the collaboration of professionals from health and HCI backgrounds. Healthcare professionals, including epidemiologists and social scientists, contribute clinical expertise, theoretical understandings of behaviour change and health outcome evaluation techniques. HCI professionals contribute user centred design methodologies which are applied to understand user needs, inform the design of digital technologies and evaluate them in terms of usability and user experience [11, 23, 24].

Despite the clear benefits of interdisciplinary collaboration, there are well recognized challenges [11, 23] relating to the academic heritage of the respective disciplines. Professionals from healthcare backgrounds put greater emphasis on measuring the effectiveness of IDHIs and evaluating outcomes. HCI professionals focus on iterative design, including alternative design representations and formative evaluation, to ensure the digital technology is usable and acceptable. As a result, interdisciplinary teams experience divergent approaches to timelines, measuring effectiveness and understanding success.

Literature in the field of behaviour change tends to limit the integration of HCI methods, and therefore collaboration, to discrete stages in the intervention development process: e.g., evaluating usability and engagement once a prototype has been developed [25].

In the HCI literature, there is more interest in exploring the boundaries of the role HCI should play in IDHI design and evaluation, rather than identifying discrete stages in the development process in which HCI approaches can be applied. Klasnja et al. [26] describe the contribution of HCI as being to understand ‘how and why’ IDHIs work, rather than measuring outcomes. In contrast, Smith et al. [27] advocate using a value chain analysis to evaluate how short term (proximal) metrics relate to long term (distal) behaviour change and health outcomes.

Marcu et al. [28] describe the Patient-Clinician-Designer framework, which seeks to integrate multiple perspectives throughout the design process. In understanding the clinical context, patient needs and technical constraints, they ensure that digital interventions meet the needs of all stakeholders and are therefore more likely to be successful when implemented [28]. They describe this in reference to a mental health application, but it has also been applied to the development of applications for stigmatised conditions including HIV [29]. Similarly, Blandford [11] highlights the value of applying HCI methodologies throughout intervention development to facilitate more systematic trade-offs between what is needed for users and clinicians and what is feasible in the context.

Person-Based Approach and integration with HCI methods

We used the PBA to inform the design and development of EPIC-HIV, drawing on SDT in planning content. The PBA [10, 25] provides guidelines on how to use qualitative research methods to identify psychosocial factors that influence the effectiveness and acceptability of interventions. Using rich qualitative research at every stage of the intervention development process facilitates an investigation of the beliefs, attitudes, needs and situations of participants in the intervention. Yardley et al., [10] propose that using PBA can make an intervention more relevant, persuasive, accessible and engaging.

The person-based approach consists of four stages [25] (Figure 1). Whilst Yardley et al., recognise the value of gathering user input, the focus is largely on how that input informs the development of content and intervention goals. They do not describe the HCI, or user centred design, methods that should be applied or how to translate the intervention goals and content into a usable and engaging digital product.

Planning	Design	Development	Implementation
Identify behaviours, needs and challenges that need to be addressed	Create guiding principles to summarise the objectives	Develop all intervention compenents	Evaluate in real-life context, modify and improve for future contexts
Review and synthesise previous studies of user experiences in similar interventions	Identify features of the intervention that are central for achieving the objectives	Evaluate and optimised from the user perspective	Use mixed methods process analyses to identify further modifications to improve acceptability, feasibility, and effectiveness
	Create personas, scenarios and use cases	*Observe and analyze user reactions to every elements of the intervention and iteratively improve the intervention*	

Figure 1:Stages in the person-based approach to intervention development and the suggested user centered design activities [25]

Blandford [30] proposes an integration of PBA with established HCI design methods to address these issues (Figure 2). The key extensions to PBA are earlier consideration of design possibilities, the identification of design representations (e.g., design patterns and task structures) and iteration between as well as within stages.

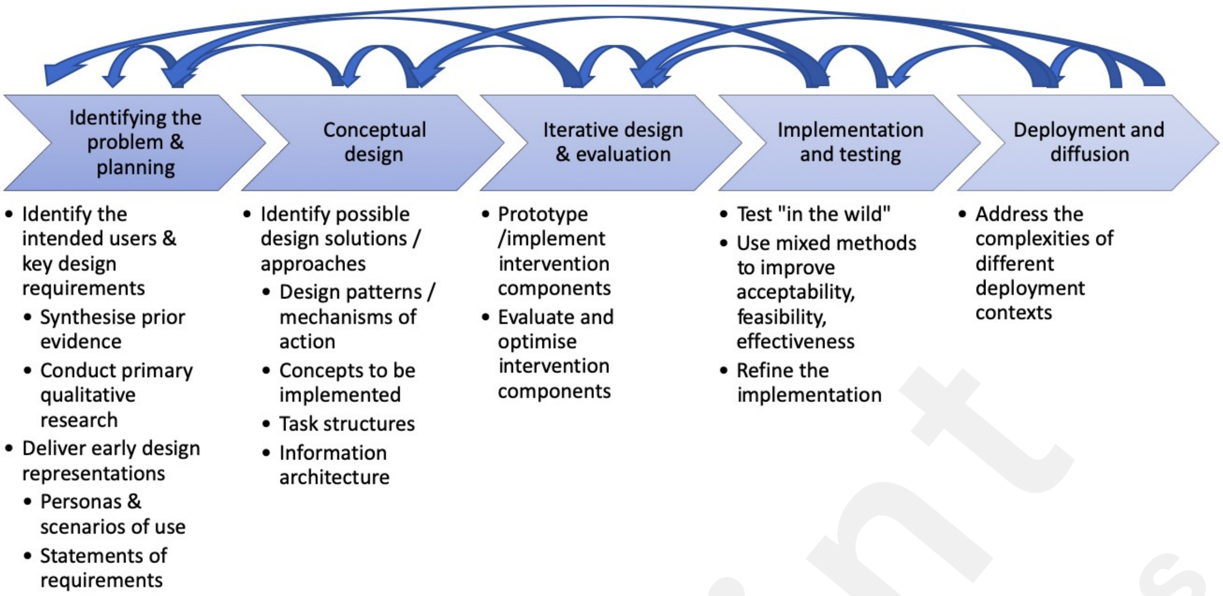
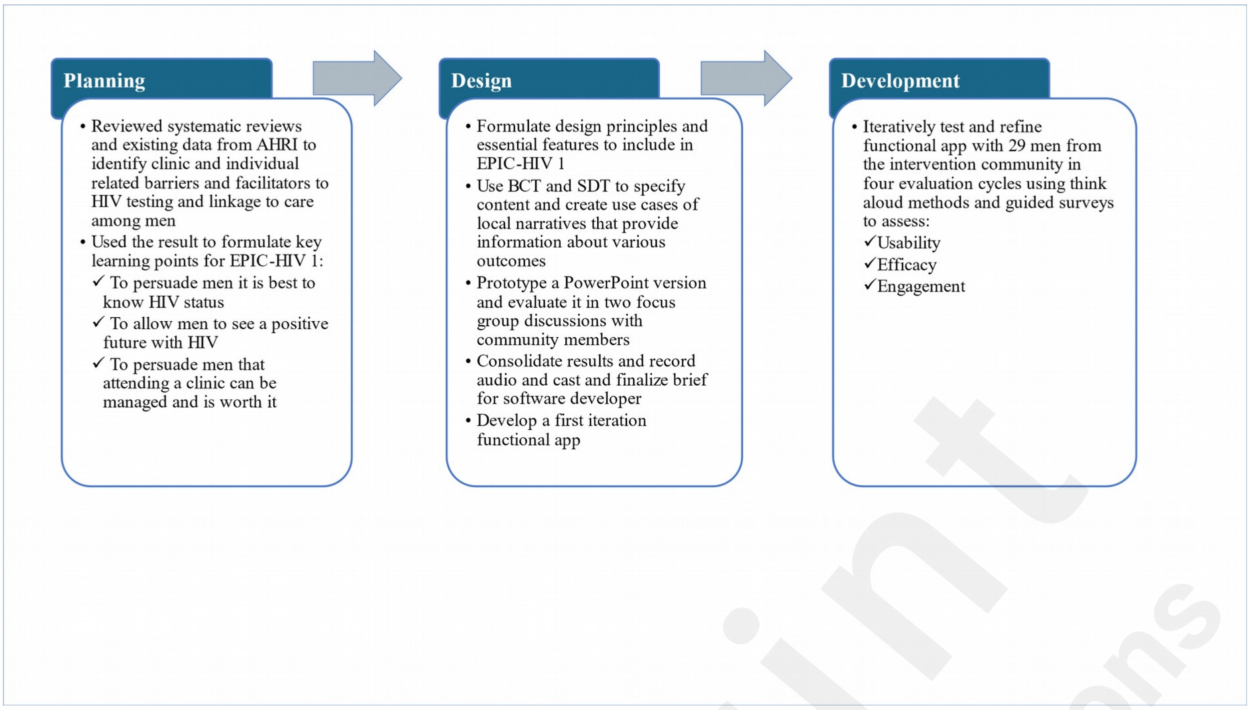


