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Health worker acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment program

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30 August 2024

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Candidate Declaration

I, Andrés Luis Larson Montaner, bearing student number 2145850, hereby declare that I have undertaken all the work detailed in the study below as outlined in the submission plagiarism declaration (Appendix 1). I am the sole author and designer of the study protocol, which received approval from the University of Witwatersrand's assessors and ethics board. I have conducted all the data collection activities for the study and organised and analysed the data using MAXQDA, R, and Excel. I have independently formulated and composed the following report. This submission is intended for the conferral of the Degree of Master of Science (MSc) at the University of the Witwatersrand, Johannesburg. Furthermore, I affirm that this work has not been previously submitted for any degree or examination at any other university.

Table 1: Research Team Members and Roles

Name	Role in Study
Andrés Montaner (MSc Candidate)	Conceptualised the research question, developed the study protocol, and submitted the work for ethical approval at the University of Witwatersrand Human Subjects Research Ethics Committee; collected and analysed the data (quantitative and qualitative); and wrote and compiled this thesis and interpreted the results, including the article within this thesis.
Prof Pedro Pisa (Supervisor)	Supervised this thesis and theoretical framework, planned, and coordinated the study, analysed the thesis statistically, interpreted the results, and co-authored the article submitted within this thesis.
Prof Charles Chasela (Co-supervisor)	Co-supervised this thesis and theoretical framework, planned and coordinated the study, interpreted the results, and co-authored the article submitted within this thesis.

30 August 2024

Abstract

Background:

As more people living with HIV (PLHIV) are being identified and prescribed antiretroviral treatment (ART) in Zambia, completing the last mile of epidemic control by detecting new HIV infections is becoming increasingly challenging. To address this, innovative targeted testing strategies are essential. Therefore, in 2018, Right to Care Zambia developed and implemented a novel digital health surveillance application, Lynx, in three Zambian provinces—Northern, Luapula, and Muchinga. Lynx is a targeted testing tool, offering real-time HIV testing data and geo-spatial analysis, and has proven effective in enhancing HIV testing yield. This study aims to assess the acceptability of Lynx among healthcare workers involved in HIV testing through qualitative and quantitative data collection methods to ensure its optimal utilisation.

Methods:

This study adopted a cross-sectional design with a mixed-methods data collection approach involving facility and community healthcare workers who conduct HIV testing. A quantitative Likert scale (1–5) survey was administered to 176 healthcare workers, 72 male, 101 female, 3 undisclosed, at Lynx facilities to gauge the acceptability of the intervention. The survey focused on the participants' perceptions of the intervention's ease of use, usefulness, and compatibility with the local context. Additionally, six qualitative key person interviews and five focus group discussions were conducted with a sample of the healthcare workers to gain an in-depth understanding of the same factors, and to identify barriers and facilitators of acceptability. Quantitative data were analysed by averaging responses to survey questions and running descriptive statistics by demographic variables. Qualitative data were transcribed and analysed in thematic coding. Data triangulation was utilised between the data sources to verify the findings.

Results:

Overall, the average score (1–5) of perceived ease of use was 3.926 (agree), perceived usefulness was 4.179 (strongly agree) and perceived compatibility was 3.574 (agree). The

frequency of the survey scores, “strongly agree/disagree”, indicates that over 10% of the respondents strongly agreed with 11/15 statements, and over 10% of the respondents strongly disagreed with 1/15 statements. Survey questions related to network requirements, resource availability, and IT support had the most “strongly disagree” responses. The qualitative data collection revealed the benefits of the Lynx programme—live digital data capture and review with the geographic information system (GIS) were perceived as useful, and the application was perceived as very easy to use. An expressed facilitator ensured that all staff received training, and Lynx received ongoing user-based updates to address changing contexts. Identified barriers included conflicting work priorities among users and inconsistent IT support.

Conclusion:

Lynx was identified as acceptable due to its perceived usefulness, staff training, and regular updates. For a mobile health intervention to be embraced in rural Zambian settings, key facilitators include robust IT support, comprehensive training, user feedback-based updates, and consideration of facility staff priorities.

Key Words: Lynx, Implementation Science, HIV Testing, Acceptability, Mobile Health, Mhealth

Structure of Dissertation

This dissertation is presented in a publication format and consists of five chapters, including an original paper submitted for publication.

Chapter 1 comprises the introduction and literature review on the evolving HIV testing strategies, healthcare data systems, mobile health innovations, and acceptability. The study justification and research question are then outlined, followed by the study objectives.

Chapter 2 outlines the research methods employed in the study. First, the chapter presents the intervention evaluated, then the study setting, study participants, study sampling, and data collection and analysis methods are described.

Chapter 3 is an article submitted to the PLOS ONE journal. The original article summarises the Zambian mobile health acceptability study of this dissertation.

Chapter 4 describes the results of the study using quantitative and qualitative methods, with descriptive tables and themes/quotes respectively.

Chapter 5 discusses the overall findings of the study. The discussion incorporates current published literature on the acceptability of mobile health and outlines implications of the way forward for future studies based on the current gaps in the literature and this study's findings.

Contents

09 February 2024

Please see the below statement to be submitted with the MSc Turnitin report of 19%.

As primary supervisor to Andres Montaner student number 2145850, I Pedro Pisa can confirm that Andres' work was entirely his own and no plagiarism took place in the writing of the dissertation.

Signature: Prof Pedro Pisa Date: 16 February 2024

09 February 2024

Please see the below statement to be submitted with the MSc Turnitin report of 19%.

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Signature:  Date: 16 February 2024

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List of Abbreviations

AIDS: Acquired Immunodeficiency Syndrome

ART: Antiretroviral Treatment

ARV: Antiretroviral

GIS: Global Information System

HIV: Human Immunodeficiency Virus

HTS_POS: Total Positive HIV Tests Completed

HTS_TST: Total HIV Tests Completed

KPI: Key Person Interview

NGO: Non-Government Organisation

PEPFAR: President's Emergency Plan for AIDS Relief

RTCZ: Right to Care Zambia

TAM: Technology Acceptance Model

Definition of Terms

mHealth: Mobile health

Modality: Health facility care entrance point leading to HIV test (e.g. paediatric ward, antenatal care ward, inpatient ward, outpatient ward, index client intake)

Tablet: Mobile device through which a mobile application is utilised

Yield: % of positive tests in a given period (HTS_POS/HTS_TST)

1 Chapter 1 Introduction and Literature Review

1.1 Introduction

The following section provides the background to the study, context and need for the intervention assessed in the study, literature review, justification, research question, and aims and objectives of the study.

1.2 Background

As of 2021, the global HIV landscape is marked by an estimated 37.7 million people living with the virus, with the African region being the most significantly affected. In 2018, 25.7 million people in Africa were living with HIV, accounting for about two-thirds of the world's new cases (1,2). Despite advancements in HIV outreach and treatment, a staggering 8.1 million individuals (21%) in the world remain unaware of their HIV-positive status (3). This lack of awareness contributes to the continued transmission and mortality associated with the virus, emphasising the urgent need for international attention and intervention in HIV detection (4). In 2020 alone, 1.5 million people acquired HIV, with 45% of new infections occurring in Eastern and Southern Africa (1).

Zambia is one of the 10 countries with the highest rates of new infections (5). In 2018, Zambia recorded 48,000 new HIV infections, bringing the total number of people living with HIV in the country to 1.2 million, with an adult prevalence rate of 11.3%, ranking Zambia as having the eighth highest adult HIV prevalence rate globally (5). Notably, Zambia has made substantial progress towards achieving the Joint United Nations Programme on HIV/AIDS (UNAIDS) goals of 95-95-95, with 88.7% of the country's adults living with HIV aware of their status in 2021. Of those aware, 98% were on antiretroviral treatment (ART), and among those on ART, 96.3% were virally suppressed (6). However, with many aware of their HIV status, detecting new HIV infections to achieve epidemic control is an uphill battle, requiring intensified targeted testing efforts (7).

Despite the marked progress achieved with mass testing and the identification of target populations, Zambia still faces the challenge of identifying and reaching individuals who remain untested or are unaware of their HIV status. Additionally, the existing gaps in HIV treatment are exacerbated by local resource constraints and competing priorities within the healthcare system. Approximately 58% of Zambia's population lives below the international poverty line, and the healthcare system is also burdened with high non-communicable disease mortality rates (8,9).

Due to limited resources, Zambia's health strategies have become increasingly targeted, focusing on critical populations and specific geographic locations based on a review of patient data (10). In response to the challenges, local programmes are implementing strategies such as patient index tracing and community testing to enhance HIV testing yield (7). One such programme is the Right to Care HIV Treatment programme.

Right to Care was introduced in Zambia in 2016 by the United States Agency for International Development to combat the HIV and AIDS epidemic. Having utilised general mass testing strategies, Right to Care Zambia (RTCZ) began more targeted approaches to continue to bring new HIV patients on treatment. RTCZ employs various targeted testing strategies, including screening tools, sexual partner tracing, and the recent incorporation of mobile health (mHealth) technology. This study focuses on the assessed acceptability of an mHealth component within the RTCZ programme, offering valuable insights for potential scalability and integration into broader healthcare systems.

1.3 Literature Review

1.3.1 Evolving HIV Testing Strategies

In the past 10 years, HIV testing strategies have moved from client-initiated testing approaches, such as voluntary testing and counselling, towards provider-initiated and community-initiated testing approaches to identify the remaining persons still unaware of their HIV-positive status (11). The original client-initiated approaches worked to identify persons who routinely came to clinics for health services. However, harder-to-reach populations such as men, require more specific targeted approaches by the provider (12). These new targeted testing strategies require specific resource allocations and planning. To address targeted testing and maximise existing limited resources in programmes, health system information such as patient data or supply chain data, needs to be streamlined and organised into easily viewable formats (7). Efficient data organisation and aggregation allow for an in-depth review and analysis of programme output and progress as measured through relevant programme indicators. Once new trends, strengths, or weaknesses are noted, more comprehensive investigations or interventions can take place to provide new insight into how programme practices or local settings influence indicator outcomes. Reviewing programme data to create new programme activity establishes evidence-based action, policy, or outreach originating from the existing data.

1.3.2 Healthcare Data Systems

Presently, in Zambia, patient information systems in public healthcare facilities rely on paper registers to document data related to new HIV testing services. These registers serve as the primary means of recording essential client information and test results. The HIV data obtained through manual entries is then assessed against the targets set by the President's Emergency Plan for AIDS Relief (PEPFAR), a programme integral to Zambia's efforts for HIV epidemic control (13).

However, the current dependence on physical paper-based systems poses considerable challenges to data integrity that can compromise the effectiveness of HIV programmes. The vulnerability of paper records to external factors, such as adverse weather conditions and logistical constraints, can result in delays, losses, or even compromise the validity of programme health data. These challenges not only hinder the accurate and timely reporting of HIV-related data but impede the ability to conduct swift and comprehensive programme strategy analyses, such as those needed for targeted testing (14).

The limitations of relying on paper-based systems underscore the pressing need for a more robust and technologically advanced solution. The vulnerabilities associated with manual data entry can have far-reaching implications for the success of HIV programmes, potentially impacting the overall effectiveness of interventions and hindering the achievement of national targets. Exploring and adopting alternative, technology-driven patient information systems could present a transformative solution, addressing the current challenges and contributing to more efficient and resilient HIV epidemic control efforts in Zambia.

1.3.3 Mobile Health Innovations

Incorporating innovative mobile technologies, such as SMS systems between clients and healthcare providers, into HIV programmes has been shown to increase patient adherence to treatment, as well as patient data reading efficiency by reducing data transfer delays within healthcare systems and increasing sophisticated data analysis possibilities (15). mHealth services allow for more complex health tools to be brought to traditionally rural points of care, outside the boundaries of cord-bound hardware. Within Zambia, new online health services are becoming available to enhance healthcare training and are being assessed for their suitability for healthcare staff training and practice support within the local context (16). By beginning to include new technologies in rural health programmes, there have been new evaluations to

investigate the implementation of the technologies, which have demonstrated user acceptance to be critical to the success of such interventions (17,18).

1.3.4 Acceptability

Implementation science research delves into measurable outcomes distinct from the effectiveness of an intervention, focusing on factors such as its acceptability, adoption, feasibility, and sustainability within the targeted service system setting (19). When assessing new technological interventions, terms like acceptance, adoption, and acceptability come into play, each offering a nuanced perspective on a person's willingness to embrace and utilise the technology.

Acceptance, as defined by Al-Youssef, refers to the extent to which individuals are willing to engage with and use technology (20). Looking at it through a behavioural lens, Schade characterises acceptance as a "prospective judgment of measures to be introduced in the future", establishing the idea that acceptance precedes the actual receipt or implementation of the intervention (21). Similarly, Adell frames acceptance as the "degree to which an individual intends to use a system and incorporate it" (22). In essence, acceptance can be viewed as the extent of a stakeholder's engagement with an object, while acceptability is the perceived quality of an intervention or object by a stakeholder (23). Proctor et al. capture this notion by defining acceptability as the "perception among stakeholders that a given service is agreeable, palatable, or satisfactory" (24). The framework for implementation outcomes and acceptability is within a previously published framework from Proctor et al. interlinking implementation, service, and client outcomes as seen in Figure 1 (24).

