Designing, Developing, pilot implementation and evaluation of a mobile android based tool to improve health outcomes in adolescents and young adults living with HIV: An Agile model Human-Centered Design Science three-phase Methodology.

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Abstract

Purpose: The objective of this study was to close the gap in healthcare providers' skills, training and information sharing in HIV management by developing a mHealth artifact, with the aim of improving health management outcomes.

Methods: This study used a three-phase Design Science human-centred methodology to *develop the AnnMac android based communication application artifact*. The design science methodology used consisted of problem identification, solution design and evaluation of the AnnMac application user experiences and impact. A descriptive cross-sectional case study used data collected from the literature review, and primary data from the participatory research approach. Secondly we used data collected from the AnnMac application user experiences and impact evaluation.

Results: The AnnMac application was designed, developed, pilot implemented and registered on Google store and was ready for download by January 2020.

Conclusions The evaluation of the AnnMac android mobile application showed a high rate (<85%) of adoption due to its simple-to-use features resulted in improved adherence to antiretroviral therapy and viral load suppression among patients and improved health care worker satisfaction and engagement in HIV care. Furthermore, the AnnMac m-health android based communication application helped health care providers communicate and engage with adolescents and young adults living with HIV using relevant guidelines and tailor made messages or information. In addition the AnnMac m-health android based communication application enabled health care providers manage adolescents and young adults living with HIV healthcare progress in improving their HIV management resulting in improved adherence to antiretroviral therapy and viral load suppression among patients.

1. Introduction

Adolescents and young adults are disproportionately affected by HIV worldwide, and yet are rarely specifically prioritized in national HIV-plans and programming efforts [1,2] .The neglect of the adolescents and young adults living with HIV (18 - 24 years) within national HIV programming as evidenced by the lack of youth-friendly health services sometimes leads to poor health outcomes, such aspoor adherence to antiretroviral therapy (ART) and poor viral load suppression. Whilst ART is regarded a powerful tool to reduce morbidity and mortality for people living with HIV globally [3],the availability of treatment alone is insufficient to meet new Joint United Nations Programme on HIV/AIDS (UNAIDS) 90-90-90 targets that call for rapid scale-up of engagement in HIV care to end the epidemic in 2030 [4] (UNAIDS (2013). These targets specify that by 2020, 90% of people living with HIV (PLHIV) will know their HIV status, 90%of people

Despite the centrality of m-health interventions in the delivery of care, there is a dearth of mobile applications for improving patient care in sub Saharan Africa, often resulting in poor HIV management outcomes for adolescents and young adults living with HIV (AaYALHIV). M-health is defined as a

healthcare delivery system that is carried out via mobile devices for better access to health care and to support the performance of health workers [4]. This study attempted to close the m-health scarcity gaps by developing an AnnMac mHealth android application informed by the human-centered design for use by health care providers in especially low resource settings and is diagnosed with HIV infection will receive ART and 90% of those on ART will be virally suppressed (viral load<1000 copies/mL) [5] (Adebisi et al, 2021). Digital technology interventions (mHealth, eHealth, and telehealth) are emerging approaches that support lifelong engagement in HIV care [6] . Technologies for m-health provide emerging and proven solutions to support the achievement of the United Nations targets for the generalized HIV-affected population [7] (UNAIDS, 2015).aimed at improving health management outcomes. The gaps that have hindered the scale up of m-health interventions which include: the cost of the intervention, variable patient phone access across gender, privacy concerns, and phone maintenance, lack of effective communication and change management strategy for sensitising stakeholders on the protocols for implementing mhealth interventions [8] (Medhanyie et al. 2015) and the need for salient data security features, informed the development of the an AnnMac mHealth android application [4, 6]. The application of mobile-enabled technology to the delivery of healthcare services has significant potential to improve HIV management outcomes for AaYALHIV aged 18 - 24 years in resource constrained settings such as Zimbabwe.