Figure 2: Integrated development lifecycle

Both approaches advocate the use of personas and scenarios. These are rich descriptions of the intended users of the intervention and of how they will use the intervention. Scenarios are commonly presented at different levels of abstraction; for example, Rosson and Carroll [31] describe problem scenarios (the broad situation), information scenarios (giving details of the information that will be provided to users) and interaction scenarios (describing the details of user interaction with the system). In this paper we report, and reflect, on the process and outcomes of applying the PBA and selected HCI methods to the development of EPIC-HIV1.

Method

This paper draws on documentation that was created during the iterative development process, including the initial prototyping of EPIC-HIV1 and the subsequent cycles of refinement and testing. That documentation was systematically gathered throughout the development process to support subsequent analysis. The retrospective analysis of the documentation involved the construction of a narrative of the processes and outcomes for the planning, design and developing stages (implementation is out of scope for this paper) outlined in Figure 3).



Planning

- Reviewed systematic reviews and existing data from AHRI to identify clinic and individual related barriers and facilitators to HIV testing and linkage to care among men
- Used the result to formulate key learning points for EPIC-HIV 1:
  - ✓ To persuade men it is best to know HIV status
  - ✓ To allow men to see a positive future with HIV
  - ✓ To persuade men that attending a clinic can be managed and is worth it

Design

- Formulate design principles and essential features to include in EPIC-HIV 1
- Use BCT and SDT to specify content and create use cases of local narratives that provide information about various outcomes
- Prototype a PowerPoint version and evaluate it in two focus group discussions with community members
- Consolidate results and record audio and cast and finalize brief for software developer
- Develop a first iteration functional app

Development

- Iteratively test and refine functional app with 29 men from the intervention community in four evaluation cycles using think aloud methods and guided surveys to assess:

✓Usability
✓Efficacy
✓Engagement

Figure 3**: methods used in first 3 phases of the PBA; implementation phase is out of scope for this paper.**

Ethics

This study was conducted with ethical approval from the University of KwaZulu-Natal Biomedical Research Ethics Committee (BFC398/16). Participants involved in empirical data collection provided written or verbal consent.

Results

Design aims for EPIC-HIV1

Two key aims for EPIC-HIV1 were ensuring that it met users' needs, that is, participants were engaged by the content and able to autonomously navigate the application, including people with low digital and health literacy; and ensuring that it met the intervention goals, that is to communicate the correct clinical messages to, and enable, men to make an informed choice about engaging with HIV care.

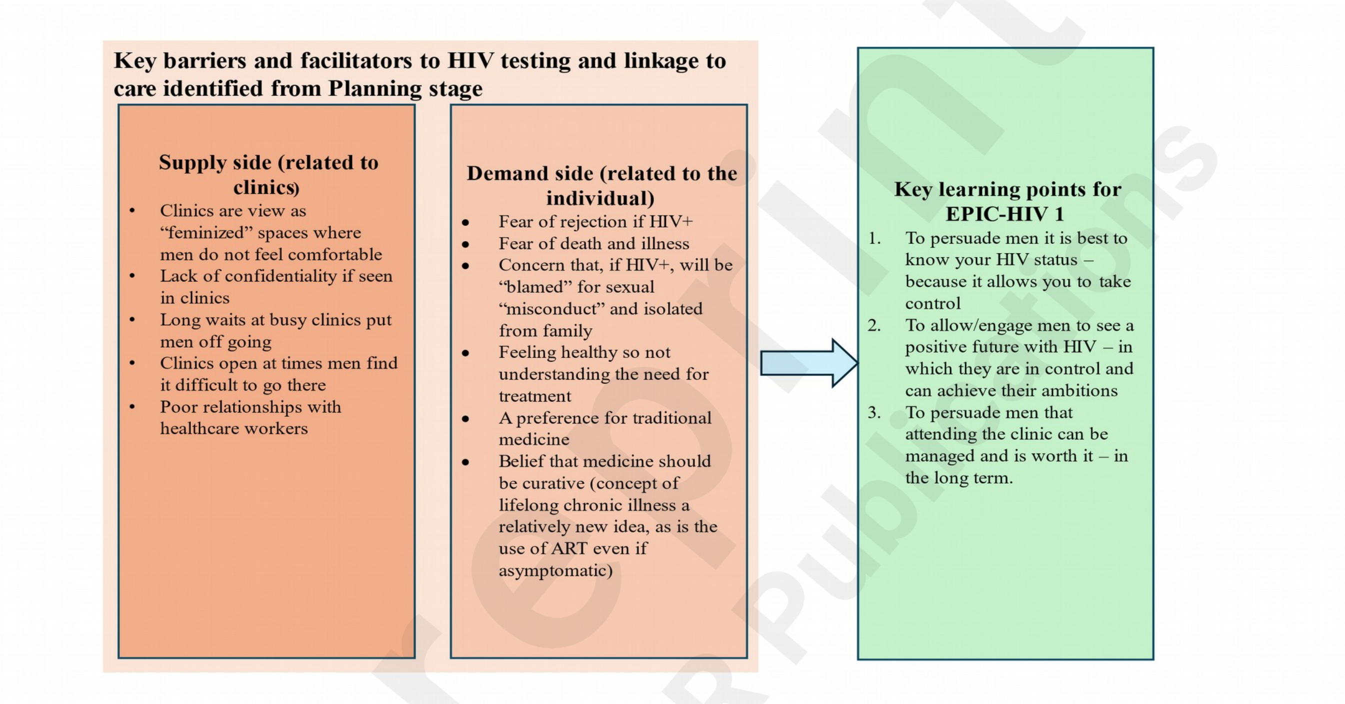
The design had to recognise the stigma related to HIV [18, 19, 32]. This relates to both the design of the intervention itself and the HCI methods employed. For example, in this case study, we did not require users to share their own experience of HIV testing (provider-initiated or self-testing) or to disclose their HIV status. Also, in order to enable study participants and future users to explore EPIC-HIV1 independently and privately earphones were offered for their use.