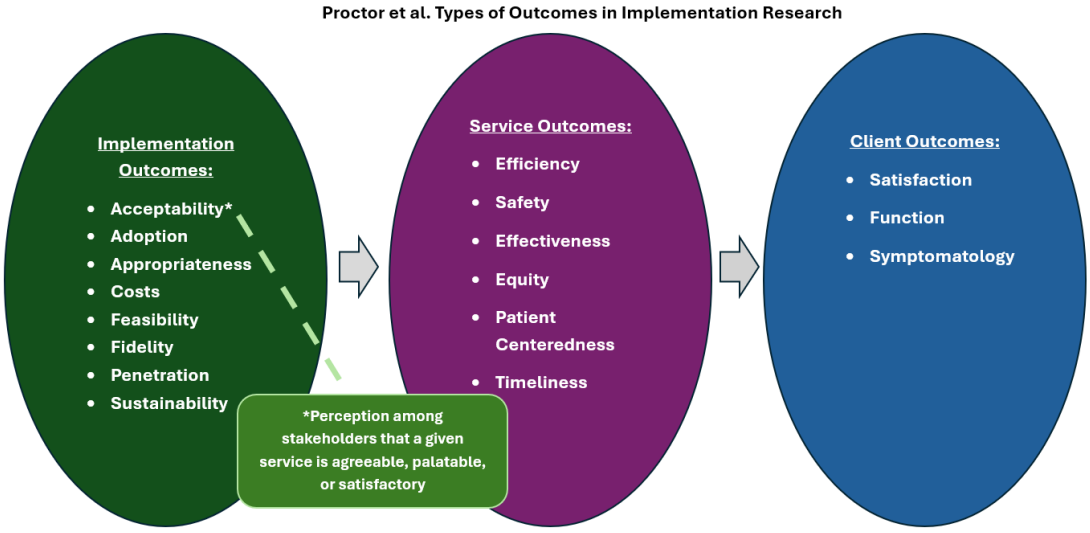

Figure 1: Proctor Framework of Outcomes (24)

Adoption, a term closely related to acceptance and acceptability, encapsulates a multi-phase process according to Carroll et al. It commences with the decision to adopt, involving selection, purchase, or commitment to use, and extends into achieving persistent use (25). Adoption, therefore, encompasses the behavioural decision to use and the sustained interaction or utilisation of the intervention. It can be posited that acceptability serves as a predictor for the adoption of a new intervention, highlighting its pivotal role in the implementation process (26).

1.3.5 Measuring Acceptability

The measurement of acceptance towards new technologies often employs the technology acceptance model (TAM), a validated framework derived from the theory of reasoned actions. The fundamental goal of TAM is to elucidate behaviour as an outcome of beliefs towards behavioural intentions. In the realm of technology acceptance, behavioural intentions are shaped by attitudes regarding perceived usefulness and perceived ease of use (27,28).

Beyond these primary factors, several other elements come into play, influencing attitudes and subsequent intentions to use technology. These include facilitating conditions, compatibility, self-efficacy, and voluntariness (27). The TAM questionnaire serves a crucial mediating role by assessing the perceived usefulness and perceived ease of use, acting as a bridge between external setting characteristics and potential technology usage (28).

Originally designed for survey or questionnaire administration, the TAM constructs have expanded in utility to include the creation of interview or discussion guides for measuring acceptability (29). By exploring users' perceptions of the technology's usefulness and ease of use, the TAM framework provides valuable insights into the factors influencing technology acceptance. This model has proven versatile, adapting to various research methodologies, including surveys, interviews, and discussions, thus offering a comprehensive approach to gauge the acceptability of new technologies in diverse contexts. In essence, TAM serves as a tool for quantitative assessments and also a qualitative guide, ensuring a thorough exploration of user attitudes and intentions towards adopting novel technological interventions.

1.4 Problem Statement

To address the challenges of reaching epidemic control within the constraints of limited resources, health facilities in rural Zambia are faced with the imperative to embrace innovative targeted health solutions that optimise existing resources. Recognising this need, RTCZ has

introduced a novel mHealth application to enhance targeted HIV testing efforts. Despite the potential benefits of this application, a critical aspect that remains unexplored is its acceptability among the healthcare professionals who are the end-users within these healthcare facilities.

The implementation of the mHealth application represents a proactive response to the challenges of resource scarcity, aiming to streamline and augment HIV-related programmes. This technological intervention holds the promise of bolstering the efficiency of targeted HIV testing, ensuring that healthcare facilities can reach underserved populations effectively. However, the success and sustainability of such innovations hinge on the acceptance and seamless integration of these technologies into the daily workflows of healthcare providers in these rural settings.

Currently, there is a crucial gap in our understanding regarding the acceptability of the mHealth application among the healthcare personnel operating in these rural healthcare facilities. Acceptability, in this context, extends beyond mere technical functionality. It encapsulates the willingness and enthusiasm of healthcare providers to incorporate this technology into their routine practices. The perceived acceptability of the mHealth application is pivotal for its successful implementation and sustained usage, ultimately determining its impact on targeted HIV testing outcomes.

Thus, it becomes imperative to undertake a comprehensive evaluation of the acceptability of the mHealth application among the healthcare professionals working in these rural facilities. Such an assessment would shed light on various dimensions, including the perceived utility, ease of use, and compatibility of the application within the existing healthcare workflows. Additionally, understanding the barriers and facilitators that influence the acceptability of this technological intervention is crucial for tailoring implementation strategies and ensuring optimal utilisation.

This study, therefore, seeks to bridge this critical gap by conducting an in-depth exploration of the acceptability of the mHealth application among healthcare providers in rural Zambia. This research endeavour aligns with the broader goal of introducing technological innovations to enhance health outcomes and also ensuring their seamless integration and sustained use within the healthcare landscape of rural Zambia. The findings of this study inform the optimisation of the mHealth application as well as contribute valuable insights to the

broader discourse on implementing technology-driven solutions in resource-limited healthcare settings.

1.5 Justification

Given the pivotal role of acceptability in determining the utilisation of mHealth interventions, it is imperative to assess the acceptability of any new mHealth intervention to ensure its optimal utilisation. Lynx, an mHealth HIV testing application, offers the HIV treatment programme real-time access to patient data aggregations, individual staff performance metrics, and GIS maps of targeted populations. Despite these potential benefits, there has been no prior evaluation of Lynx's acceptability at the time of this study.

It has been well-established that new interventions with low acceptability are prone to rejection or underutilisation by their intended users (30). The absence of an evaluation regarding Lynx's acceptability poses a potential barrier to its effective integration into the existing healthcare system. Recognising the significance of acceptability, it becomes crucial to measure and strive towards higher levels of acceptability for the Lynx application.

Assessing acceptability serves as a proactive approach to identifying any weaknesses or concerns associated with the application, paving the way for targeted interventions to address them. By understanding the factors that contribute to or hinder acceptability, healthcare stakeholders can implement tailored strategies to enhance Lynx's acceptability among its users. This process is essential for unlocking the full potential of the application, particularly in improving the efficiency of HIV testing initiatives.

This report endeavours to fill the existing gap by evaluating the acceptability of the Lynx mHealth application. By conducting a thorough assessment, we aim to uncover insights that can guide strategies to enhance Lynx's acceptability, ultimately maximising its potential impact on improving the efficiency of HIV testing. This approach aligns with the broader goal of ensuring that technological interventions are introduced and also seamlessly embraced and effectively utilised within the healthcare landscape.

1.6 Research Question

To what extent do healthcare workers in a rural Zambian HIV treatment programme find an HIV testing mobile application acceptable?

1.7 Study Aim and Objective

1.7.1 Study Aim

To determine the acceptability of an HIV testing mobile application by healthcare workers within a rural HIV treatment programme across three Zambian provinces.

1.7.2 Study Objectives

1. Assess the acceptability of an HIV testing application to healthcare workers of a rural HIV treatment programme through the below factors:
    a. Perceived usefulness
    b. Perceived ease of use
    c. Compatibility to the local context
2. Determine the factors that enhance or act as barriers to the acceptability of Lynx.

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2 Chapter 2 Methodology

2.1 Introduction

The following section provides the overall design of the study conducted, details of the intervention assessed, the study setting, population, sample size, and the data collection and analysis methods.

2.2 Design

This is a cross-sectional study that uses a concurrent mixed method approach with a combination of quantitative and qualitative research methods. The quantitative component included a survey adopted from the verified TAM (1). The survey consisted of closed-ended questions based on the three acceptability factors to measure the acceptability of the intervention among healthcare workers, addressing objective one. Similar methods have been used for comparable mHealth applications in sub-Saharan Africa (2). The qualitative component consisted of key person interviews (KPIs) and focus group discussions (FGDs) aimed at acquiring a more in-depth understanding of participants' perceived acceptability and identifying relevant barriers and facilitators, complementing the quantitative data for objective one while addressing objective two.

2.3 Intervention

To achieve effective HIV epidemic control through optimised resource utilisation in HIV testing programmes, RTCZ has introduced Lynx, an innovative HIV testing mobile health application in Zambia. This intervention is strategically positioned within the broader HIV care and treatment strategy, as illustrated in Figure 2, where highlighted areas underscore the specific focus of the intervention. Tailored to align seamlessly with the National Zambian HIV testing guidelines and the rural context supported by RTCZ, Lynx serves as a critical tool for enhancing the efficiency and precision of HIV testing efforts.

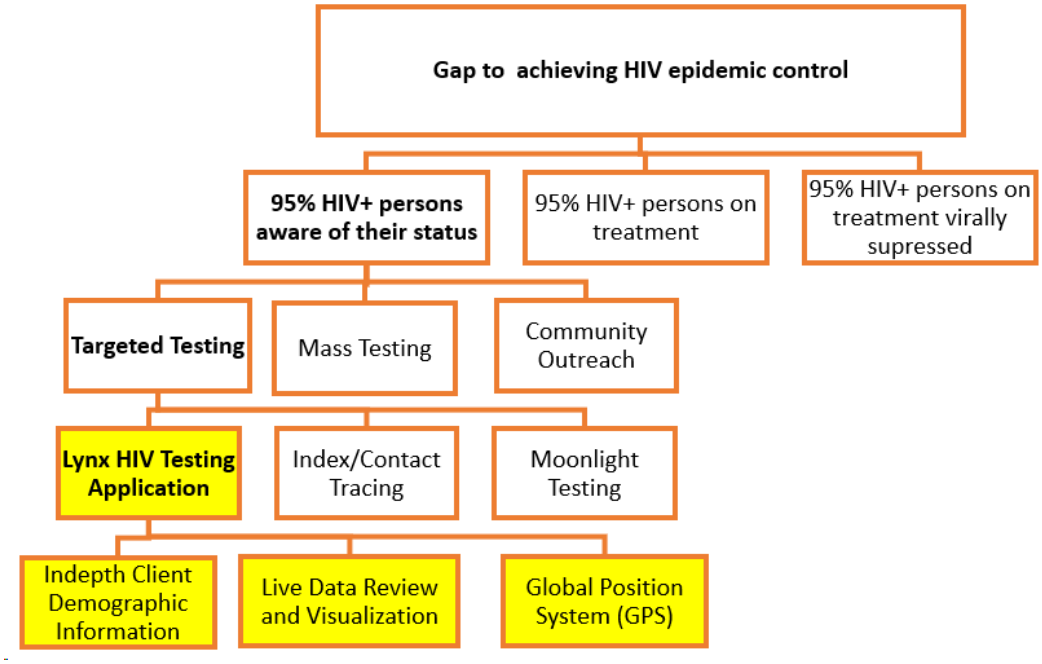

Figure 2: Lynx Mobile Heath Application Intervention Concept

Lynx operates by storing HIV testing information directly on the mobile device, ensuring rapid and secure uploading to an online platform whenever a network connection is established. This dynamic tool is utilised by HIV testing staff both within health facilities and the surrounding communities, facilitating the comprehensive capture of HIV testing data through electronic mobile tablets. Patient information about the HIV testing process, including demographics, sexually transmitted disease (STD) and tuberculosis (TB) screening, geographic information system (GIS) coordinates, client care point modality, HIV test kit information, HIV test results, and completion times for testing and counselling, is meticulously recorded through the application.

The collected HIV testing data is then aggregated in a centralised online data warehouse, showcased in Figure 3, where the programme staff can review and analyse the information. Local staff regularly examine this data to assess HIV testing client demographics, facility entry points, facility staff performance, and GIS hotspots within the surrounding community. This ongoing review process allows for timely adjustments and interventions to optimise the effectiveness of the HIV testing programme.

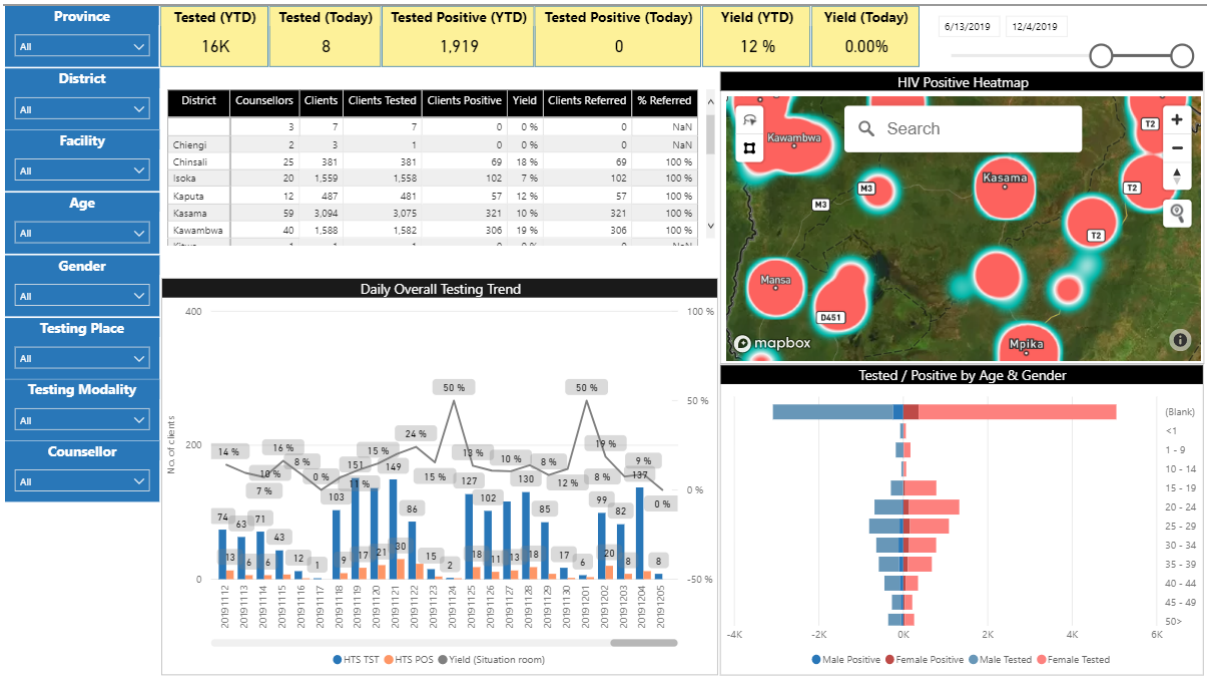

Figure 3: Screenshot of Lynx Online Data Dashboard

The overarching goal of the Lynx intervention is to contribute significantly to the efficient maximisation of available resources within Zambia by streamlining the processing of in-depth patient information. The implementation of this cutting-edge technology is currently underway, involving healthcare workers in selected RTCZ-supported priority facilities situated in the Luapula, Muchinga, and Northern provinces of Zambia.