Adolescent HIV/AIDS is a separate epidemic and needs to be handled and managed separately from adult HIV [9] [7]. The adolescent group (18-24) can be subdivided into student, slum and street youth; street adolescents being most vulnerable to HIV/AIDS [7]. The sub categories of adolescents and young adults experience complex behavioural and psychological challenges as a result of living with HIV [10] [8]. Worldwide, about 5 million young people within the age group of 15 to 25 years are living with HIV. (World Health Organisation 2021), Zimbabwe is one of the countries in sub-Sahara Africa with a high HIV infection, with an incidence rate of 0.53% among adolescent and young women compared to 0.14% in young men [11][9] (ZIMPHIA 2016). The HIV prevalence in young women is 5.9%, which is almost double that of males, 3.3% [11]. Zimbabwe is on track towards achieving viral suppression among adults (87%). However, adolescents have only achieved 44% by 2016 [12]. In Harare city, 57% of adolescents had attained viral suppression after 12 months on ART compared to 88 % among adults [13] (Sithole et al, 2018). However, despite the high prevalence rate of HIV and poor viral load suppression among adolescents and young adults there is a shortage of healthcare providers (HCPs) with specialised training in adolescents and they often find it difficult to effectively engage, communicate, engage, analyse, track and manage adolescents and young adults living with HIV [8].

This scenario of poor management of AaYALHIV has been attributed to the healthcare providers' lack of the requisite knowledge and management skills, resulting in poor HIV management outcomes such as poor viral load suppression. Additionally, the current way of information sharing (training workshops, information sharing, guidelines) which is not offered to every healthcare provider, the unavailability of guidelines and clinical updates to health care workers, limited access to expert advice and ineffective decision making process that are not optimised for dealing with AaYALHIV, have negatively impacted on

the management of AaYALHIV in all health care facilities especially rural and hard to reach health facilities.

Digital technology interventions such as mHealth are emerging as effective interventions for supporting lifelong engagement in HIV care among other conditions [4,7] [4, 6]. However, there is a dearth of mobile applications in southern Africa for assisting healthcare workers in managing AaYALHIV. Against the background of the health care providers' incapacitation to manage adolescents and young adults living with HIV, we developed the AnnMac mHealth android application for use by health care providers and is aimed at improving health management outcomes. The development of an online application was needed to assist healthcare providers engage, communicate and manage AaYALHIV based on set HIV management resources in real-time, resulting in the improvement AaYALHIV management outcomes.

2. Methods

Scope

The study was conducted at 15 healthcare facilities, selected across 4 of the 8 rural provinces in Zimbabwe (Mashonaland East, Mashonaland West, Mashonaland Central and Matabeleland North), where adolescents and young adults living with HIV (18-24 years) go for treatment and psychosocial support. These health care facilities are located in the most impoverished and remote parts of Zimbabwe though communications are accessible via internet and or mobile phone. A three-phase methodology was used consisting of derived problem identification, Solution design and Evaluation of the developed AnnMac m-health android based communication application. The emphasis of the first phase of problem identification was to understand HIV management in Zimbabwe, the use of mhealth in sub Saharan Africa and the health care workers preferred attributes for m-health interventions. The second phase involved the solution design and the usability of the mhealth interventions based on the outcomes and feedback of the first phase. The third phase involved refining the hypothesis case study and summarization of results.

Design science

A three-phase methodology was derived:

Phase 1 Problem identification: Emphasis was on understanding HIV management in Zimbabwe using the participatory research action (PRA) and literature review in the use of mHealth in SSA and Healthcare providers' preferred mHealth attributes.

Phase 2 Solution design: Emphasized the use of expert usability mHealth designing and development models which are the outcomes/ findings from the Phase 1 feedback. Pilot user testing with target end users using feedback comments to measure the user experience and improve the final mHealth application.

Phase 3 Evaluation Emphasized on refining the hypothesis, Case study and Summarisation of results

RESEARCH PHASES

The study went through three phases divided as shown in Figure 1 below:

Design science Phase 1: Problem identification

The gaps in AaYALHIV HIV management and the health care system information sharing and training were first identified in order to inform the development of the new mobile health application attributes through participatory research action (PRA) with purposively selected end-users in Zimbabwe so as to engage the local people and communities who input at times neglected in health systems strengthening [10] [9]. **PRA results** review analysis from training workshops the communication and training system which was in use then, appeared not very favourably.