Another design challenge in resource-constrained settings is low literacy [33]. Solutions proposed for low-literacy users include graphical interfaces, interactive voice interfaces, and mediated usage [34]. Designing for low literacy populations extends beyond catering for users not being able to read, to multiple cognitive and emotional factors that influence how users engage with content [35, 36]. For healthcare interventions, there is added complexity: individuals with lower literacy tend to have lower health literacy [37], and having lower health literacy puts an individual at higher clinical risk and is associated with reduced ability to exert control over health through informed decision making [37, 38]. The approaches taken in both design and testing to be inclusive of users with low digital and health literacy are discussed below.

EPIC-HIV was developed following the four stages of PBA (Figure 1). The planning and design stages were led by social scientists and health professionals (JS, SW, MS, TZ, PM and TM) and the development phase was led by HCI specialists (AB and AZ) and the technology partner. Each stage employed different recruitment and sampling methods as described in detail below.

PBA stage 1: planning

The planning stage is described in detail by Mathenjwa et al.[12]. In summary, we reviewed systematic reviews and existing data from AHRI to identify facilitators to HIV testing and linkage to care (see Figure 4 – adapted from Mathenjwa et al[12]) and used the results to define the user requirements of the app.



Key barriers and facilitators to HIV testing and linkage to care identified from Planning stage

Supply side (related to clinics)

- Clinics are view as "feminized" spaces where men do not feel comfortable
- Lack of confidentiality if seen in clinics
- Long waits at busy clinics put men off going
- Clinics open at times men find it difficult to go there
- Poor relationships with healthcare workers

Demand side (related to the individual)

- Fear of rejection if HIV+
- Fear of death and illness
- Concern that, if HIV+, will be "blamed" for sexual "misconduct" and isolated from family
- Feeling healthy so not understanding the need for treatment
- A preference for traditional medicine
- Belief that medicine should be curative (concept of lifelong chronic illness a relatively new idea, as is the use of ART even if asymptomatic)

Key learning points for EPIC-HIV 1

1. To persuade men it is best to know your HIV status – because it allows you to take control
2. To allow/engage men to see a positive future with HIV – in which they are in control and can achieve their ambitions
3. To persuade men that attending the clinic can be managed and is worth it – in the long term.

Figure 4: barriers and facilitators to HIV testing and linkage to care. Adapted from [30]

PBA stage 2: Design

The aim of this stage was to formulate the design principles of the application and essential features that should be included. First, using the results from the planning stage, we identified barriers that can be modified by EPIC-HIV1 and key learning points to be incorporated into the app. We then formulated intervention features relevant to the learning points to support informed decision making about taking an HIV test and linking to care where necessary. Finally, we identified specific behaviour techniques from the BCT [21] to support feelings of autonomy, competence and relatedness from SDT to specify the content and create use cases. The components are interrelated as illustrated in Table 1.

Table 1: Key learning points and the identified barriers addressed and how it links to the SDT and BCT

Learning point	Factor	SDT relevant	BCT from taxonomy
1. To persuade men it is best to know your HIV status –	Concern that if HIV+ will be 'blamed' for sexual	Persuading users that knowing their status allows them to	9.1 credible source 5.1 information about health

because it allows you to take control	‘misconduct’ and isolated from family Feeling healthy (so not understanding the need for a test), ·	take control of important aspects of their lives (such as upholding traditional values, caring for a family or having sex and children) (supporting autonomy).	consequences 5.2 salience of consequences
2. To allow/engage men to see a positive future with HIV – in which they are in control and can achieve their ambitions	Concern that if HIV+ will be shunned	Maintaining a positive illness context throughout – that it is easily possible to live with HIV and do all one wants to do. Educating men about HIV and the benefits of testing and taking ART (supporting autonomy).	9.1 credible source 5.1 information about health consequences 5.2 salience of consequences 13.5 identity associated with changed behaviour 13.1 identification of self as role model
3. To persuade men that attending the clinic can be managed and is worth it – in the long term.	A preference for traditional medicine Long waits at busy clinics put people off going ·	Persuade men that they can handle going to the clinic through positive examples of men talking about what it was like and how they managed it (supporting relatedness, competency and autonomy).	13.5 identity associated with changed behaviour 13.1 identification of self as role model

The conceptual design

The app was intended to be used by all men aged 15 and above contacted by a field worker at home during annual biobehavioural surveillance. However, it was designed to be used in any community setting that offers HIV testing to men. The high-level design concept was to provide experiential information from local men living with HIV that users could identify with. The content was rooted in local narratives to provide information about various outcomes to increase risk perception, salience, and likelihood of response by making the decision to test or link to care explicit. Personas were implicitly encapsulated in the descriptions of the characters who were to be introduced through EPIC-HIV1: men of different ages and with different health beliefs and levels of digital literacy.

The problem scenario was that the app was intended to provide validated health information to enable men to make an informed choice about testing for HIV and linking to care. As described above, the envisaged context of use for EPIC-HIV1 was that it would be administered by the AHRI fieldworker during the annual individual biobehavioural surveillance home visit. When the time came to explore EPIC-HIV1, the fieldworker was expected to hand over the tablet computer with the app opened (start screen) to the user (consenting man), together with earphones (that the man could keep) and wait while they interacted with the app in private. The app was designed to take 5-10 minutes depending on the pathway that the user selected to align with the time constraints of the fieldwork.

The information scenario was based on the notion that the app should acknowledge and refute common misconceptions about HIV (how it is transmitted and what treatments are effective) and concerns about attending a clinic and making other people aware of their HIV status.

The interaction scenario involved the user working through 3 sections (illustrated in Figure 5):

1. First, there was a short introduction, after which the user was given the choice to either find out about HIV testing and treatment (if they were not ready to test) or just find out about treatment (if they were ready to test).
2. In the testing section, users were given the option to listen to short vignettes describing common reasons for men not wanting to test for HIV. Users were then presented with information, delivered by a nurse, addressing each of these reasons and providing a counter argument.
3. In the treatment section, three characters described their journey since being diagnosed with HIV; these characters represented different personas and the user could listen to one of their stories (ideally the one they found most relatable).