2.4 Setting

RTCZ operates actively in the Northeast region of Zambia, encompassing the Luapula, Muchinga, and Northern provinces. These rural and sparsely populated regions grapple with limited resources, presenting unique challenges for healthcare interventions. They are situated at a considerable distance of 14 hours by car from the country's capital, Lusaka. This region requires tailored healthcare solutions to address the specific needs and constraints of its remote and resource-strapped communities.

For geographic reference, please refer to Figure 4, which provides an up-to-date map of Zambia with the identified provinces, showcasing the expansive reach of RTCZ's operations in the Luapula, Muchinga, and Northern provinces (3). This strategic presence in the Northeast region underscores RTCZ's commitment to extending healthcare services to underserved

populations in remote areas and its dedication to addressing health disparities and promoting comprehensive healthcare access in Zambia.

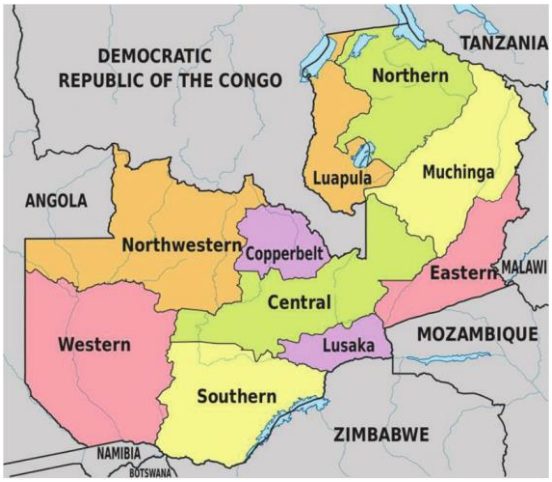

Figure 4: Provincial Map of Zambia

Each year Zambia experiences rainy and dry seasons, which greatly affect the local logistics, such as road conditions and general transport. The HIV treatment programme is affected by the seasons as it becomes increasingly challenging to collect data by hand when the rural roads become flooded or damaged by adverse climatic conditions. Figure 5 visualises the average annual rainfall experienced in Zambia from 2000 to 2016 (4).

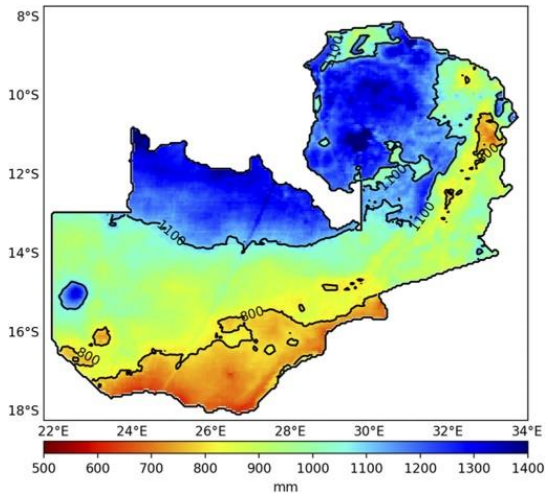

Figure 5: Mean Annual Rainfall Map of Zambia, 2000–2016

The HIV programme of RTCZ, in which the study is imbedded, supports a set amount of public health HIV treatment facilities in Zambia, 168 in total, both primary and secondary care. The data collection took place within the HIV treatment facilities where the mobile health application has been implemented.

2.5 Study Population

The study focuses on healthcare workers involved in HIV treatment, specifically those conducting HIV tests using the mHealth application. The selection of mHealth intervention sites was based on the performance levels of HIV testing within the broader RTCZ HIV treatment programme. Out of the total 168 HIV treatment facilities under the programme's purview, a subgroup of 55 facilities, termed "priority facilities", significantly contributes to 85% of the total new HIV-positive clients identified across the Luapula (17 facilities), Muchinga (21 facilities), and Northern (17 facilities) provinces. In contrast, the remaining 113 facilities, referred to as "normal facilities", collectively contribute 15% of the newly identified HIV-positive clients.

To ensure a comprehensive representation, the mHealth intervention was implemented across all 55 priority facilities. Rigorous training and equipping of all HIV testing and treatment staff within these priority facilities with the mHealth application were carried out by RTCZ.

In this study, the entire cadre of HIV testing healthcare workers using Lynx from the selected facilities was included in the participant pool. This inclusive approach aimed to capture a holistic view of the experiences and perspectives of healthcare workers involved in HIV testing at the designated priority facilities. By encompassing diverse roles and responsibilities within these healthcare settings, the study aimed to provide nuanced insights into the utilisation and impact of the mHealth application in the context of HIV testing and treatment.

2.6 Sample Size

The survey was completed through census sampling, the KPIs were completed through random and sampling, and the FGDs were completed through purposive sampling based on health facility size. To complete the survey, the researcher invited all the HIV testing healthcare workers at all mHealth intervention facilities (four to 16 per facility) to complete the survey in English. The researcher does not have direct authority over the participants. One HIV testing staff manager from two new random lottery-selected facilities in each province was invited in English to participate in six planned KPIs. The researcher invited the individuals directly to prevent them from facing any pressure due to power dynamics. During the data collection, one of the managers was unavailable and an FGD was conducted instead.

The largest facility of each province was invited to partake in the FGDs. Mansa General Hospital was invited in Luapula province, Nakonde Urban Health Center was invited in Muchinga province, and Mpulungu Urban Health Center was invited in Northern province. All potential participants were invited in English by the researcher directly to prevent any undue pressure due to power dynamics. Two additional FGDs were conducted during data collection to ensure the data saturation of the qualitative themes. Each discussion included all mHealth intervention staff from the largest intervention facility in each province. Again, all potential participants were invited in English by the researcher directly to prevent any undue pressure due to power dynamics. Invitations for the survey, KPIs, and FGDs were first sent to facility heads and managers of the relevant healthcare workers for approval. The total number of participants is outlined in Table 2.

Table 2: Sample Sizes of Data Collection

Data Collection Tool	Sample Size
Surveys (Quantitative)	176 Persons
Key Person Interviews (Qualitative)	5 Persons
Focus Group Discussions (Qualitative)	6 Groups (31 Persons)

2.7 Data Collection

2.7.1 Quantitative

The online survey (Appendix 3) hosted on REDCap consisted of questions with five-point Likert scale responses. The questions and method were directly adopted from the verified TAM questionnaire with language adjustments made to fit the study intervention and local programme contexts (5,6). A substantial amount of work has been published using the TAM to evolve an understanding of the predictors of human behaviour towards an acceptance or rejection of a new technology (1). The survey was broken into sections of questions addressing each factor of acceptability: perceived usefulness, perceived ease of use, and compatibility. Participants had invitations sent via email and SMS with attachments of the study information and a link to the survey itself. The survey was written in English. Before data collection, the survey was reviewed and adapted by five local Zambian experts with experience in HIV care and treatment to ensure the survey questions were comprehendible and perceived clearly. The adapted survey was then pilot-tested with five users of the application from a randomly selected facility. Following the piloting, the participants regarded the survey as compensable, relevant, and perceivable.

2.7.2 Qualitative

While the survey was being completed, the researcher conducted semi-structured KPIs with open-ended questions and prompts related to the barriers to the implementation and the facilitators of compatibility, perceived ease of use and usefulness. The interview guide is available in Appendix 4. Two KPIs were planned per province with randomly selected HIV testing staff managers, titled, "Professional HIV Counsellors", for a total of six KPIs. During the collection, one KPI was replaced by an FGD due to the availability of staff, and five KPIs were conducted. The managers were randomly selected and emailed invitations to participate in the interview with the study materials attached. Following this, interviews were scheduled at a time of their convenience at their facility. The interviews, lasting 30 minutes at the most, were conducted in English by the researcher in meeting rooms at the selected healthcare worker's facility. Each interview was conducted by the researcher to ensure minimal variance in the interview question formatting and tone. Before data collection, the interview guide was reviewed and adapted by five local Zambian experts with experience in HIV care and treatment to ensure the interview questions were comprehendible and perceived clearly. The reviewed interview guide was then pilot-tested with two users of the application from a randomly selected facility. Following the piloting, the participants regarded the tool as compensable and relevant and that the questions were comprehensible.

One FGD was planned within each province with five randomly selected users from the largest facility. During the data collection, two additional FGDs were conducted to ensure data saturation and one KPI became a FGD due to staff availability. Six FGDs were conducted during data collection. The discussion guide focused on the mHealth application's acceptability from the health worker's perspective. The FGD guide was built off the guide developed for the KPIs with questions phrased from a group perspective instead of an individual's perspective. The FGD guide is available in Appendix 5. The selected users were emailed an invitation to participate in the discussion with the study materials attached. Once confirmed, the KPIs were scheduled at their facilities at a time of their convenience. Each group discussion was conducted in English by the researcher in meeting rooms in the selected healthcare workers' facilities for up to 40 minutes. Each group discussion was conducted by the researcher to ensure minimal variance in the interview question formatting and tone.

2.8 Measurement of Outcomes

Acceptability outcomes were gauged through a dual-method approach, encompassing both quantitative and qualitative assessments. In the quantitative strand, respondents provided

Likert scale scores, ranging from one (strongly disagree) to five (strongly agree), for questions related to perceived usefulness, perceived ease of use, and compatibility. Higher scores on this scale indicated heightened levels of acceptability.

Concurrently, in the qualitative aspect, KPIs and FGDs were conducted, focusing on coding responses about perceived usefulness, perceived ease of use, and compatibility. This qualitative exploration provided a more nuanced understanding of the factors influencing the acceptability of the mHealth application.

To enhance the rigour and reliability of the findings, data triangulation was employed, aligning the quantitative and qualitative data to validate the outcomes. This convergence of data sources lends credibility to the assessment of acceptability, ensuring a more comprehensive and robust evaluation.

Furthermore, to delve into the intricacies of acceptability, barriers and facilitators were identified by coding the transcripts from KPIs and FGDs. These qualitative insights shed light on the contextual factors shaping the acceptability of the mHealth application among healthcare workers involved in HIV testing.

In summary, this comprehensive methodology, incorporating both quantitative and qualitative approaches with data triangulation, allows for a thorough examination of the acceptability outcomes. The multifaceted insights derived from this research approach contribute to a holistic understanding of the factors influencing the acceptance of the mHealth application within the targeted healthcare settings.

2.9 Data Analysis

2.9.1 Quantitative

Survey data was directly entered online into the REDCap platform by participants. The data was then extracted into an excel file, which was cleaned and analysed using R. Survey questions 2, 13, and 15 had their scores from 1–5 reversed to align the responses of the rest of the survey, with five being the strongest acceptability score and one being the weakest. Cronbach's alpha was used to measure the internal reliability and validity of the survey questions. Only participants who have used the mHealth intervention were included in the analysis. Outliers were identified and removed using z-scores. Responses with z-scores greater than three were removed.

Participant demographics were reported as frequencies and proportional percentages. Responses for each statement were averaged with standard deviation to review the average response of each statement. The frequencies of the highest and lowest responses to each statement were also captured. The response averages were between 1.00 and 4.99. Averages 3.00–3.99 were categorised as "agree", and averages 4.00–4.99 were categorised as "strongly agree". Averages 2.00–2.99 were categorised as "disagree", and averages 1.00–1.99 were categorised as "strongly disagree".

The responses related to the three acceptability factor groups were averaged for each participant. The dataset was tested for normality using the Shapiro-Wilk test. The factor group scores were then aggregated by demographic details and with significance accounted for. Data triangulation between the quantitative and qualitative results was used to verify the findings.

2.9.2 Qualitative

The KPIs and FGDs were recorded and then transcribed by the researcher. The transcripts were coded for thematic analysis through MAXQDA by the researcher. The coding was done deductively by the researcher based on the themes: perceived usefulness, perceived ease of use, and compatibility, breaking into subsections of barriers and facilitators of each factor. Inductive coding was used to identify emerging related themes, and the related barriers and facilitators. Meaning units within the recorded text were identified as the beginning of an expressed relevant topic in the text up to its completion or change to another topic. These meaning units were grouped into codes under the above-mentioned themes. The coding tree used in analysis can be found in Appendix 6. Themes that did not fit the analysis were disregarded. Reflexivity was employed by the researcher while coding to ensure validity. Data triangulations between the qualitative and quantitative results were used to verify the findings.

2.10 Ethical Considerations

This study was approved by the University of the Witwatersrand Human Research Ethics Committee (Medical) (Clearance certificate number M220720) Appendix 7 and ERES Converge IRB in Lusaka Zambia (Ref No. 2021-Oct-003) Appendix 8.

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3 Chapter 3 Submitted Paper – PLOS ONE

The following section was written following the PLOS ONE Journal Submission guidelines found in Appendix 9.

Health worker acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment programme

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Key Words: Lynx, Implementation Science, HIV Testing, Acceptability, Mobile Health, mHealth

3.1 Introduction

As of 2021, the global burden of HIV remains significant, with an estimated 37.7 million people living with the virus worldwide, and the African region continues to be the most affected, accounting for approximately two-thirds of new cases (1,2). Despite substantial progress in managing the HIV epidemic, more than 8.1 million individuals remain unaware of their HIV status, contributing to ongoing transmission and mortality, with 1.5 million new infections reported in 2020 (3,4). This underscores the critical importance of expanding HIV testing efforts.