Healthcare providers (HCPs) that were purposively selected for this study had many perceptions and experiences from individual level challenges, weakness of the health systems. These weaknesses include lack of guidelines (60%), the 40% who had them had received them from an implementing partner not MoHCC.

Design science Phase 2: Designing, Developing, implementing and evaluating the AnnMac mHealth android communication application

Design- Agile Model

Design, development, implementation and evaluation of a health care provider process user-centred design, which involve the end user throughout the AnnMac mHealth android communication application development and testing process, was crucial in ensuring that the it meets the needs and capabilities of the user, particularly in terms of usability, acceptability, learnability and positive user experience. The user centred design was done in order to establish the preferred designs by health care providers to develop a user friendly, usable, reliable and dependable AnnMac mHealth application. Development of the AnnMac mHealth application was done from August 2018 to September 2019.

The Design Process followed the Agile model for software design, development, implementation and evaluation. Agile process model refers to a software development approach based on iterative development. In this model the business team and the IT team work together to develop an artefact. The following steps were followed in the development of the AnnMac application.

Agile Phase 1: Requirement analysis

Brain storming/ requirements gathering was done and the findings where gathered as listed below:

Primary desired requirements of an App

The mobile application was built in a manner that ensured that it is compatible with phones on the market as the android platform is constantly updated, in a manner that safeguards the security and

privacy of client data. The development of the app also ensured that it ensures client feedback, is simple and easy to learn and use the features, credible and acceptable for adoption and sustainable integration with the mainstream health information system.

Agile Phase 2: Design documents & prototype

In this phase design requirements from phase 1 were used to come up with a prototype is of the AnnMac mHealth application. We adopted five critical success factors (SF) described below, for an enduring implementation of mhealth applications to come up with the AnnMac app [13] (Niemoller et al. 2016).

SF1: Technology choice – Building on convening technology and user knowledge

We factored in the development of mHealth applications, so that the services can be provided on the appropriate mobile devices such as mobile phones, tablet and laptops with an android software.

SF2: User-oriented design – Taking special background into account

The development approach in the application´s design considered the health care providers (users) as central. Some key elements that were considered were; the educational background as well as the official and region-based languages of the user group, in this case users were health care providers and their official language was English.

SF3: Simplicity – Focusing on reachable goals instead of providing a holistic approach

A comprehensive medical care for an entire population especially adolescents and young adults living with HIV demands diverse applications to fit the heterogeneous requirements and user groups. The AnnMac mHealth application was developed and it comprised of: guidelines, clinical updates, frequently asked questions and answers as the main features of the application relevant for our setting.

SF4: Exploitation of synergies – Providing interoperability between applications

The interoperability between services maximized the benefits for the user and developer of the applications, the application was used in disseminating information during the COVID-19 movement restrictions. The documents on the AnnMac can be shared through all media handles like "Whats app.", Instagram, email, Twitter, Facebook, etc.

SF5: Strong partnerships for sustainability – Integrating partners to the mHealth project

For success of any mHealth application it must have supporters in different fields and bring various strengths to the project, hence in this study a Professor leading the School of Health and science technology school which houses the Medical and science technology department was the main supervisors, an IT specialist was the 2nd supervisors, two senior medical personnel were the 3rd and 4th supervisors. The users, health care providers who contributed to the app design and development have

several professional backgrounds doctors, nurses, midwives, professional counsellors, Laboratory, pharmacy and some lay team like client experts also contributed.

The user and the adolescents and young adults living with HIV which are the beneficiaries of the service would benefit from knowledge which is now readily available in real-time, promotion of the national project and the connection to an existing national guidelines and clinical updates. There is a promising cooperation in active AnnMac mHealth application project including local medical authorities like Ministry of Health and Child Care, Nurses Council and the Biomedical Research and Training Institute (BRTI), telecommunication companies, network operators and Non-Governmental Organizations [13] (mHealth Alliance, 2013).

Agile Phase 3: Iterations, demo and feedback

Development/ construction

Using the information from phase 1 and 2 an AnnMac app. design wireframe was developed and as shown in figure 2 below:

Software Application

Software is a set of instructions, data, or program used to operate computers and execute specific task.