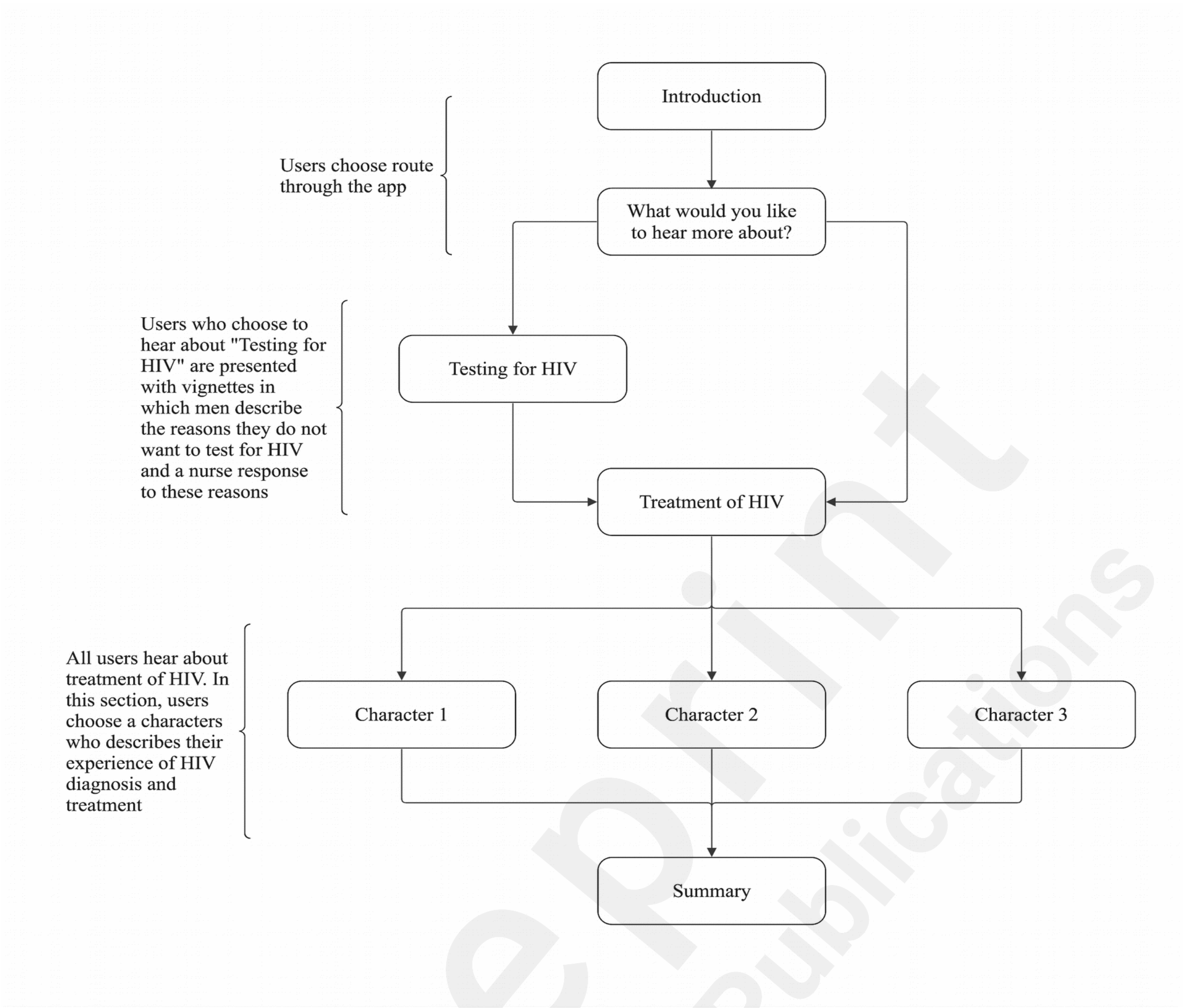


Figure 5: Overview of user journey through the app

As well as relatable characters, the app also featured a male nurse character who guided users throughout by introducing options for navigating the app, provided instructions and summarised key points. All app content and instructions were provided in text and audio format. Still images, including photographs of individuals (with faces obscured) and artefacts from the intervention community, supported the audio descriptions.

We identified a male nurse from AHRI to serve as a guide character in the app. The nurse acted as a credible source to encourage men to test early and address common concerns that the other characters raised as barriers to test. The nurse guide gives an introduction and explain how the app works. He then reads out the two options (‘I am sure I will have an HIV test today’ and ‘I might not have an HIV test today’) and asks the user to select which statement he agrees with. In the ‘ready to test’ section, the nurse applauds the user for taking the decision to test today. In the ‘not ready to test’ section, we used 7 characters to give short vignettes discussing common reasons for men not wanting to test for HIV which were identified during the planning stage (see Figure 6). The nurse comes back to address the reason each character lists, providing a counter argument. Users can then go into more detail by selecting one of 3 main characters that persuade men that knowing their HIV status gives them control of important aspects of life, that it is possible to live with HIV and still achieve goals and finally that they can manage going to the clinic.

Figure 6: the illustration of 7 characters from the PowerPoint prototype

Testing the conceptual design

We developed a low fidelity PowerPoint protype of the app and evaluated it with two focus groups of men from the community advisory board (CAB). The CAB is a body representing members of the intervention community that act as a bridge between AHRI and the community, safeguarding the rights of the study participants. We sought to include younger and older CAB members to represent the HITS trial participants. The focus of the evaluation was on whether the characters and messages selected were acceptable to men in our community. Since we sought to assess acceptability of the content and characters, findings were categorized into content or character related and the app functionality (See Table 2).

Table 2: Summary of the focus group discussion results and how we addressed them

Main issues	Steps Taken and Revision of Content
Content *Self stigmatization after testing HIV-positive* *Fear of weakness because of illness* *Manhood is about becoming isoka (Casanova)* *Testing is for everyone, not for particular groups/types* *Most men want to wait until they get sick before testing, long queues in clinics, feminised spaces of health care*	Positive reinforcement on autonomy, competence and relatedness among all characters
Characters *Groups preferred characters to look like strong men* *Groups commented on what characters should wear* *Groups mentioned that characters' gestures should be open and clear*	Only the nurse character will be seen by users No other faces will be shown, real settings will not be used Men wearing what was proposed in groups Characters' gestures open and clear
Functionality *Asked for a rewind button so that people can go back and listen* *Privacy and confidentiality*	No rewind option because of time App will be private and fieldworker will clarify to each participant that they will not know how the participant navigated the app

We used the results to refine the content and characters and finalized the brief for the software developer. All the content was provided in audio format including the instructions and prompts for users. We selected a cast of actors from the local community to represent the different characters and did an audio recording of voice overs and a photo shoot at AHRI offices and a local community centre. This was sent to the software developer with the brief. We received a first iteration of a functional app, as illustrated in Figure 7; however, it was not considered by the team to be engaging.

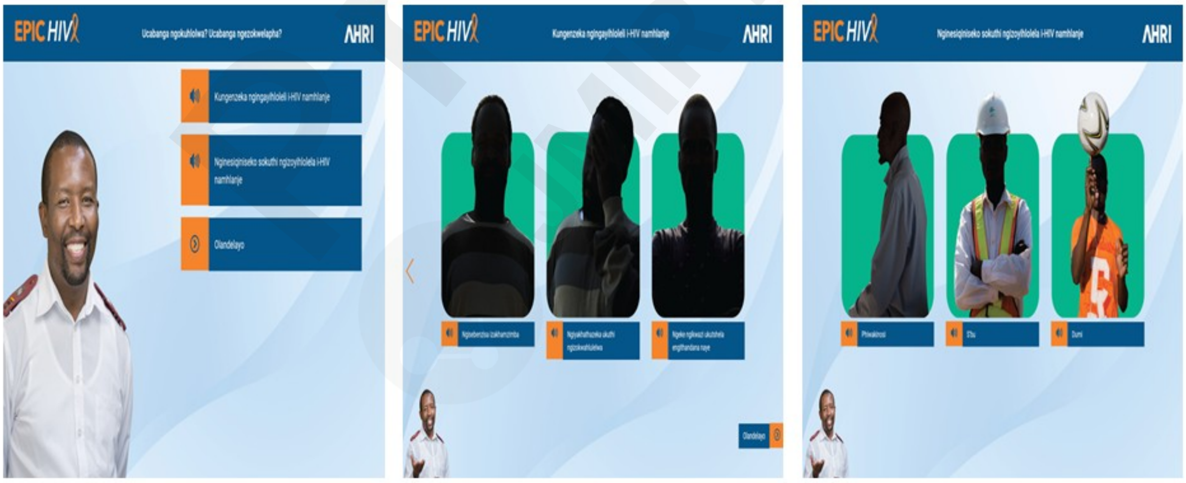


Figure 7: EPIC-HIV 1 Cycle (Left to right).
Screenshot 1 - Introduction: Nurse introduces the app, users receive instructions and choose route through the app
Screenshot 2 - Testing Section: User hears common reasons why men do not want to test for HIV and nurse's rebuttal
Screenshot 3 - Treatment Section: User hears stories of men since HIV diagnosis

PBA stage 3: Iterative testing and design changes

We iteratively tested and refined EPIC-HIV1 to ensure that the app was interactive, usable and acceptable for a broad spectrum of users with varying education and digital literacy. In total, four cycles of user-centred evaluation and design were conducted, based on design sprints each lasting two weeks. These cycles were structured using a simple interaction design model[39], whereby initial user requirements were identified, design improvements were generated, and the new design was evaluated. The evaluation metrics are summarised in Table 3.