Zambia has demonstrated remarkable strides in aligning with UNAIDS goals, particularly the ambitious 95-95-95 targets, aiming for 95% of all people living with HIV to be aware of their status, 95% of diagnosed individuals to receive sustained antiretroviral therapy (ART), and 95% of those on ART to achieve viral suppression by 2025(5,6). In 2021, 88.7% of adults living with HIV in Zambia were aware of their status, with 98% on ART and 96.3% achieving viral suppression (7). To reach the final milestone in identifying HIV-positive individuals, increasing testing has been identified as a pivotal strategy (8,9).

While mass testing and community outreach strategies have been instrumental in managing the HIV epidemic in Zambia, novel and efficient innovations such as index tracing

and moonlighting are now being deployed by HIV treatment organisations to access harder-to-reach populations (10). Right to Care-Zambia (RTCZ) has implemented the "Lynx" intervention, a mobile health (mHealth) application designed for targeted HIV testing. This application furnishes the HIV treatment programme with real-time HIV testing data aggregations, individual staff performance metrics, and geographic information systems (GIS) maps pinpointing targeted populations.

However, the success of such technological interventions hinges on the acceptance or "willingness to use" of their target users. Therefore, accounting for and ensuring high acceptability is crucial for maximising the application's potential in improving targeted HIV testing efficiency (11). This study aims to evaluate the acceptability of the Lynx HIV testing mobile application among healthcare workers within a rural HIV treatment programme spanning three Zambian provinces. Acceptability is assessed through users' perceived ease of use, usefulness, and compatibility, while also investigating barriers and facilitators to inform future implementation considerations. The goal is to enhance our understanding of how healthcare providers engage with and perceive this innovative tool, ultimately optimising its integration into the healthcare system for more effective HIV testing strategies.

3.2 Materials and Methods

3.2.1 Design

The study employed a mixed-method, cross-sectional design, integrating both quantitative and qualitative research components involving public health workers. In the quantitative phase, a survey was utilised, adapted from a well-established and validated tool known as the technology acceptance model (TAM) (12,13). This tool comprises closed-ended questions designed to assess the acceptability of a given intervention, considering factors such as perceived ease of use, usefulness, and compatibility within a specific context. This survey draws on similar methodologies previously employed for assessing mHealth applications in sub-Saharan Africa, establishing its appropriateness for this study (14).

Complementing the quantitative approach, the qualitative component involved semi-structured key person interviews (KPI) and focus group discussions (FGD). These qualitative methods aimed to delve deeper into participants' perceptions and provide a richer and more nuanced understanding of their experiences with the intervention. The ensuing analysis

incorporated data triangulation, reconciliation and validation of findings obtained from both quantitative and qualitative data collection methods.

This comprehensive mixed-method design ensures a multifaceted exploration of the acceptability of the intervention among public healthcare workers, offering a more holistic perspective that combines quantitative metrics with qualitative insights. Such an approach enhances the study's robustness and facilitates a more thorough comprehension of the complex dynamics surrounding the acceptance of the mHealth intervention in this particular public health context.

3.2.2 Intervention

In pursuit of optimising HIV testing programme resources through targeted testing, RTCZ has introduced an innovative HIV testing mHealth application in Zambia. This intervention is strategically aligned with the initial goal of the 95-95-95 targets, specifically focusing on HIV awareness, as illustrated in Figure 2. mHealth is meticulously tailored to adhere to the National Zambian HIV testing guidelines, serving as a comprehensive tool for both healthcare facilities and community-based HIV testing staff (15). This application is installed on mobile tablets and digitally captures detailed patient testing information, including demographics, sexually transmitted disease (STD) and tuberculosis (TB) screening, GIS coordinates, client care point modality, HIV test kit details, HIV test results, and the completion time for testing and counselling.

The captured HIV testing data is then aggregated in a central online data warehouse, facilitating its review and analysis by the programme staff. Local staff engage in regular assessments, scrutinising demographic trends among HIV testing clients, evaluating facility entry points, appraising facility staff performance, and identifying GIS hotspots within the surrounding community. The overarching aim of this mHealth intervention is to enhance operational efficiency by streamlining the processing of in-depth patient information, thereby maximising available resources within Zambia.

The selection of intervention sites was based on the HIV testing performance of facilities within the broader HIV treatment programme. Among the 168 HIV treatment facilities covered by the programme, a subset of 55 "priority facilities" emerged, contributing a significant 85% of the total newly identified HIV-positive clients. The mHealth intervention has been strategically implemented across all 55 priority facilities, distributed across Luapula (17 facilities), Muchinga (21 facilities), and Northern (17 facilities) provinces. To ensure

seamless integration, all HIV testing and treatment staff in these priority facilities have undergone thorough training and have been equipped with the mHealth application, paving the way for comprehensive utilisation.

3.2.3 Setting

RTCZ's HIV care and treatment initiatives operate actively in the northeast region of Zambia, spanning Luapula, Muchinga, and Northern provinces. This geographical area is characterised by its rural nature, sparse population, and constrained resources. It is situated approximately 14 hours by car from the nation's capital, Lusaka. Within this region, the HIV programme, serving as the backdrop for the research, extends support to a total of 168 public health HIV treatment facilities. These facilities encompass both primary and secondary care levels, collectively contributing to the comprehensive healthcare services delivered in this challenging and resource-limited environment.

3.2.4 Participant Selection

Data were collected at purposively sampled HIV treatment facilities. A majority of the participant population is comfortable in reading and speaking English. All invitations were first sent to facility heads and managers of the relevant health workers for approval. All HIV testing healthcare workers using the HIV testing application were invited to participate in the survey over email. One HIV testing staff manager from two new random lottery selected facilities was invited in English from each province for six planned KPIs, though only five were completed due to the unavailability of staff.

The largest facility of each province was invited to partake in the FGDs. Mansa General Hospital was invited in Luapula province, Nakonde Urban Health Center was invited in Muchinga province, and Mpulungu Urban Health Center was invited in Northern province. Three additional FGDs were conducted during data collection to ensure data saturation of the qualitative themes. Each discussion included all mHealth intervention staff from the facility. All potential participants were invited in English over email. The total number of participants for each collection method is outlined in Table 3.

Table 3: Sample Sizes of Data Collection

Data Collection Tool	Sample Size
Surveys (Quantitative)	176 persons
Key Person Interviews (Qualitative)	5 persons
Focus Group Discussions (Qualitative)	6 groups (31 persons)

3.2.5 Data collection

3.2.5.1 Quantitative

All identified survey participants received a link to the online survey. The survey was anonymised, and self-administered in English on a user-friendly platform, REDCap. All healthcare workers had access to a computer with internet. The survey consisted of 15 statements written in plain English, four on the ease of use and usefulness, and seven on compatibility (Appendix 3). Participants were asked to rate their level of agreement on a 5-point Likert scale, where one was "strongly disagree" and five was "strongly agree". Before data collection, the survey was reviewed and adapted by five local Zambian experts with experience in HIV care and treatment to ensure that the survey questions were comprehendible and perceived clearly. The adapted survey was then pilot-tested with five users of the application from a randomly selected facility. Following the piloting, the participants regarded the tool as compensable, and relevant, and perceived the questions.

3.2.5.2 Qualitative

A semi-structured interview schedule (Appendix 4 and 5) was developed to guide the KPIs and FGDs. Questions focused on participants' perceptions relating to barriers and facilitators of the application's compatibility, and ease of use and usefulness. KPIs and FGDs were conducted in English, on-site at the participant's respective facility and took approximately 20–40 minutes. Before data collection, the interview guide was reviewed and adapted by five local Zambian experts with experience in HIV care and treatment to ensure the interview questions were comprehendible and perceived clearly. The reviewed interview guide was then pilot-tested with two users of the application from a randomly selected facility.

3.2.6 Data analysis

Survey data were inputted online through the REDCap platform and subsequently extracted into an Excel file for cleaning and analysis using R. Internal reliability and validity of the survey questions were assessed using Cronbach's alpha. The analysis focused exclusively on participants who had utilised the mHealth intervention (144 out of 176), with outliers identified and removed through z-scores. Utilising a Likert scale ranging from one to five, response averages fell within the range of 1.00 to 4.99. Each question received a mean score with standard deviations recorded, and responses were categorised into "agree" (averages 3.00–3.99), "strongly agree" (averages 4.00–4.99), "disagree" (averages 2.00–2.99), and "strongly disagree" (averages 1.00–1.99).

The questions within each factor group were further averaged, accounting for standard deviations. To assess the significance of participant demographics on acceptability factors, Kruskal-Wallis and Wilcoxon rank sum tests were employed.

As for qualitative data, the KPIs and FGDs transcriptions underwent coding in MAXQDA, utilising both inductive and deductive coding methods based on themes related to perceived usefulness, ease of use, and compatibility. Codes were applied to segments of the text representing the beginning and conclusion of relevant topics or transition to another subject. These codes were then organised into themes associated with the acceptability factors. Data triangulation, comparing findings from each data collection tool, was employed to validate key insights and ensure consistency across the diverse data sources. This robust approach enhances the reliability and credibility of the study's findings.

3.2.7 Ethical Considerations

This study was approved by the University of the Witwatersrand Human Research Ethics Committee (Medical) (Clearance certificate number M220720) and ERES Converge IRB in Lusaka Zambia (Ref No. 2021-Oct-003).

3.3 Results

3.3.1 Quantitative Findings

3.3.1.1 Survey Participant Characteristics

Cronbach's Alpha of the 15-item survey was 0.663. Table 4 outlines the socio-demographic characteristics of the survey participants, the majority of whom are women, who came from Luapula and Northern Provinces, and were aged 25–34.

Table 4: Sociodemographic Characteristics of Survey Participants

	Luapula N (%)	Muchinga N (%)	Northern N (%)	Total N (%)
Gender				
Men	23 (33%)	3 (21%)	24 (39%)	50 (35%)
Women	46 (66%)	11 (79%)	37 (61%)	94 (65%)
Age Group				
18–24	4 (1%)	0 (0%)	2 (3%)	6 (4%)
25–34	23 (33%)	7 (50%)	24 (39%)	54 (38%)
35–44	13 (19%)	2 (14%)	13 (21%)	28 (19%)
45–54	16 (23%)	2 (14%)	10 (16%)	28 (19%)
55+	13 (19%)	3 (21%)	12 (20%)	28 (19%)
Total				
	69 (48%)	14 (10%)	61 (42%)	144

3.3.1.2 Acceptability of Lynx

Each statement has an averaged response score between 1.00 and 4.99. As seen in table 5, most of the responses averaged 3.00–3.99 "agree" followed by 4.00–4.99 "strongly agree". A review of the frequency of the strongest scores, "strongly agree/disagree", in the responses indicated that over 10% of respondents strongly agreed with 11/15 statements, and over 10% of respondents strongly disagreed with 1/15 statements. These scores indicate that the intervention was perceived as easy to use and useful to the HIV testing staff, but there were factors, which could improve the compatibility with the context. These included issues related to statements 9, 11, and 14 of Table 5. Statement 9, relating to reliance on network connectivity, had the lowest response average of all questions, and the most "strongly disagree" responses. Statements 11 and 14 relating to healthcare workers' adequate resources and support to complete the application at work also scored lower.

Table 5: Survey Responses

	Acceptability Factor	Question	Averaged (1–5) (SD)	Frequency of 1 "Strongly Disagree" (%n)	Frequency of 5 "Strongly Agree" (%n)
1	Perceived Ease of Use	Lynx is easy to use	4.242 (0.430)	0 (0%)	31 (21.5%)
2	Perceived Ease of Use	It was (not*) hard for me to learn to use Lynx	3.590* (1.132)	8*(5.5%)	21*(14.6%)
3	Perceived Ease of Use	The application layout is simple when moving between questions	4.16 (0.368)	0 (0%)	20 (13.9%)
4	Perceived Ease of Use	Whenever I made a mistake using Lynx, I could correct the mistake quickly and easily	3.721 (0.956)	1 (0.7%)	20 (13.9%)
5	Perceived Usefulness	Lynx is useful for my HIV testing practice	4.233 (0.425)	0 (0%)	28 (19.4%)
6	Perceived Usefulness	Lynx helped me manage my patient's health effectively	4.000 (0.790)	0 (0%)	28 (19.4%)
7	Perceived Usefulness	Lynx improved my access to delivering health care [sic] services	4.175 (0.479)	0 (0%)	26 (18.1%)
8	Perceived Usefulness	Lynx has provided a helpful way to deliver healthcare services	4.129 (0.428)	0 (0%)	19 (13.2%)
9	Perceived Compatibility	I could use Lynx even when the internet connection was poor or not available	2.188 (1.085)	33 (22.9%)	4 (2.8%)
10	Perceived Compatibility	I think that Lynx fits well with the way I work	3.940 (0.794)	0 (0%)	21 (14.6%)
11	Perceived Compatibility	I have the resources necessary to use Lynx	3.407 (1.207)	12 (8.3%)	14 (9.7%)
12	Perceived Compatibility	I have the knowledge necessary to use Lynx	4.202 (0.447)	0 (0%)	24 (1.67%)
13	Perceived Compatibility	Lynx is not compatible (is compatible*) with the way I work	3.712* (0.962)	1* (0.7%)	18* (12.5%)
14	Perceived Compatibility	A specific person (or group) is available for assistance if I have difficulties concerning Lynx	3.661 (1.134)	11 (7.6%)	18 (12.5%)

15	Perceived Compatibility	If I had the opportunity, I prefer (not*) working on paper	3.492* (1.076)	4*(2.8%)	13* (9%)

** indicates that the response scale of the question (2,13,15) was inverted to align with the overall scale of "5/strongly agree" indicating higher acceptability*

Overall, statements under the "perceived usefulness" category had the most "strongly agree" responses, as well as slightly higher overall response averages as seen in Table 6.

Table 6: Averaged Acceptability Factor Scores

Characteristic	$N = 144^1$
Perceived Ease of Use	3.926 (*0.436*)
Perceived Usefulness	4.179 (*0.422*)
Perceived Compatibility	3.574 (*0.467*)
[1] Mean (*SD*)	

Table 7 visualises the intervention's three acceptability factors by province. All factors scored over three, "agree" and "strongly agree". Yet, across all provinces, the perceived compatibility scored the lowest. Muchinga had the highest scores but also had the smallest sample size (n = 14). The data set failed the Shapiro-Wilk test for normality resulting in the use of medians, and the Kruskal-Wallis revealed none of the provinces to be significant on the acceptability factors.

Table 7: Survey Findings by Province

Characteristics	Province			*p*-value[2]
	Luapula, $N = 69^1$	Muchinga, $N = 14^1$	Northern, $N = 61^1$	
Perceived Ease of Use	4.000 (*0.500*)	4.000 (*0.500*)	4.000 (*0.500*)	0.089
Perceived Usefulness	4.000 (*0.500*)	4.375 (*0.500*)	4.000 (*0.000*)	0.11
Perceived Compatibility	3.714 (*0.429*)	3.857 (*0.429*)	3.571 (*0.536*)	0.5
[1] Median (*IQR*)				
[2] Kruskal-Wallis rank sum test				

Both genders matched the trend of lower perceived compatibility of the intervention compared to ease of use and usefulness as seen in Table 8. The Wilcoxon revealed neither gender to be significant on the outcomes.

Table 8: Survey Findings by Gender

Characteristics	Gender		*p*-value[2]
	Male, $N = 50^1$	Female, $N = 94^1$	
Perceived Ease of Use	4.000 (*0.500*)	4.000 (*0.500*)	0.7
Perceived Usefulness	4.000 (*0.750*)	4.000 (*0.250*)	0.5
Perceived Compatibility	3.714 (*0.571*)	3.571 (*0.571*)	0.5
[1] Median (*IQR*)			

[2] Wilcoxon rank sum test

Table 9 indicates a tendency among all age groups to score perceived compatibility lower, but 18–24 also had lower scores overall. It is worth noting that 18–24 also had the smallest group sample size (n = 6). The Kruskal-Wallis revealed none of the age groups to be significant on the outcomes.

Table 9: Survey Findings by Age

Characteristics	Age Group					*p*-value[2]
	18–24, *N* = 6[1]	25–34, *N* = 54[1]	35–44, *N* = 28[1]	45–54, *N* = 28[1]	55+, *N* = 28[1]	
Perceived Ease of Use	3.875 (*0.313*)	4.000 (*0.500*)	4.000 (*0.500*)	4.000 (*0.500*)	4.000 (*0.500*)	0.5
Perceived Usefulness	3.875 (*0.438*)	4.000 (*0.250*)	4.000 (*0.000*)	4.000 (*1.000*)	4.000 (*0.500*)	0.14
Perceived Compatibility	3.357 (*0.286*)	3.714 (*0.429*)	3.571 (*0.571*)	3.500 (*0.714*)	3.571 (*0.643*)	0.4
[1] Median (*IQR*)						
[2] Kruskal-Wallis rank sum test						

3.3.2 Qualitative Findings

Six themes were identified concerning the acceptability of the Lynx intervention. These included efficiency gains, training, network/IT, feedback-based updates, community vs facility, and work priorities.

3.3.2.1 Efficiency Gains

The KPI and FGD findings revealed an overall perception that the Lynx innovation was easy to use and incredibly useful for a range of work benefits. The main healthcare uses highlighted were the live reporting function and the production of local GIS HIV testing maps. The HIV testing staff noted that Lynx allows for live programme reporting through the tablet, which saves data recording and submission times, and enables managers to see each staff member's work performance in real-time.

"it [sic] has simplified matters because if we are using hard copies to send this information it would take a long time to reach you, and maybe in the process we loose [sic] the documents but this is instant, so it's good" - Kasama General health worker.

"Its [sic] not (difficult) …… because paper work is tedious and using paper work you can easily lose the information" - Mpika Urban health worker.

"And the paper will pass through many people, our supervisor, the district in the process it may get lose [sic] and things like that so redo this, but this is just direct I think it's good" - Kasama General health worker.

"well [sic] no it's a good tool, it was effective, at time [sic] it could give us accurate information that we could get better results" - Luwingu District Hospital health worker.

3.3.2.2 Training

While most participants perceived Lynx as easy to complete, it was clear that comprehensive training facilitated the HIV testing staff's ease of use of the application. Those who received training appreciated the capacity building and those who did not receive training expressed their desire to be trained.

"For the first time it was quite difficult for me but when I got used to it, it was very nice" - Tazara Rural Health Clinic health worker.

"Lynx it is easy, so what can I say" - Lubwe Mission Hospital health worker.

"No no we did not train, I think that was the biggest challenge more [sic] especially with me because I am not too conversant with smart phones so some applications where [sic] difficult to use" - Mpika Urban health worker.

3.3.2.3 Network and IT

Some participants faced a barrier to using Lynx due to network and IT challenges that come with rural community work. It was noted that IT repair times varied and could prevent HIV testing staff from using Lynx for weeks at a time.

"For me since I was always based at the facility it was easy because of network [sic], except for the counsellors that [sic] were going in the field. Yes we have a bit of a challenge because you find that they have to be there and it can be something where you test somebody and you record but then you find that sometimes you don't have network [sic]., so, it's a bit of a challenge" - Mpepo Rural Health Clinic health worker.

"I think for me as well especially when the tablet is ok, there is no problem" - Kasama Urban health worker.

"When they take it to the office [for repair], but for those people to bring it back, it takes ages. That's the only thing" - Tazara Rural Health Clinic health worker.

"Lynx has stopped working as right [sic] now so that I can make a request to the office so they can bring us in [sic] the normal system so that Lynx would start working again, that is the biggest challenge I have seen." - Lubwe Mission Hospital health worker.

"sometimes [sic] we need upgrading when you take these tablets to the office they are not done in time" - Kasama General health worker.

"he [sic] is just alone using the tablet so mostly he only captures the ones he has tested himself" - Chibansa Urban health worker.

3.3.2.4 Feedback-based Updates

Several HIV testing staff noted that a previous update of the application further facilitated Lynx's compatibility and ease of use in their work setting. The update was based on user feedback.

"At first, it was a bit difficult to use Lynx, because it was too long and the questions were too many" - Chibansa Urban health worker.

"Now that the questions have been simplified and some parts have been updated, … it made the usage a little bit familiar and user friendly" - Chibansa Urban health worker.

"Today some of the questions have been removed. They are not necessarily because some are a duplication of information. But as it is now, it's ok" - Kasama Urban health worker.

3.3.2.5 Facility vs Community

In general, the tablet application was described as compatible with rural settings, but there were different opinions on whether Lynx was a better fit for the community or the facility. Some counsellors prefer using Lynx in a more structured facility as opposed to using it in the community.

"so {sic] you don't have a place where you can properly work on the Lynx, unlike the facility, because at the facility obviously I will have a room where each client has privacy… and the client is siting [sic] comfortable [sic] as I enter. For the community its [sic] different" - Mpepo Rural Health Clinic health worker.

By contrast, for some, it was the lack of disturbance in the community that made the use of the app more feasible in the community.

"in [sic] the community we are free, there are no disturbances but here some we are disturbed by people coming in this room coming in, come knocking knocking" - Lubwe Mission Hospital health worker.

Additional concerns revolved around patient's negative perceptions, and feelings of discomfort and distress with their information being captured into a tablet.

"…where we are as a set up the clients would find it a bit rude when you are on the phone they would not understand that it's the application that I am using, yes so it was a bit difficult" - Mpepo RHC health worker.

"That is what I am saying I am saying it's the area, maybe in other places it might be different where these people are acquainted to [sic] electronics, but for [sic] here it's kind of difficult it's like you are on the phone you are not paying attention to the client (inaudible) hinder us in a way" - Mpepo RHC health worker.

3.3.2.6 Work Priorities

A few of the HIV testing staff noted that the application required too much time to complete in a busy facility setting, especially since the staff are required to double capture the data into paper registers and the Lynx tablet. This challenge was often brought up about the previously mentioned training and IT challenges.

"what she is saying [sic] maybe we are not in the ward, there is [sic] a lot of patients whom I need to do, to test, now that is a challenge for me to enter those clients in the Lynx because it take [sic] 45 minutes for me to complete a session because what we were told is that we should take 45 minutes for one clients [sic], so for me I don't know" - Mansa General Hospital health worker.

"double [sic] capture which is more of time consuming [sic] in that way maybe Lynx could be consistently [sic] if we just use it that data are able to extract it from there of the same client" - Luwingu District Hospital health worker.

"when [sic] it's a busy day he doesn't enter directly on the Lynx application so that it quickens the process he would just use the hard copy to screen into and capture all the details that he needs to use" - Chibansa Urban health worker.

"especially with the facility like this there is too much work to do mostly we use registers" - Kasama Urban health worker.

"the [sic] only challenge that we have is time management, you know when you need to counsel a person and we need that information the client feels like you are delaying them, for us to do the exact way but the client feels you are delaying them. For an [sic] example if you ask this question you ask this one you ask this one, and they feel you are wasting their time" - Mansa General Hospital health worker.

3.4 Discussion

This study aimed to evaluate the acceptability of a targeted HIV testing mobile application within a Zambian rural HIV treatment programme. The results indicate that a substantial majority of the participating HIV testing staff found the mHealth intervention acceptable within their setting. Survey findings underscored the strong perception of the intervention's usefulness, ease of use, and compatibility with the demands of a rural HIV testing environment. Barriers and facilitators influencing the application's use and overall acceptability were identified. Notably, no significant differences were observed between provinces, age groups, or genders among survey participants.

Qualitative data echoed the perceived usefulness of the intervention, emphasising the theme of efficiency gained through its implementation. While the GIS capability was

acknowledged, the clear benefit highlighted by participants was the digital data-capturing feature. Existing studies on data digitalisation and real-time reporting in healthcare underscore the efficiency gains associated with such technological advancements (16–18). Participants valued the instantaneous review of individual performance and the efficiency of digital data submission for HIV testing programme data.

The ease of use of the mHealth intervention was acknowledged by survey participants, aligning with the broader trend of healthcare workers in sub-Saharan Africa finding mobile-based interventions accessible (19). Training emerged as a critical facilitator, a well-established factor in the success of mHealth interventions, with repeated training sessions over time being suggested in some studies (20). Additionally, the study participants appreciated user-based updates, ensuring the intervention's adaptation to their evolving contextual and work requirements.

Perceived compatibility differed between facility and community settings, with some participants expressing a preference for the structured environment of a facility, while others favoured the more flexible community work setting. These insights suggest the need for future investigations and consideration in design strategies, including tailored updates or training to address specific contextual challenges.

Despite overall positive perceptions of the application's potential, instances were reported where its use could make HIV testing clients uncomfortable or feel judged, particularly in rural communities. This finding suggests a need for nuanced strategies, possibly incorporating new feedback-based updates, adapting the intervention to specific settings, or providing additional training to address contextual challenges.

Within facility settings, competing priorities and IT challenges emerged as barriers to consistent use. Some staff did not consistently prioritise the time to complete the application due to multiple demands during a work shift and data capturing requirements on different platforms. IT support, particularly issues related to internet reliance, power availability, and equipment functionality, surfaced as significant barriers. This emphasises the importance of clear IT support systems to overcome technical challenges and ensure sustained use. The study highlights the need for strategic placement of trained personnel onsite to assist with common IT challenges, particularly in settings where technical knowledge for maintenance remains limited despite the widespread adoption of mobile technology in Africa (19,21,22).

The study provides valuable insights into the acceptability of the targeted HIV testing mobile application within a Zambian rural HIV treatment programme. The findings emphasise the multifaceted nature of the challenges and opportunities associated with mHealth interventions, suggesting the importance of tailored strategies and ongoing support to enhance their effectiveness and acceptance within diverse healthcare settings.

3.5 Conclusion

The Lynx HIV testing application received favourable perceptions from HIV testing staff, who found it easy to use, compatible with a rural HIV programme, and incredibly useful. This study underscores the significance of providing comprehensive training for all users and emphasises the crucial role of feedback-based updates to address evolving programme needs and user contexts. While the intervention has gained acceptance among its targeted users through effective training and updates, challenges persist, particularly concerning competing work priorities and consistent IT support.

Although acceptability is conventionally regarded as a user's perception and willingness to use an intervention, this study illuminates how acceptability levels can be influenced by contextual barriers or facilitators. Understanding these dynamics is vital for the RTCZ HIV treatment programme to navigate challenges and leverage facilitators effectively, ultimately enhancing the acceptability of the mHealth HIV testing intervention among its staff. By incorporating these findings on the barriers and facilitators of acceptability, the RTCZ programme can tailor strategies to boost acceptability levels, leading to improved outcomes in the implementation of the mHealth HIV testing intervention.

3.6 Acknowledgements

We express our gratitude to the study participants for their valuable contribution to the study as well as the Zambia Action HIV and Right to Care Organisations for their support in the study design.

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4 Chapter 4 Results: Additional Qualitative Findings

4.1 Introduction

The following section provides the additional qualitative findings and quotes not mentioned in the embedded paper.

4.2 Qualitative

Six themes were identified concerning the acceptability of the Lynx intervention. These included efficiency gains, training, network/IT, feedback-based updates, community vs facility, and work priorities. Throughout the KPIs and FDGs participants emphasised Lynx as an easy to use and useful intervention. The identified barriers and facilitators for Lynx's acceptability related to training, IT, feedback-based updates, and work priorities. The below sections outline the key findings within each theme with quotes from the participants.

4.2.1 Efficiency Gains

The KPI and FGD findings revealed an overall perception that the Lynx innovation was easy to use and incredibly useful for a range of work benefits. The main healthcare uses highlighted were the live reporting function and the production of local GIS HIV testing maps. The HIV testing staff noted that Lynx allows for live programme reporting through the tablet, which saves data recording and submission times, and enables managers to see each staff member's work performance in real-time.