Table 3: Summary of evaluation metrics

Metric	Questions	Method
Usability i.e. navigation/overall usability	Is it clear how to move between screens? Is it clear how to engage with the information on each screen (i.e. choose options, listen to audio, exit audio)?	Observations during think aloud
Efficacy i.e. understanding of key message	Are they key messages communicated? Do participants gain new information as a result of using the app? Is the information they gain factually accurate?	Questions in think aloud protocol and guided survey
Engagement i.e. acceptability of the content	Is the interaction pleasant? Is the presentation of content appropriate and interesting?	Questions in think aloud protocol and guided survey

We employed pop-up user testing because we wanted to ensure participants were as comfortable as possible and we wanted to recruit in an informal and purposive way. However, this had to be balanced with a lack of privacy, given that participants were recruited in public spaces. We gave participants a choice of where they would like to test the app – e.g., in the car or walking to a quiet spot nearby. Such considerations also provided information on who conducted recruitment: a male researcher from the community. These decisions helped to establish a level of mutual trust and collaboration between the researchers and participants. Unlike most accounts of pop-up research, the planned time for each individual's participation was not particularly short: it lasted 20-30 minutes, sometimes more if the participant had lower literacy levels.

During each cycle, participants were asked to complete defined tasks and articulate their thoughts about EPIC-HIV1and the task. Both actions and verbalisations were recorded to identify the main usability challenges and build an understanding of the acceptability of content. Participants were paused after the introductory screens and asked questions regarding their initial expectations of the app's content and purpose. After using the app, participants were asked further questions of their understanding of the content and reflections on the design. This guided verbally administered survey, ensured that we did not exclude low-literacy participants. It consisted of a mix of open and closed questions and was used to gather insight into usability, comprehension and design preferences.

The evaluations were conducted in isiZulu, with a bilingual (isiZulu-English) researcher administering procedures. Before each evaluation, participants were read a standardised information sheet and gave verbal informed consent. Participants were observed as they used the application. At the end of the evaluation participants were thanked and provided with sandwiches and soft drinks.

Participants

We conducted evaluations with 29 unique isiZulu speaking males (excluding pilot participants) over the four iterative cycles. All participants were asked their age to confirm they were over 18 years old and able to consent to participation.

All participants were adult men from the community in which the intervention would take place. In the first evaluation cycle, convenience sampling was used to recruit participants in or close to the research institute. In the following evaluation cycles, sampling became increasingly purposive as we sought to recruit participants who represented specific user groups within the intervention cohort, especially those who had been identified as likely to have low technological literacy.

Overview of evaluation cycles

Across the four cycles, the evaluations became more refined, but the objectives and the metrics were consistent. Correspondingly, there was consistency across the protocols. For example, some of the questions (see Table 3) were the same and were asked at the same point in the evaluation. The key features of each evaluation cycle are summarised in Table 4.

Table 4: summary of evaluations

	Objectives	**Methods**	**Example findings**	**Example changes made**
Evaluation 1 2 pilot participants; 6 in main study	***Primary***: Identify main usability challenges Gather understanding of target user group's needs Assess understanding of content ***Secondary***: Gather insight into potential design improvements	Think aloud Observation Guided survey	The objective of the app was unclear – some users expected the app to check their HIV status. Users don't know how to make option selection throughout the app.	Introductory information and additional instructions added to clarify the purpose of EPIC-HIV1 and how to use it. Onboarding split across three screens.
Evaluation 2 1 pilot participant; 6 in main study	***Primary***: Make layout easy to use for people who are novice tablet users and have low literacy	Observation Retrospective usability questions Guided	Users not clear how to initiate use of the app. Users did not consistently understand option	A call to action was added to the first screen, Key segments of audio

	Assess understanding of content ***Secondary***: Gather insight into preferred look and feel of app	survey	selection at the start of the app. Users not able to make informed choices about how much content they listen to or whose stories they wanted to learn more about (instead listening to every piece of content but in unintended orders). Users gathering some incorrect messages. Preferences for images of people in context.	stitched together.
Evaluation 3 1 pilot participant; 12 in main study	***Primary***: Test whether users know to select options Assess understanding of content Make content more engaging ***Secondary***: Ensure that uninterrupted participants were completing the app in an appropriate time	Observation Retrospective usability questions Guided survey Task completion times	Users did not consistently understand option selection at the start of the app. Users lost interest during longer sections of audio. Users making informed option selection regarding which character stories to listen to. Users understanding correct key messages. Users completing the app within the target time	Descriptions of options re-worded and additional audio added at the start of the app. Shorten length of character stories.
Evaluation 4	***Primary:*** assess whether the	Observation Retrospective	No significant new usability	None

5 participants	changes made to the application affected users' expectations, such that they were making more informed decisions	usability questions Guided survey	issues had emerged	

Specifics of each evaluation cycle

For the first evaluation, convenience sampling was used to recruit from the community, working in or close to the research institute. The evaluation took place in various locations within the research institute. After interacting with the first version of the app, participants were presented with low fidelity interactive prototypes of different sections of the app and asked which they preferred, which was most relatable and which was most clear.

In Evaluation 2, the primary objective was to identify and address the needs of the least technically experienced members of the intervention cohort. Pop-up research [40] in the community simulated some of the environmental constraints and social considerations that would be experienced by fieldworkers when administering the IDHI, such as lack of access to the internet and difficulty finding private spaces. Additionally, it had the potential to reduce participant response biases [35] by making the environment more familiar and less formal than the research institute. Participants were approached in public spaces, such as at bus stops or tuck shops, and evaluations were conducted either in those spaces or close by in the researchers' car (illustrated in Figure 8).

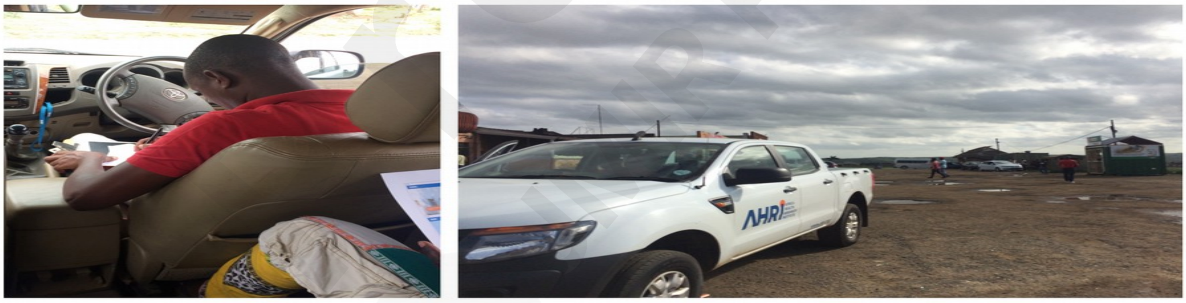


Figure 8: pop-up evaluation testing in remote locations using an AHRI car

Based on learnings from Evaluation 1, we administered retrospective usability questions rather than asking participants to articulate their thoughts concurrently. We also printed screenshots of design variations on paper and described the differences to participants then asked them which they preferred, rather than continuing to use low-fidelity interactive prototypes after the first part of each session. We included closed questions that were asked while participants were interacting with EPIC-HIV1; for example, we added a help button; in the evaluation, we stopped users after the instruction screen and asked them to indicate which button to press if it was not clear what to do next. Most participants were unaware they could skip content or be selective, which indicated that the app was not supporting autonomous decision making. When presented with design alternatives, all six participants selected the interface with photo images because it was "clear". This supported the use of rich and contextually relevant images throughout the app to optimise the relatability of the content.

Design changes following Evaluation 2 were intended to support lower literacy members of the intervention cohort. Previews were either automated or removed, which meant users would only be presented with choices when it was critical. We added extra instructions on how to select options, made button states more distinct and provided additional nudges in the form of button animations and instructions from the nurse character. Additional photographs of paid professionals who were representative of the intended cohort were added to the character stories to make them more engaging (Figure 9).

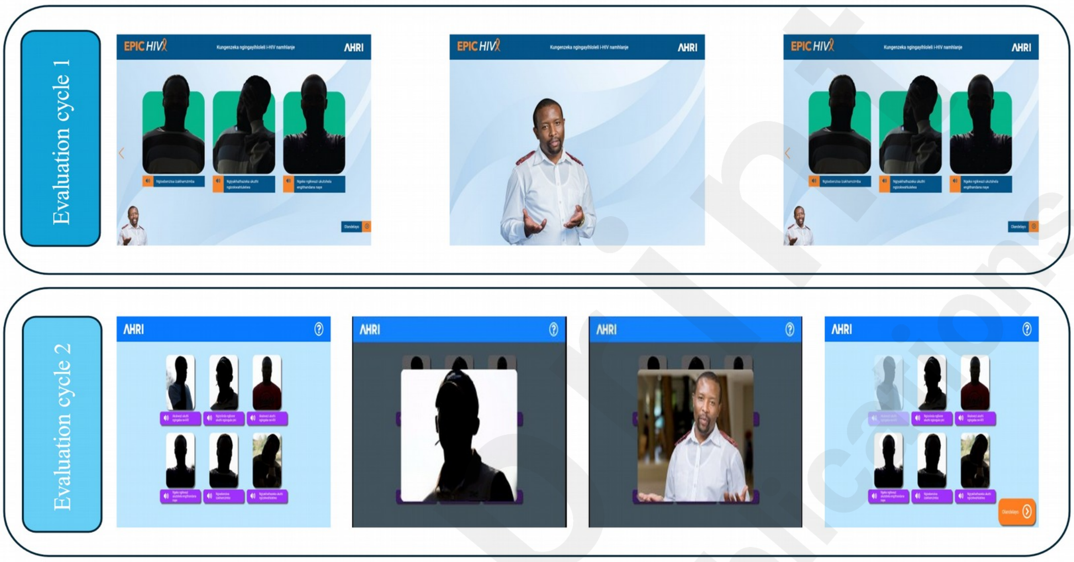


Figure 9. Evaluation cycle 1: User previews character, gets character's full reason for not testing, selects next, clicks on same character to receive nurse's response to the character's reason (4 clicks). Users have a choice at every stage as to whether they listen to more about the character and the reasons they don't want to test for HIV. Evaluation Cycle 3: User selects character and gets character's full reason for not testing and nurse's rebuttal (one click).

In Evaluation 3, as well as assessing whether participants knew how to select options, understood correct messages and found the content engaging, we wanted to ensure that participants were completing the app within a given time. We split participants into two groups: one was interrupted to assess their option selection while the other was uninterrupted, to gather their task completion time and observe the full user flow. Having identified rural and older people as those who were least comfortable using the app, we actively recruited males representing this category, reducing the proportion of young peri-urban males (the easiest to find and recruit). After conducting evaluations with 12 participants from various locations, we had reached saturation in responses. Compared to earlier evaluation cycles, we focused more on option selection and expectations. For example, at the beginning participants were asked what they had expected to find if they had selected the other option so that we could assess whether participants were actively choosing what they wanted to hear about. This was particularly important because users could only engage with EPIC-HIV1 once as part of the planned intervention and could not return to content of interest.

Evaluation 4 did not reveal any additional usability issues. Participants were able to describe what they would have had if they had selected the other option, indicating the changes to the language used at the beginning of the app were effective and supported informed decision making.

Reflections

Both the evaluation objectives and the methods became more refined during the process. For example, the objective of the first evaluation was to get a sense of what users were finding difficult and what evaluation style would be contextually appropriate. Convenience sampling was used to recruit participants and the questions in the evaluation were relatively general. In the third evaluation, two of the objectives were to know if the participants could make accurate option selections and complete the app within a given time. Purposive sampling was used to recruit participants who represented a range of users we had previously encountered, especially those who had had usability challenges (i.e. low literacy, novice users, older people). The evaluation was more focused, questions were more specific and the methods were altered to support our objectives.

Although pop-up research was an effective and valuable means of recruiting participants and conducting evaluations, we had to ensure that we adequately addressed considerations including: ethics - ensuring the participants did not feel coerced; privacy - ensuring that participants could freely engage with content without passers-by hearing; community-institution relationships – avoiding contributing to ‘participant fatigue’ near the research centre; and our own safety as we went into remote places and invited people into our car or worked with them in unfamiliar environments.

PBA stage 4: implementation

The implementation stage (i.e., deployment in a clinical trial) beyond the scope of this paper and is described in the HITS trial evaluation papers [4, 41, 42]. The HITS trial was not designed to evaluate the effectiveness of using a tablet-based app to deliver information, or to evaluate the detailed design of EPIC-HIV. Rather, EPIC-HIV was a means of delivering male targeted decision support informed by self-determination theory, and it was implicitly assumed that it would do that effectively. The primary trial question was whether delivering a theoretically informed intervention to support testing or financial incentives would be clinically effective in increasing uptake of HIV testing when offered at home. As discussed by Mathenjwa et al., EPIC-HIV proved challenging to implement as intended with reports of inconsistent use of earphones, older participants struggling to navigate the app independently and select stories that appeal to them and other participants quitting before the end (incomplete use) [43].

Discussion

We have showed that combining a theory-based approach to conceptual design, drawing on SDT and the Behaviour Change Technique Taxonomy with HCI is feasible and enabled us to tackle the problem to be addressed (the low rate of engagement with HIV testing and care by men in the area), by explicitly designing a usable app to engage with the factors that contributed to that, and provide clinical messages that could address those factors. A specific opportunity to administer the digital intervention had been identified – namely, via a tablet-based app during the annual individual surveillance visit. However, this opportunity imposed constraints on the app design: most notably, that it had to be possible for the user to complete the interaction within 10 minutes. The earlier (stage 1 and 2) person-based approach focussed on content and did not, include any early assessment of appropriate design and interaction factors. The later HCI work (during Stage 3 of the person-based approach to intervention development) addressed issues including checking that the app was usable by a high proportion of the target population and that the correct clinical messages were being communicated.

One key lesson from this study is that where a digital intervention is to be administered to individuals – particularly those with low digital and health literacy – it is essential to design the introduction (or “onboarding”) very carefully, to ensure that users are empowered to use the app effectively and that expectations of what they will experience are set appropriately. Another key lesson is that an appropriate balance had to be achieved between autonomy (enabling people to navigate as they choose) and ensuring that the correct clinical messages are communicated.

The conceptual design featured a series of dialogues between relatable characters and a trustworthy nurse. These dialogues were accompanied by still images of the characters in familiar settings. However, this approach was never tested against alternative design strategies. Early decisions about the design and mode of the interaction were based on informal understanding and intuition rather than evidence. Resource limitations (both time and funds) meant that we did not have capacity to revisit earlier design decisions such as the appropriateness of using a tablet computer or the general approach of presenting dialogues. Thus, it was not possible to engage in the broader cycles of iteration proposed by Blandford [30].

In resource-constrained settings and when dealing with stigmatised health conditions, user needs are particularly complex and sensitive. There was a need to draw on methods that do not feature in mainstream HCI literature to address the specific questions and context of the study.