"Because it really help [sic] us to know where we need to do more of our services, for example using it to get where we have more positives, then we map out that [sic] Hot spots, so it's really helping us in that way" - Luwingu District Hospital health worker.

"the [sic] benefits of us using the tablet in the community, it will show where we are the location where you worked rather than that is what we do" - Mansa General Hospital health worker.

"it has simplified matters because if we are using hard copies to send this information it would take a long time to reach you, and maybe in the process we loose [sic] the documents but this is instant, so it's good" - Kasama General health worker.

"Its [sic] not (difficult) …… because paper work is tedious and using paper work you can easily lose the information" - Mpika Urban health worker.

"And the paper will pass through many people, our supervisor, the district in the process it may get lose and things like that so redo this, but this is just direct I think it's good" - Kasama General health worker.

"well [sic] no it's a good tool, it was effective, at time [sic] it could give us accurate information that we could get better results" – Luwingu District Hospital health worker.

"its [sic] an immediate communication… because immediately I am asking questions… immediately I am entering and that information is linked to the network other than writing because you write and then you start posting to what ,[sic] the other thing that I have seen its quite easier actually its [sic] not a complicated program to use the Lynx" – Manasa General Hospital health worker.

"it [sic] is still difficult to identify the counsellors who are struggling at the office if they can be able to see what you are going through in Lynx it can be helpful to the office that this counsellor is performing this and this today" Lubwe Mission Hospital health worker.

"It's a good device it helps in working very good also its [sic] makes it easier to pass over information to relevant people using Lynx" - Kasama Urban health worker.

"they [sic] are useful, all questions are very useful" - Luwingu District Hospital health worker.

"those [sic] questions also serve as are [sic] important purpose [sic] for us knowing where we should also look at how [sic] look a" - Luwingu District Hospital health worker.

"the [sic] important thing was sending information direct [sic]" - Tazara Rural Health Clinic health worker.

"even [sic] the paper is destroyed, using the computers information is restored" - Mpika Urban health worker.

"it [sic] was helpful because reporting was easier" - Mpika Urban health worker.

"Yes Lynx it saved me and previously it saved us for reporting especially when we are in the field we report through using Lynx" - Luwingu District Hospital health worker.

"Yes unlike the hard copy because no one will see that they can do their work so it was better because then people are able to see that since the tablets came with a name attached]they are able to see that she is working at this particular time so she is saying it was better than the hard copies" - Mpepo Rural Health Clinic health worker.

4.2.2 Training

While most participants perceived Lynx as easy to complete, it was clear that comprehensive training facilitated the HIV testing staff's ease of use of the application. Those who received training appreciated the capacity building and those who did not receive training expressed their desire to be trained.

"For the first time it was quite difficult for me but when I got used to it, it was very nice" - Tazara Rural Health Clinic health worker.

"Lynx it is easy, so what can I say"- Lubwe Mission Hospital health worker.

"some [sic] counsellors they [sic] don't know how to use Lynx, they don't know how to use it well, so in terms of submit [sic] they don't know so if they fail to capture or submit it can be also I think that" - Lubwe Mission Hospital health worker.

"No no we did not train, I think that was the biggest challenge more [sic] especially with me because I am not too conversant with smart phones so some applications where [sic] difficult to use" - Mpika Urban health worker.

"We never had adequate training on how to handle because it was one day, training some of us are not conversant with these smart phones [sic] and its [sic] not easy" - Mpika Urban health worker.

"hen [sic] we start to use that Lynx it was difficult to do it but now I understand" - Kasama Urban health worker.

"For the first time it was quite difficult for me but when I got used to it, it was very nice" - Tazara Rural Health Clinic health worker.

"what [sic] we can ask for to over come [sic] these challenges is adequate training maybe" - Mpika Urban health worker.

4.2.3 Network and IT

Some participants faced a barrier to using Lynx due to network and IT challenges that came with rural community work. It was noted that IT repair times varied and could prevent HIV testing staff from using Lynx for weeks at a time.

"For me since I was always based at the facility it was easy because of network [sic], except for the counsellors that were going in the field. Yes we have a bit of a challenge because you find that they have to be there and it can be something where you test somebody and you record but then you find that sometimes you don't have network [sic]., so, it's a bit of a challenge" - Mpepo Rural Health Clinic health worker.

"I think for me as well especially when the tablet is ok, there is no problem" - Kasama Urban health worker.

"When they take it to the office [for repair], but for those people to bring it back, it takes ages. That's the only thing" - Tazara Rural Health Clinic health worker.

"Lynx has stopped working as [sic] right now so that I can make a request to the office so they can bring us in the normal system so that Lynx would start working again, that is the biggest challenge I have seen" - Lubwe Mission Hospital health worker.

"sometimes [sic] we need upgrading when you take these tablets to the office they are not done in time" - Kasama General health worker.

"he [sic] is just alone using the tablet so mostly he only captures the ones he has tested himself" - Chibansa Urban health worker.

"So sometime maybe another co-worker could come and help unfreeze and maybe if you were trained on how to fix" - Mpika Urban health worker.

"Since 2020 we haven't used them" - Mpepo Rural Health Clinic health worker.

"And another challenge is that our tablets doesn't [sic] really work for long… even now as we are speaking they are not working so that is really a challenge… but we know it's a good tool it was effective at time [sic] it could give us accurate information that we could get better results" - Luwingu District Hospital health worker.

"they [sic] don't use the tablet for like 6 months it will stop operating the way its supposed to" - Chibansa Urban health worker.

"(due to broken devices) he [sic] has more work load [sic], he has to capture the clients by himself so it's a bit difficult for him" - Chibansa Urban health worker.

"if [sic] our tablets are consistently working our system is consistently working we can use it would also help us" - Luwingu District Hospital health worker.

"if [sic] there was someone local to work on the issue that can develop by the system, it would be easier for us to continue using the service" - Luwingu District Hospital health worker.

"Yes and we need someone who can take care of the Lynx when they stop working so that we can capture" - Samfya Stage II health worker.

4.2.4 Feedback-based Updates

Several HIV testing staff noted that a previous update of the application further facilitated Lynx's compatibility and ease of use in their work setting. The update was based on user feedback.

"At first, it was a bit difficult to use Lynx, because it was too long and the questions were too many" - Chibansa Urban health worker.

"Now that the questions have been simplified and some parts have been updated, … it made the usage a little bit familiar and user friendly." - Chibansa Urban health worker.

"Today some of the questions have been removed. They are not necessarily because some are a duplication of information. But as it is now, it's ok" - Kasama Urban health worker.

"you [sic] have reduced the [sic] some of the questions so for now all is fine the questions have been reduced… it took time for me to capture that client, so we thank you for have you reduced for now" - Kasama Urban health worker.

"For me its fine, yes but as she had said the first time we had difficulties but currently it's fine" - Kasama Urban health worker.

"when [sic] you are testing it would count minutes from 20… but for now at least you have made it easier" - Kasama General health worker.

4.2.5 Facility vs Community

In general, the tablet application was described as compatible with rural settings, but there were different opinions about whether Lynx was a better fit for the community or the

facility. Some counsellors preferred using Lynx in a more structured and equipped facility as opposed to using it in the community.

"so [sic] you don't have a place where you can properly work on the Lynx, unlike the facility, because at the facility obviously I will have a room where each client has privacy… and the client is siting comfortable [sic] as I enter. For the community its [sic] different" - Mpepo Rural Health Clinic health worker.

"For me [sic] since I was always based at the facility it was easy because of network" - Mpepo Rural Health Clinic health worker.

"At the facility [sic] it was also easier because when you test from here you enter, you enter data from Lynx and in the register" – Namukolo health worker.

By contrast, for some, it was the lack of facility activities or disturbances that made the use of the application more feasible in the community.

"in [sic] the community we are free, there are no disturbances but here some we are disturbed by people coming in this room coming in, come knocking knocking" - Lubwe Mission Hospital health worker.

"As hinted to you before especially with the [sic] facility like this there is too much work to do mostly we use registers and unlike in the field, there [sic] in the field [sic] we use the instrument because the clients that we normally attend to are individuals you take your time and talk to them and discuss with counsel" - Kasama Urban health worker.

"when [sic] we go in the field when we are carrying a tablet it instead of carrying books you just carry the tablet, and in keeping information it really helped very much" - Kasama Urban health worker.

"there [sic] is not much of privacy in the community, just the comfortability of you being able to sit and enter you [sic] work" - Mpepo Rural health clinic.

Additional concerns revolved around patient's negative perceptions, and feelings of discomfort and distress with their information being captured into a tablet.

"…where [sic] we are as a set up the clients would find it a bit rude when you are on the phone they would not understand that it's the application that I am using, yes so it was a bit difficult" - Mpepo RHC health worker

"That is what I am saying I am saying it's the area, maybe in other places it might be different where these people are acquainted to [sic] electronics, but for here it's kind of difficult it's like you are on the phone you are not paying attention to the client (inaudible) hinder us in a way" - Mpepo RHC health worker.

"looking [sic] at the nature of the tablet it's big, going to the community you are talking to a client you are busy capturing the client feels uncomfortable maybe you are boastful, you want to show off to them that you have a big phone so it's much easier use at the facility because they know that this is a facility set up the information that they are capturing will be used at the facility" - Chibansa Urban health worker.

"in [sic] the community [sic] people get suspicious you are talking to them you are using a tablet, they ask why are you using this where are you taking this information" - Kasama General health worker.

4.2.6 Work Priorities

A few of the HIV testing staff noted that the application required too much time to complete in a busy facility setting, especially since the staff are required to double capture the data into paper registers and the Lynx tablet. This challenge was often brought up concerning the previously mentioned training and IT challenges.

"what [sic] she is saying maybe [sic] we are not in the ward, there is [sic] a lot of patients whom I need to do, to test, now that is a challenge for me to enter those clients in the Lynx because it take 45 minutes for me to complete a session because what we were told is that we should take 45 minutes for one clients, so for me I don't know" - Mansa General Hospital health worker.

"we [sic] have a lot of indicators, today we concentrate on this indicator, tomorrow they will change they will tell you [sic] do this, the other day they tell you to do something else" - Mansa General Hospital health worker.

"double [sic] capture which is more of time consuming in that way maybe Lynx could be consistently if we just use it that data are able to extract it from there of the same client" - Luwingu District Hospital health worker.

"when [sic] it's a busy day he doesn't enter directly on the Lynx application so that it quickens the process he would just use the hard copy to screen into and capture all the details that he needs to use" - Chibansa Urban health worker.

"especially [sic] with the facility like this there is too much work to do mostly we use registers" - Kasama Urban health worker.

"the [sic] only challenge that we have is time management, you know when you need to counsel a person and we need that information the client feels like you are delaying them, for us to do the exact way but the client feels you are delaying them. For an example [sic] if you ask this question you ask this one you ask this one, and they feel you are wasting their time" - Mansa General Hospital health worker.

"because [sic] when you test from here you enter, you enter data from Lynx and in the register" - Namukolo health worker.

"Yes you have to enter in the Lynx and in the register" - Samfya Stage 2 health worker.

"Yes, you have to write somewhere maybe in the book, when you come back in the facility you have to enter in the register" - Samfya Stage 2 health worker.

5 Chapter 5 Discussion and Conclusion

5.1 Introduction

The following section provides the overall discussion and conclusion of the study.

5.2 Discussion

This study assessed the acceptability of a targeted HIV testing mobile application to a Zambian rural HIV treatment programme. The results from the quantitative and qualitative data collections concurrently provided insight on the mHealth intervention's acceptability with similar findings from both collections. The results revealed that HIV testing staff perceived the mHealth intervention as acceptable to their setting, but there are several identified key barriers and facilitators to acceptability.

Findings in the quantitative survey showed the intervention to be strongly perceived as useful, easy to use, and compatible with a rural HIV testing setting. The survey results further revealed significant barriers to the application's use and consequent acceptability by its users due to matters related to reliance on IT, and users having all the necessary resources to complete the mobile application. The barriers and facilitators were further discussed and identified in the qualitative data collections. No significant differences were found between the provinces, age groups, or genders of the participants of the survey.

The qualitative data corroborated the strongly perceived usefulness through the identified theme of efficiency gained from the intervention. The intervention's GIS capability was brought up, but the clear benefit to the staff was the digital data capturing for real-time data sharing. Studies on data digitalisation and real-time data reporting have highlighted and confirmed the benefit of efficient monitoring of healthcare information through digitalisation (1–3). The participants valued the efficiency of digital data capturing and submission for HIV testing for programme data submission and the instant review of their performance.

Survey participants found the mHealth intervention to be easy to use, which follows the trend of healthcare workers in sub-Saharan Africa finding mobile phone or tablet-based interventions as easy to use with the rise of mobile phone availability (4). A clear facilitator to this was training for the intervention users. Training is a known factor of mHealth interventions, with some studies even suggesting repeated training over time (5). Additionally, this study's participants valued the practice of user-based updates, ensuring that the intervention is adapted to their contextual and work requirements. Ensuring the mHealth

intervention is adapted to the local contextual requirements has been found effective in reducing the risk of failure for an intervention in other African settings (4).

Several participants noted a difference in perceived compatibility between use in the facility and community. Some preferred the more structured setting of a facility, while others preferred the more "free" community work environment. Such insights could be the focus of further investigation and should be considered in future design strategies including new feedback-based updates, tailoring the intervention to one or both settings, or through training to address any challenges faced in a specific context.

Despite findings around the application's perceived overall potential in assisting with more sensitive or stigmatised situations, some indications were found for occasions where this was not the case. When used in rural communities, some application users reported that the intervention could make HIV testing clients uncomfortable or "feel judged", with a reluctance to have their information captured. Evidence shows that stigma decreases when mHealth interventions are used, such as consultations or transactions through SMS communications, or when clients directly utilise an online tool instead of visiting a facility (4). An explanation of this contradiction includes the fact that an HIV staff member is still present during testing when using Lynx.

Within a facility, HIV testing staff discussed participating in multiple supportive roles, facing multiple priorities during a work shift, and being required to capture data on multiple platforms. It was clear that some staff did not always prioritise the time to complete Lynx when faced with competing priorities in the facility, even when the same participants mentioned Lynx was easy to complete and incredibly useful. It emphasised that IT challenges, and a lack of staff trained or equipped with a tablet can add to this barrier. The value of efficient data capturing and submission and the need for updates to address changing contexts is again highlighted as staff deal with multiple data capturing requirements and time constraints.

Another barrier identified was related to the IT support of the application. Survey responses with the lowest acceptability scores related to the intervention's reliance on the internet, resources available to the users to complete the intervention (power and functioning mobile tablet) and knowing who can assist the users if assistance is required. Given that Lynx is designed to be used offline, the reliance on the network is either a training issue or a technical issue to be addressed. IT resources and support are another matter. The capacity of an organisation to support mHealth interventions has been found as a potential barrier to success,

and accounting for clear IT support systems for users is a must for sustained use (6,7). When staff face slow turnaround time for hardware repairs or maintenance, programme data is not captured, and in a few cases, the skills are forgotten. Several facilities requested someone onsite to be trained or equipped to assist with common IT challenges. Even though mobile access has spread in Africa, the technical knowledge for maintenance is still limited and needs to be strategically placed (4).

5.2.1 Implications/Recommendations

For the optimal capture and submission of HIV testing data, RTCZ should conduct a thorough review of the roles and responsibilities of HIV testing staff within the facilities, along with their data-capturing requirements. The goal is to streamline these roles and practices, consolidating data-capturing efforts and ensuring proper allocation of time for each facility activity. While this study did not encompass all aspects of HIV testing staff responsibilities, the observed challenges related to time management among participants highlight the importance of investigating this aspect further.

For the ongoing implementation of mHealth interventions, it is essential to conduct comprehensive training sessions to ensure the capability to use the innovative technology and adherence to programme policy for all participants, including those who receive the intervention post-launch. Regular refresher training can contribute to maintaining high acceptability levels by reinforcing the necessary skills. To adapt to evolving user and contextual requirements, feedback-based updates derived from user input are crucial. Additionally, robust IT support is imperative. Addressing common IT issues can be expedited by training a local staff member for a quick turnaround but given the tablets' usage in busy facilities and communities, semi-routine hardware and software repairs will be necessary. Participants frequently expressed the need for timely tablet repairs, as extended periods without functionality hindered their ability to submit data.

To counteract community members' stigma towards the intervention, training programmes should incorporate best practices for introducing mobile health devices to rural individuals. Further research is warranted to delve into the specific nature of the stigma held by rural community members regarding the use of mobile health devices. By addressing these considerations, RTCZ can enhance the effectiveness and acceptance of the mHealth intervention within the HIV testing programme.

5.2.2 Strengths and Limitations

This study stands out due to its comprehensive approach, encompassing both quantitative user acceptability surveys and qualitative individual and group acceptability data to gauge the acceptability of an mHealth intervention. By employing a survey, mHealth users directly assessed acceptability, while KPIs and FGDs provided valuable contextual insights through the sharing of lived experiences.

However, the reliance on self-reported findings introduces potential biases, including selective memory, attribution errors, or exaggeration. Social desirability bias, influenced by participants' involvement in the HIV programme, may contribute to more positive feedback, a phenomenon that will be thoroughly explored in the KPIs and FGDs. Furthermore, the study is constrained by its language of data collection, as multiple dialects, including English, are spoken by the target population. Although English is widely spoken in the area, the decision to conduct data collection solely in English may introduce bias related to language fluency. Pilot testing of the data collection tools and participants occasionally translating for one another during discussions assisted in mitigating any language barrier.

An additional limitation lies in the study's exclusive focus on health workers, omitting the perspectives of mHealth intervention clients. The absence of client perceptions poses a potential gap in the overall understanding of the intervention's acceptability within the broader context of its intended beneficiaries.

5.3 Conclusion

The study found that the Lynx HIV testing application was perceived as easy to use, useful, and compatible with the testing staff of a rural HIV programme. While acceptability is widely understood as a user's perception and, in turn, willingness to use an intervention, the acceptability levels can be hindered or supported through related contextual barriers or facilitators. This study highlighted the need for training for all users and the importance of feedback-based updates to address changing programme needs and user context during implementation of the application. The participants perceived the intervention as easy to use while highlighting the importance of their training and user-based updates in their perception. The main barrier identified related to the IT support of the intervention, which was reinforced as a critical component for any mHealth intervention. Quick repairs allow the mHealth tool to stay in use. Additionally, multiple priorities and data capturing requirements in the application can prevent the HIV testing staff from completing all of their responsibilities, both of which

will need to be reviewed. Recognising acceptability factors is vital for the RTCZ HIV treatment programme to navigate challenges and leverage facilitators effectively, enhancing the acceptability of the mHealth HIV testing intervention among its users. Ultimately, the RTCZ HIV treatment programme can utilise these findings on the barriers and facilitators of acceptability to increase the acceptability of the mHealth HIV testing intervention amongst their HIV testing staff and further enhance its positive outcomes.

5.4 Acknowledgements

We express our gratitude to the study participants for their valuable contribution to the study as well as the Zambia Action HIV and Right to Care Organisations for their support in the study design and completion.

5.5 References

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Appendices

Appendix 1. Plagiarism Declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Andres Montaner (Student number: 2145850) am a student registered for the degree of MSc Dissertation Med in the academic year 2023.

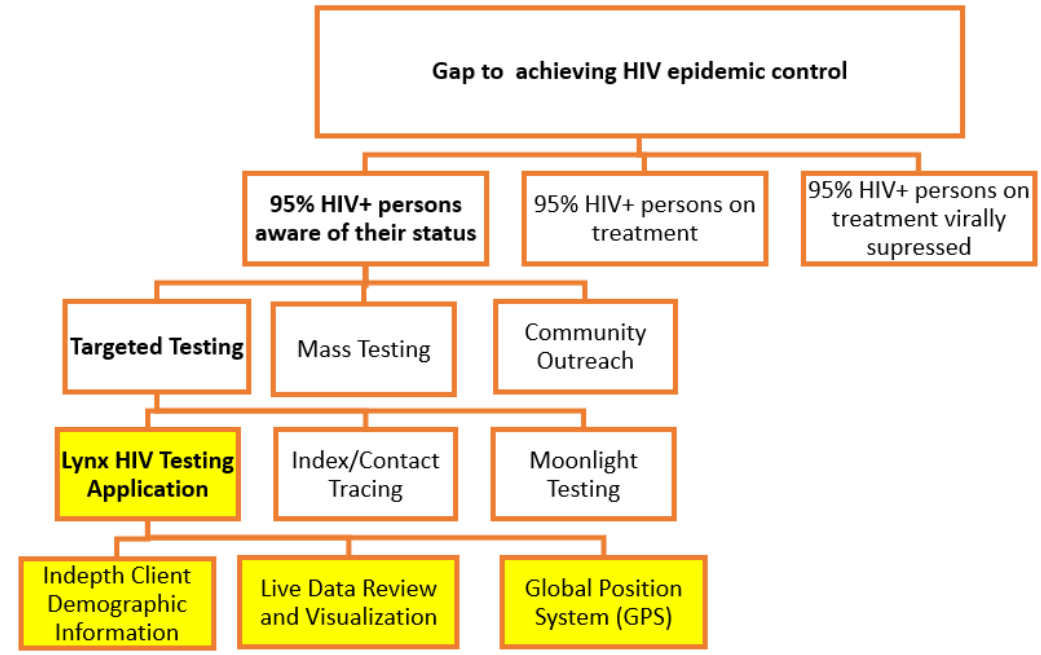
I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature:  Date: 05 Feb 2024

1

Appendix 2. mHealth Intervention "Lynx" Conceptual Framework within HIV Program



Appendix 3. Lynx Acceptability Survey

Facility: _____

Please select one answer for each question. For questions with the 1-5 scale select based on if you agree or disagree with the statement, 1 being strongly disagree up to 5 bring strongly agree.

Gender:
Man Woman Other

Age Group:

18-25 26-35 36-45 46-55 56+

Perceived Ease of Use

1. Lynx is easy to use
   1 2 3 4 5
2. It was easy for me to learn to use Lynx
   1 2 3 4 5
3. The application layout is consistent when moving between questions
   1 2 3 4 5
4. Whenever I made a mistake using Lynx, I could correct the mistake easily and quickly

   1 2 3 4 5

Perceived Usefulness

5. Lynx is useful for my HIV testing practice

   1 2 3 4 5

6. Lynx helped me manage my patient's health effectively

   1 2 3 4 5

7. Lynx improved my access to delivering health care services

   1 2 3 4 5

8. Lynx has provided an acceptable way to deliver healthcare services

   1 2 3 4 5

Perceived Compatibility

9. I could use Lynx even when the internet connection was poor or not available

   1 2 3 4 5

10. I think that using Lynx fits well with the way I like to work

    1 2 3 4 5

11. I have the resources necessary to use Lynx

    1 2 3 4 5

12. I have the knowledge necessary to use Lynx

1 2 3 4 5

13. Lynx is not compatible with the way I work

1 2 3 4 5

14. A specific person (or group) should be available for assistance with difficulties concerning Lynx

1 2 3 4 5

15. If I had the opportunity, I prefer working on paper

1 2 3 4 5

This is the end of the survey, thank you for your participation.

Appendix 4. Key Person Interview Guide

Note to researcher: questions are not to be completed in particular order but can be completed based on the natural progression of the dialogue

Usefulness and Usability of Lynx application

1. What is your experience of using the Lynx system?
    a. Probe on: outputs of Lynx (testing services, testing strategies)
    b. Probe on: why positive or negative
2. How does the Lynx mobile capturing process differ from the traditional paper-based capturing?
    a. Probe on: resources required and available for each
    b. Probe on: time of capturing process, effect of time use (more or less)
    c. Probe on: benefits or weaknesses of Lynx instead of paper
3. How difficult is it to complete Lynx data capturing?
    a. Probe on: time required
    b. Probe on: resources (network, power)
    c. Probe on: software difficulty (education and training)

Compatibility for completing client capturing on Lynx

4. Can you discuss the conditions in which it is more easy and more difficult to complete Lynx capturing?
    a. Probe on: different work settings (rural or urban, facility or community)
    b. Probe on: staff objectives and support
5. What could be improved to increase compatibility?
    a. Probe on: software and hardware of application
    b. Probe on: work setting

6. Do you have any final comments on your experience using Lynx?

Appendix 5. Focus Group Discussion Guide

Note to researcher: questions are not to be completed in particular order but can be completed based on the natural progression of the dialogue

Usefulness and Usability of Lynx application

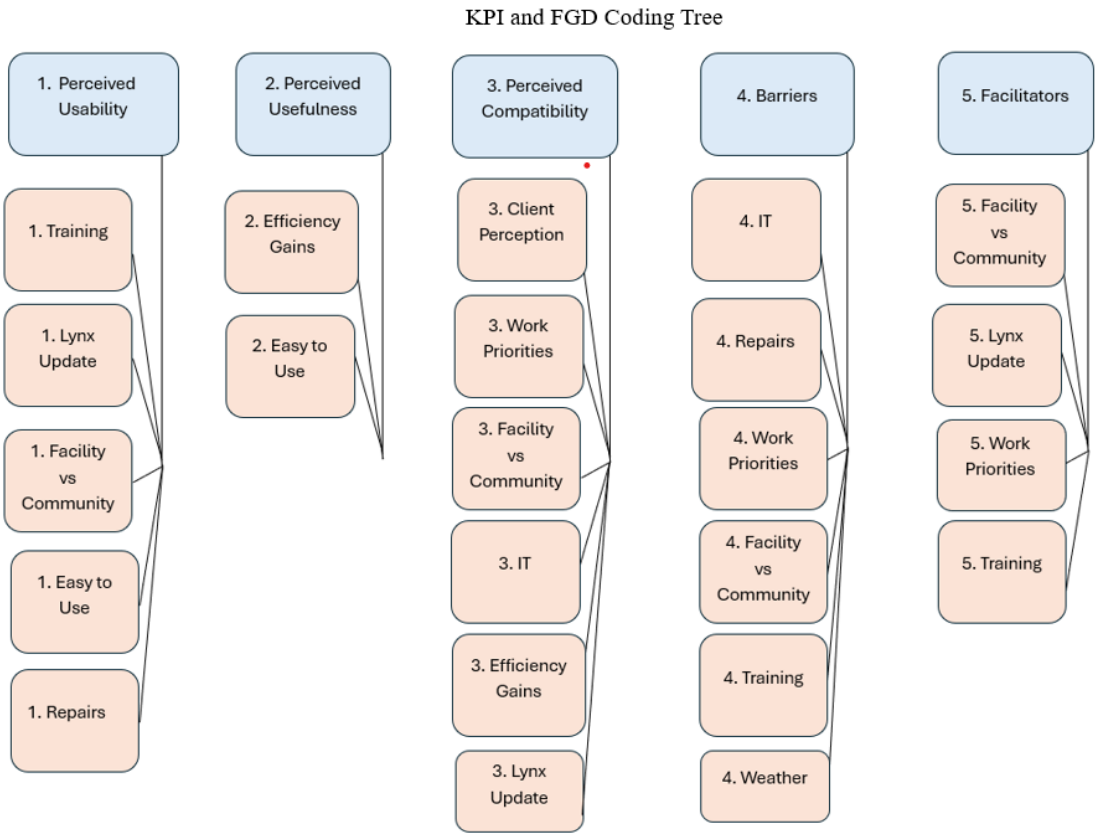
1. What is your experience of using the Lynx system?
    a. Probe on: outputs of Lynx (testing services, testing strategies)
    b. Probe on: why positive or negative
    c. Probe on: why one participant's experience is different
2. How does the Lynx mobile capturing process differ from the traditional paper-based capturing?
    a. Probe on: resources required and available for each
    b. Probe on: time of capturing process, effect of time use (more or less)
    c. Probe on: benefits or weaknesses of Lynx instead of paper
    d. Probe on: why one participant's experience is different
3. How difficult is it to complete Lynx data capturing?
    a. Probe on: time required
    b. Probe on: resources (network, power)
    c. Probe on: software difficulty (education and training)
    d. Probe on: why one participant's experience is different