Early design decisions, such as the approach of focusing much of the app on a dialogue between relatable characters and a trustworthy nurse, and about the content of the dialogue, were also based on the key scenario of use – i.e., that the tablet computer would be lent to the individual for up to 10 minutes within the annual health visit; this imposed a significant constraint on the design. For example, the main interaction design issue raised by members of the CAB in the Stage 2 testing – that people would like a “rewind” option – was not addressed due to this time constraint.

Through the iterative testing of an interactive prototype, the main area of concern, and where many changes were made, were in the introduction, or “onboarding”, for the app. It was found necessary to set expectations about the app (e.g., that it would not deliver an HIV test result) and to provide detailed verbal instructions about how to select options and press buttons on a touch screen.

We needed to balance needs for the app to be engaging and inclusive. Participants were diverse, and levels of technical, educational and health literacy varied widely. Some participants were comfortable using the tablet app and owned touch screen smartphones. Testing highlighted the tension between providing literal choice in interaction design and meaningful choice regarding how the user engaged with the intervention. For example, giving users a choice about whether or not to listen to the nurse’s response after hearing a character’s concerns proved counter-productive as it did not support the concept of “informed choice”, so the choice point between concern and response was removed after the first evaluation cycle.

Changes to the design were intended to support low-literacy users: for example, by adding audio instructions, highlighting one option at a time, and reducing the amount of user input required. However, we maintained critical choice and ensured it was well understood. The reduction in user input was balanced with ensuring that the app remained engaging and persuasive for participants with higher literacy levels. Through iterative cycles, we were able to deliver a design that was inclusive of as much of the target cohort as possible.

Nevertheless, we had to recognise that the delivery of the intervention was likely to exclude a small proportion of the potential beneficiaries. For these people, for whom the app was inaccessible, a conversation with the visiting health worker would be a possible alternative. HCI evaluations traditionally focus on efficiency, effectiveness and satisfaction [44]. Efficiency relates to how quickly people can complete tasks using the system; effectiveness is defined as “accuracy and completeness with which users achieve specified goals” and is not usually considered in terms of clinical effectiveness – i.e., how well clinical messages are understood or any behavioural changes that follow from changed understanding. Satisfaction includes many aspects of user experience including how engaging a system is. In the context of EPIC-HIV1, priorities for engagement were relatable characters and interactivity.

Strengths and limitations

The analysis of existing theory and data enabled the team to identify and address the most important barriers to men engaging in HIV testing and care in a cost-effective way. The use of HCI methodologies enabled the team to translate the intervention goals – communicating persuasive messages in a way that would promote behaviour change – into design strategies and ensure the application was usable. The resulting application was inclusive of the intended population, supported meaningful choice in how users engaged with the application, and ensured the correct clinical messages were communicated.

As noted above, HCI methodologies had not been involved during the early stages of intervention development. As a result, the remit of HCI was to fix the app: to make it as good as possible given the time and resources remaining. We believe the app design could have been stronger if HCI methodologies had been employed alongside PBA and BCT approaches from the outset. For example, there was no opportunity for exploratory research to define what interactivity meant for the intended population or understand whether a tablet-based app was an appropriate approach to communicating HIV/AIDS information in this context, or whether it could inadvertently bias participant responses, as indicated by previous research [45], or exclude a proportion of the intended target population.

There was also no opportunity for HCI focused summative research – for example, to understand, how users had navigated through the app, areas of interest or potential drop off points [26]. As noted above, the HITS clinical trial results suggest that EPIC-HIV1 did not increase men’s uptake of HIV testing. This raises many questions that could be the focus of future research; for example, would a different kind of digital intervention have been more effective, are digital interventions inappropriate in this context, or does the intervention need to be better tailored towards different sub-populations (e.g., those with different levels of digital literacy or different priorities in life)?

Conclusion

The aim in developing EPIC-HIV was to support a clinical trial investigating whether financial incentives and/or a digital intervention was more effective than the established approach to encouraging men to test for and engage in care for HIV. The implicit assumption was that any digital intervention would be equally effective and no comparison between different digital interventions was planned.

By applying an iterative design approach, we were able to make systematic choices regarding design that would facilitate usability, engagement and comprehension required for the intervention. The value and necessity of these choices were brought into sharp focus with this case study as many of the challenges of developing an IDHI were exacerbated by the study context (resource constrained, low digital literacy and stigmatised condition).

Developing Digital Health as an interdisciplinary field requires close collaboration throughout the intervention design process to ensure that the resources and expertise required are available in a timely way.

Acknowledgements

This study was funded by i-sense IRC (EPSRC grant EP/K031953/1) and the People Curie Actions of the European Union’s seventh Framework Programme FP7/2007-2013 under REA grant agreement n° 612216. The HITS trial was funded by the National Institute for Health R01AI124389 and the AHRI demographic Surveillance Information system and population intervention program is funded by the Wellcome Trust (082384/Z/07/Z) and the South Africa Population Research

Infrastructure Network (funded by the South African Department of Science and Technology and hosted by the South African Medical Research Council). NMcG and MS are supported by NIHR Research Professorship awards (Ref:RP:2017-08-ST2-008 and NIHR 301634 respectively) using UK aid from the UK Government to support global health research. This research was funded in whole, or in part, by Wellcome [Grant number Wellcome Strategic Core award: 227167/A/23/Z]. For the purpose of open access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission.

The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding bodies or the UK government. We are grateful to all participants in this study. The authors wish to appreciate Velaphi Gumede for participant recruitment and data collection.

Conflict of interests

The authors have no competing interests.

Abbreviations

AHRI: Africa health research institute

ART: antiretroviral therapy

BCT: behaviour change taxonomy

CAB: community advisory board

EPIC-HIV: empowering people through informed choices for HIV

HCI: human computer interaction

HITS: home-based intervention to test and start

IDHIs: interactive digital health interventions

PBA: person-based approach

SDT: self-determination theory

References

1. UNAIDS. Addressing a blind spot in the response to HIV — Reaching out to men and boys. 2017.
2. Iwuji CC, Orne-Gliemann J, Larmarange J, Okesola N, Tanser F, Thiebaut R, et al. Uptake of Home-Based HIV Testing, Linkage to Care, and Community Attitudes about ART in Rural KwaZulu-Natal, South Africa: Descriptive Results from the First Phase of the ANRS 12249 TasP Cluster-Randomised Trial. PLoS Med. 2016 Aug;13(8):e1002107. PMID: 27504637. doi: 10.1371/journal.pmed.1002107.
3. Randera-Rees S, Safari WC, Gareta D, Herbst K, Baisley K, Grant AD. Can we find the missing men in clinics? Clinic attendance by sex and HIV status in rural South Africa. Wellcome open research. 2021;6.
4. Tanser FC, Kim HY, Mathenjwa T, Shahmanesh M, Seeley J, Matthews P, et al. Home-Based Intervention to Test and Start (HITS): a community-randomized controlled trial to increase HIV testing uptake among men in rural South Africa. Journal of the International AIDS Society. 2021;24(2):e25665.
5. Blandford A, Wesson J, Amalberti R, AlHazme R, Allwihan R. Opportunities and challenges for telehealth within, and beyond, a pandemic. The Lancet Global Health. 2020;8(11):e1364-e5.
6. Patrick K, Hekler EB, Estrin D, Mohr DC, Riper H, Crane D, et al. The pace of technologic change: implications for digital health behavior intervention research. Elsevier; 2016. p. 816-24.
7. Cresswell KM, Blandford A, Sheikh A. Drawing on human factors engineering to evaluate the effectiveness of health information technology. Journal of the Royal Society of Medicine. 2017;110(8):309-15.
8. Murray E, Hekler EB, Andersson G, Collins LM, Doherty A, Hollis C, et al. Evaluating digital health interventions: key questions and approaches. Elsevier; 2016.
9. Viljoen A, Klinker K, Wiesche M, Uebernickel F, Krcmar H. Design principles for mhealth application development in rural parts of developing countries: the case of noncommunicable diseases in Kenya. IEEE Transactions on Engineering Management. 2021;70(3):894-911.
10. Yardley L, Ainsworth B, Arden-Close E, Muller I. The person-based approach to enhancing the acceptability and feasibility of interventions. Pilot and feasibility studies. 2015;1:1-7.
11. Blandford A. Lessons from working with researchers and practitioners in healthcare. interactions. 2018;26(1):72-5.
12. Mathenjwa T, Adeagbo O, Zuma T, Dikgale K, Zeitlin A, Matthews P, et al. Development and acceptability of a tablet-based app to support men to link to HIV care: mixed methods approach. JMIR mHealth and uHealth. 2020;8(11):e17549.
13. Mathenjwa T, Kim HY, Zuma T, Shahmanesh M, Seeley J, Matthews P, et al. Home-based intervention to test and start (HITS) protocol: a cluster-randomized controlled trial to reduce HIV-related mortality in men and HIV incidence in women through increased coverage of HIV treatment. BMC public health. 2019;19(1):969. doi: 10.1186/s12889-019-7277-0.
14. Gareta D, Baisley K, Mngomezulu T, Smit T, Khoza T, Nxumalo S, et al. Cohort profile update: Africa Centre Demographic Information System (ACDIS) and population-based HIV survey. International journal of epidemiology. 2021;50(1):33.
15. Andalibi N, Haimson OL, De Choudhury M, Forte A, editors. Understanding social media disclosures of sexual abuse through the lenses of support seeking and anonymity.

Proceedings of the 2016 CHI conference on human factors in computing systems; 2016.
16. Sorcar P, Strauber B, Loyalka P, Kumar N, Goldman S, editors. Sidestepping the elephant in the classroom: Using culturally localized technology to teach around taboos. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems; 2017.
17. Aronson ID, Bennett AS, Guarino H, Marsch LA, Bania TC, editors. Mobile Interventions to Increase HIV Testing Among Underserved: High-Risk Populations. Proceedings of the 2016 ACM Workshop on Multimedia for Personal Health and Health Care; 2016.
18. Singh A, Gibbs J, Estcourt C, Sonnenberg P, Blandford A, editors. Are HIV smartphone apps and online interventions fit for purpose? Proceedings of the 2017 international conference on digital health; 2017.
19. Bennett AS, Aronson ID, Guarino H, Bania T, Marsch LA, editors. Perspectives on Tablet-based Multimedia Interventions for Behavioral Health: Populations, Venues, and Delivery Modalities. Proceedings of the 2016 ACM Workshop on Multimedia for Personal Health and Health Care; 2016.
20. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American psychologist. 2000;55(1):68.
21. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. Annals of Behavioral Medicine. 2013;46(1):81-95. doi: 10.1007/s12160-013-9486-6.
22. WHO. WHO guidelines: recommendations on digital interventions for health systems strengthening Geneva 2019.
23. Poole ES. HCI and mobile health interventions: how human–computer interaction can contribute to successful mobile health interventions. Translational behavioral medicine. 2013;3(4):402-5.
24. Duffy A, Christie GJ, Moreno S. The challenges toward real-world implementation of digital health design approaches: narrative review. JMIR Human Factors. 2022;9(3):e35693.
25. Yardley L, Morrison L, Bradbury K, Muller I. The person-based approach to intervention development: application to digital health-related behavior change interventions. Journal of medical Internet research. 2015;17(1).
26. Klasnja P, Consolvo S, Pratt W, editors. How to evaluate technologies for health behavior change in HCI research. Proceedings of the SIGCHI conference on human factors in computing systems; 2011.
27. Smith W, Wadley G, Webber S, Ploderer B, Lederman R, editors. Unbounding the interaction design problem: the contribution of HCI in three interventions for well-being. Proceedings of the 26th Australian computer-human interaction conference on designing futures: the future of design; 2014.
28. Marcu G, Bardram JE, Gabrielli S, editors. A framework for overcoming challenges in designing persuasive monitoring and feedback systems for mental illness. 2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops; 2011: IEEE.
29. Marcu G, Dowshen N, Saha S, Sarreal RR, Andalibi N, editors. TreatYoSelf: Empathy-driven behavioral intervention for marginalized youth living with HIV. Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare; 2016.
30. Blandford A. HCI for health and wellbeing: Challenges and opportunities. International journal of human-computer studies. 2019;131:41-51.
31. Rosson MB, Carroll JM. Usability engineering: scenario-based development of

human-computer interaction: Morgan Kaufmann; 2002. ISBN: 1558607129.
32. Pendergrass TM, Hieftje KD, Duncan LR, Arora T, Fiellin LE. A pilot intervention to encourage HIV testing and counseling among minority adolescents. Proceedings of the Technology, Mind, and Society2018. p. 1-.
33. Medhi I, Gautama SN, Toyama K, editors. A comparison of mobile money-transfer UIs for non-literate and semi-literate users. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems; 2009.
34. Islam MN, Khan NI, Inan TT, Sarker IH. Designing User Interfaces for Illiterate and Semi-Literate Users: A Systematic Review and Future Research Agenda. SAGE Open. 2023;13(2):21582440231172741.
35. Dell N, Vaidyanathan V, Medhi I, Cutrell E, Thies W, editors. " Yours is better!" participant response bias in HCI. Proceedings of the sigchi conference on human factors in computing systems; 2012.
36. DePaula R, editor. Lost in translation: a critical analysis of actors, artifacts, agendas, and arenas in participatory design. Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices-Volume 1; 2004.
37. Nutbeam D. The evolving concept of health literacy. Social science & medicine. 2008;67(12):2072-8.
38. Chen X, Hay JL, Waters EA, Kiviniemi MT, Biddle C, Schofield E, et al. Health literacy and use and trust in health information. Journal of health communication. 2018;23(8):724-34.
39. Rogers Y. Interaction design gone wild: striving for wild theory. interactions. 2011;18(4):58-62.
40. Manual GDS. User Research: Doing pop-up research. Open Government Licence; 2017 [cited 2019 19 July 2019]; Available from: https://www.gov.uk/service-manual/user-research/doing-pop-up-research.
41. Kim H-Y, Inghels M, Mathenjwa T, Shahmanesh M, Seeley J, Matthews P, et al. The impact of a conditional financial incentive on linkage to HIV care: Findings from the HITS cluster randomized clinical trial in rural South Africa. medRxiv. 2024:2024.03. 15.24304278.
42. Kim H-Y, Inghels M, Mathenjwa T, Shahmanesh M, Seeley J, Matthews P, et al. Effect of a male-targeted digital decision support application aimed at increasing linkage to HIV care among men: Findings from the HITS cluster randomized clinical trial in rural South Africa. medRxiv. 2024:2024.03. 15.24304373.
43. Mathenjwa T, Bain LE, Adeagbo O, Kim H-Y, Inghels M, Zuma T, et al. Increasing HIV testing and linkage to care among men in rural South Africa using conditional financial incentives and a decision support app: A process evaluation. PLOS Global Public Health. 2024;4(6):e0003364.
44. ISO IfS. Ergonomics of human-system interaction: Part 210: Human-centred design for interactive systems. ISO; 2010.
45. Cheng KG, Ernesto F, Ovalle-Bahamón RE, Truong KN. Barriers to acceptance of personal digital assistants for HIV/AIDS data collection in Angola. International Journal of Medical Informatics. 2011;80(8):579-85.