Compatibility for completing client capturing on Lynx

4. Can you discuss the conditions in which it is more easy and more difficult to complete Lynx capturing?
    a. Probe on: different work settings (rural or urban, facility or community)
    b. Probe on: staff objectives and support
    c. Probe on: why one participant's experience is different
5. What could be improved to increase compatibility?
    a. Probe on: software and hardware of application
    b. Probe on: work setting

6. Do you have any final comments on your experience using Lynx?

Appendix 6. Qualitative Coding Tree



Appendix 7. University of Witwatersrand Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mr Andres Luis Larson Montaner

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M220720

NAME: (Principal Investigator)	Mr Andres Luis Larson Montaner
DEPARTMENT:	School of Public Health
PROJECT TITLE:	Health worker acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment program
DATE CONSIDERED:	29/07/2022
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Pedro Pisa and Prof Charles Chasela
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	04/10/2022

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

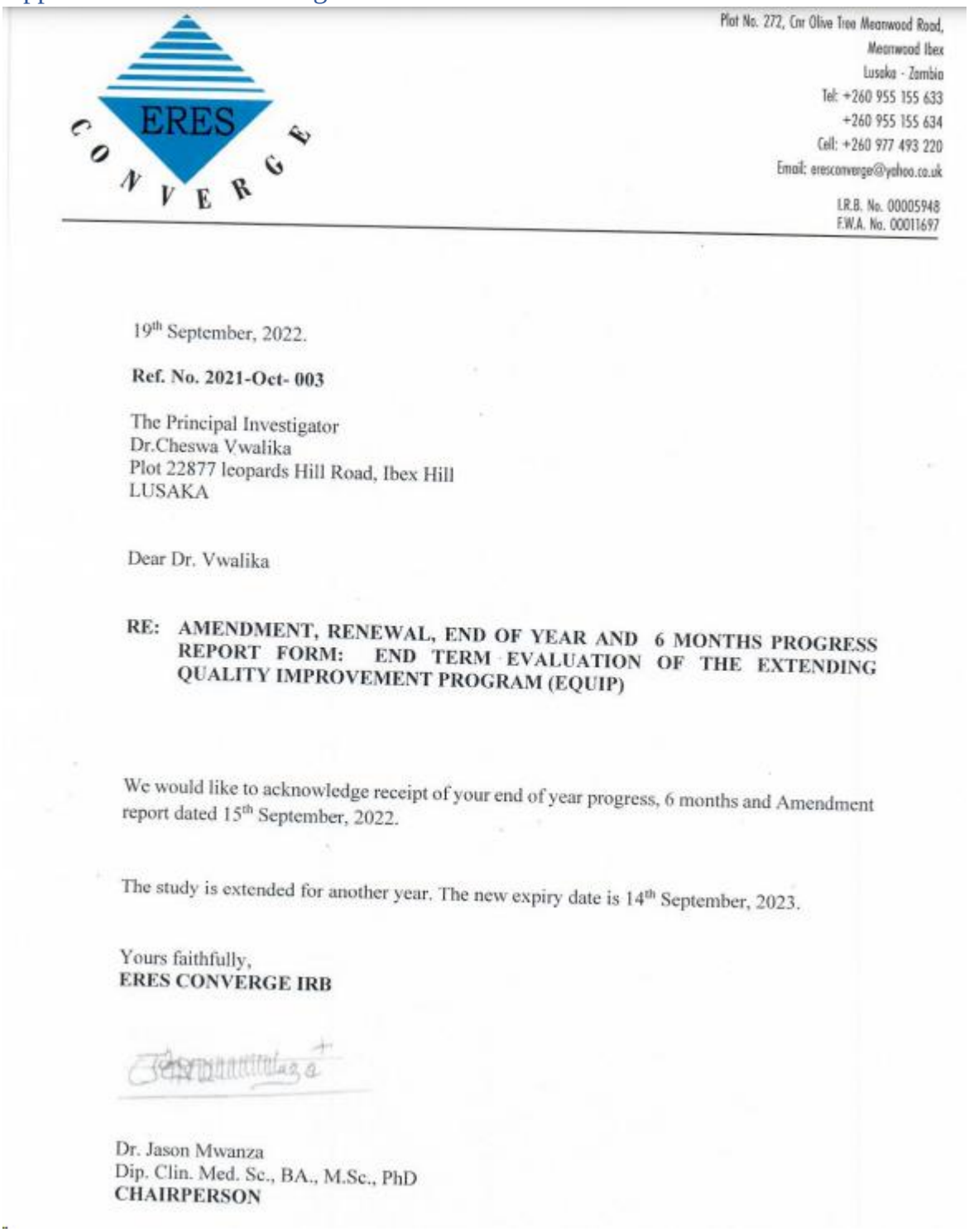
DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **July** and will therefore be due in the month of **July** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature — Date: 04/10/2022

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 8. ERES Converge Zambia Ethical Clearance Certificate



Plot No. 272, Cnr Olive Tree Mearwood Road,
Mearwood Ibex
Lusaka - Zambia
Tel: +260 955 155 633
+260 955 155 634
Cell: +260 977 493 220
Email: eresconverge@yahoo.co.uk

I.R.B. No. 00005948
F.W.A. No. 00011697

19th September, 2022.

Ref. No. 2021-Oct- 003

The Principal Investigator
Dr.Cheswa Vwalika
Plot 22877 leopards Hill Road, Ibex Hill
LUSAKA

Dear Dr. Vwalika

RE: AMENDMENT, RENEWAL, END OF YEAR AND 6 MONTHS PROGRESS REPORT FORM: END TERM EVALUATION OF THE EXTENDING QUALITY IMPROVEMENT PROGRAM (EQUIP)

We would like to acknowledge receipt of your end of year progress, 6 months and Amendment report dated 15th September, 2022.

The study is extended for another year. The new expiry date is 14th September, 2023.

Yours faithfully,
ERES CONVERGE IRB

Dr. Jason Mwanza
Dip. Clin. Med. Sc., BA., M.Sc., PhD
CHAIRPERSON

Appendix 9. PLOS ONE Submission Guidelines

Style and Format

File format

Manuscript files can be in the following formats: DOC, DOCX, or RTF. Microsoft Word documents should not be locked or protected.

LaTeX manuscripts must be submitted as PDFs. Read the LaTeX guidelines.

Length

Manuscripts can be any length. There are no restrictions on word count, number of figures, or amount of supporting information.

We encourage you to present and discuss your findings concisely.

Font

Use a standard font size and any standard font, except for the font named “Symbol”. To add symbols to the manuscript, use the Insert → Symbol function in your word processor or paste in the appropriate Unicode character.

Headings

Limit manuscript sections and sub-sections to 3 heading levels. Make sure heading levels are clearly indicated in the manuscript text.

Layout and spacing

Manuscript text should be double-spaced.

Do not format text in multiple columns.

Page and line numbers

Include page numbers and line numbers in the manuscript file. Use continuous line numbers (do not restart the numbering on each page).

Footnotes

Footnotes are not permitted. If your manuscript contains footnotes, move the information into the main text or the reference list, depending on the content.

Language

Manuscripts must be submitted in English.

You may submit translations of the manuscript or abstract as supporting information. Read the supporting information guidelines.

Abbreviations

Define abbreviations upon first appearance in the text.

Do not use non-standard abbreviations unless they appear at least three times in the text.

Keep abbreviations to a minimum.

Reference style

PLOS uses “Vancouver” style, as outlined in the ICMJE sample references.

See reference formatting examples and additional instructions below.

Equations

We recommend using MathType for display and inline equations, as it will provide the most reliable outcome. If this is not possible, Equation Editor or Microsoft's Insert→Equation function is acceptable.

Avoid using MathType, Equation Editor, or the Insert→Equation function to insert single variables (e.g., "$a^2 + b^2 = c^2$"), Greek or other symbols (e.g., β, Δ, or ′ [prime]), or mathematical operators (e.g., x, ≥, or ±) in running text. Wherever possible, insert single symbols as normal text with the correct Unicode (hex) values.

Do not use MathType, Equation Editor, or the Insert→Equation function for only a portion of an equation. Rather, ensure that the entire equation is included. Equations should not contain a mix of different equation tools. Avoid "hybrid" inline or display equations, in which part is text and part is MathType, or part is MathType and part is Equation Editor.

Nomenclature

Use correct and established nomenclature wherever possible.

Units of measurement Use SI units. If you do not use these exclusively, provide the SI value in parentheses after each value. Read more about SI units.

Drugs Provide the Recommended International Non-Proprietary Name (rINN).

Species names Write in italics (e.g., Homo sapiens). Write out in full the genus and species, both in the title of the manuscript and at the first mention of an organism in a paper. After first mention, the first letter of the genus name followed by the full species name may be used (e.g., H. sapiens).

Genes, mutations, genotypes, and alleles Write in italics. Use the recommended name by consulting the appropriate genetic nomenclature database (e.g., HGNC for human genes; we strongly recommend using this tool to check against previously approved names). It is sometimes advisable to indicate the synonyms for the gene the first time it appears in the text. Gene prefixes such as those used for oncogenes or cellular localization should be shown in roman typeface (e.g., v-fes, c-MYC).

Allergens The systematic allergen nomenclature of the World Health Organization/International Union of Immunological Societies (WHO/IUIS) Allergen Nomenclature Sub-committee should be used for manuscripts that include the description or use of allergenic proteins. For manuscripts describing new allergens, the systematic name of the allergen should be approved by the WHO/IUIS Allergen Nomenclature Sub-Committee prior to manuscript publication. Examples of the systematic allergen nomenclature can be found at the WHO/IUIS Allergen Nomenclature site.

Manuscript Organization

Beginning section *The following elements are required, in order:*

- Title page: List title, authors, and affiliations as first page of the manuscript

	• Abstract • Introduction
Middle section	*The following elements can be renamed as needed and presented in any order:* • Materials and Methods • Results • Discussion • Conclusions (optional)
Ending section	*The following elements are required, in order:* • Acknowledgments • References • Supporting information captions (if applicable)
Other elements	• Figure captions are inserted immediately after the first paragraph in which the figure is cited. Figure files are uploaded separately. • Tables are inserted immediately after the first paragraph in which they are cited. • Supporting information files are uploaded separately.

Appendix 10. University of Witwatersrand Participant Consent Sheet

WITS UNIVERSITY

1. PARTICIPANT CONSENT SHEET

Acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment program

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Andres Montaner - 0793458308 2145850@students.wits.ac.za

Pedro Pisa - pedro.pisa@righttocare.org

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: _____
Date: _____
Place: _____
Signature or mark _____

Witnessed by:

Name of Witness: _____
Signature: _____
Date: _____

Appendix 11. University of Witwatersrand Consent for Audio Recording

2. CONSENT FORM FOR AUDIO RECORDING OF STUDY PARTICIPATION

Acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment program

I hereby consent to audio recording of the interview[1], or focus group discussion[1], or classroom interaction[1]

.

I understand that:

- The recording will be stored in a secure location (a locked cupboard or password protected computer) with restricted access to the researcher and the research supervisor.
- The recording will be transcribed and any information that could identify me will be removed,
- The recordings will be erased within either (a) two (2) years of the publication of the research findings, or (b) six (6) years, if no publications arise from this research
- Anyone wishing to access this information in the future will first have to obtain the approval of the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg
- Direct quotes from my interview, without any information that could identify me, may be cited in the research report or other write-ups of research.

Name of Participant: _____
Date: _____
Place: _____
Signature or mark _____

Witnessed by:

Name of Witness: _____
Signature: _____
Date: _____

Appendix 12. Participant Study Information Document

Acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment program

Good day Right to Care Zambia staff.

I am doing research on acceptability of a mobile health application. Research is a process used in seeking new knowledge. In this study we want to learn more about factors relating to how fitting a mobile health application is to your regular work practices. The study is part of a University of Witwatersrand Masters program and will be used to further the knowledge of implementation sciences.

I am inviting you to take part in this research study. The study entails the following:

1. The participants will be asked to complete a survey or take a 30 minute interview or take part in a 40 minute focus group discussion
2. The study will take place from August to October of 2022
3. Any data collection will require less than an hour of the participant's time
4. The survey will be conducted in English online, shared through an email/SMS link
5. Questions will be relating to the level of acceptability of the mobile health application will be asked to identify strengths and areas of improvement.

There are no identified risks or benefits of being involved in this study.

The resulting thesis and any publications from the research are able to be shared at any participant's request.

Participation is voluntary, that means refusal to participate will involve no penalty or loss of benefits to which the Participant is otherwise entitled. There is no requirement to provide a reason for withdrawing and any data collected on such a person will in default be destroyed, unless the Participant specifically consents to its retention.

Personal information will be treated in the strictest confidence and will only be available to the Principal Investigator (PI) and his/her Supervisor, in the case wherein the PI is a postgraduate student. The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law
2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit
3. the South African Health Products Regulatory Authority (SAHPRA), which is the successor body to the South African Medicines Control Council (SAMCC), might conceivably require access to personal data, if conducting an investigation into a drug trial

The surveys and interviews will be have their data recorded anonymously. During focus group discussions, participants may very well recognize each other and while the PI may request confidentiality, he/she is not in a position to enforce it. For the same reason, anonymity cannot be guaranteed in focus group discussions.

All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

Principle Investigator: Andres Montaner – 0793458308 - 2145850@students.wits.ac.za

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg (“Committee”). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

Date: June 2022

Appendix 13. Turnitin Report

09 February 2024

Please see the below statement to be submitted with the MSc Turnitin report of 19%.

As primary supervisor to Andres Montaner student number 2145850, I Pedro Pisa can confirm that Andres' work was entirely his own and no plagiarism took place in the writing of the dissertation.

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