An application is a software that fulfils a specific need or performs tasks. The software was chosen and used as it is the one designed to meet user needs for training and education. The raw software application was purchased from application service provider website.

Agile team

After adopting the Agile application development, the researcher set up a team with business and IT professionals. The team included:**2 Experts** -Zimbabwe MoHCC National HIV (Medical) and TB Director and Director IT Chinhoyi University of Technology (IT).**Provincial, District and Facility cadres-** Doctors, nurses, pharmacy personnel, laboratory personnel, Community adolescents treatment supporters (CATS), Monitoring and evaluation officers, professional counsellors, biostatistician and IT personnel.

Construction

The Medical experts gave information and advised on the healthcare system, HIV management and mHealth issues in Zimbabwe. The IT experts gave advice on design science. The facility based team gave information gaps in HIV management information/skill sharing and preferred attributes of a good mHealth app. The researcher worked with the IT officer and held several meetings to work on how to develop the AnnMac app. using the gathered information. The plain android application software was purchased from an application vendor. The business team lead by the researcher worked with the IT officer to develop the AnnMac app.

Agile Phase 4: Iterations, demo and feedback Testing/quality assurance

Application testing was done from September 2019 to January 2020.White box testing is software testing technique in which internal structure, design and coding of the software are tested to verify flow of input-output and to improve design, usability and security. The techniques which were used are; branch coverage, control flow testing and data flow testing. Google play store also tested the artefact for bugs and it was found to be meeting the Google online requires as a health training and education artefact.

Black box testing

Black box testing was used to check the application under test from the user's perspective. It is based on the requirements and checks the system to validate against predefined requirements including;

Functionality – functional testing is concerned only with the functional requirements of the system, represent the main features, capabilities, generality and security. (Was being done continuously during the development).

*Non-functionality-*Evaluation of the readiness of the system according to various criteria which are not covered by functional testing e.g. Usability, Performance and Reliability Features, configurability, connectivity, workflow, compatibility, extensibility, and maintainability (was being done continuously during the development) *and Regression-*Regression testing was performed after code fixes, upgrades or any other system maintenance to check new if changes had not been affected any existing functionality. Checking integrability, persistence and adaptability was done in July 2020 when other features like the download option were added to the application and the version was changed to version 2. Black box testing was done and the artefact passed.

Agile Phase 5: Production and technical support

Deployment and implementation of the AnnMac application was from February 2020- July 2021

User instructions

The AnnMac application user instructions, audio and pamphlet were shared with users during the application trainings. The instruction information (audio and pamphlet) was as follows:

After the complete download and installation of the AnnMac Mhealth application, start looking for the AnnMac MedScieTec icon on your gadget. It is an 'a' that is orange in colour. Open the AnnMac app and load from home page. Anything from home page needs internet access. If you don't have it will indicate that u don't have internet access. If you have the internet all documents will be downloaded on the platform. There first thing to do first time opening the AnnMac application is the creation of your personal account, make sure top fields are filled with your identification and email and password.

There is a function for searching articles, if searching for an article go to search and type the common word e.g. ARVs and all the articles with the word "ARV" will open up then you select the one you want. At

the bottom of each document there will be comments part, if you want to leave a comment you have to give username and email to submit comment. Every comment will be approved by the administrator for everyone to see.

On the top of every document on the top right there are 3 icons, the clock icon, sharing icon and the view in browser icon. If you click the clock icon the document will be download and saved as a read later document which you will be able to access in the "later" feature on home page. If you click on the sharing icon the opened document will be share through all the available media handles e.g. Facebook, what app, Instagram, twitter, email etc. If you click the last (third) icon the document will be opened in browsers e.g. Firefox or google etc.

On the left of the AnnMac application there is a menu with category feature where one can view document according to categories, guidelines, Clinical updates and frequently asked questions and answers. All these documents will have been published from the administrator website using internet. On the menu again there is later feature where all read later documents are accessed without internet. You can also join "Whats app" group with the link on each document.

Implementation

Implementation testing was done at 3 health facilities in Mashonaland East province Epworth mission clinic, St Pauls Musami hospital and St Joseph clinic from September 2019 to January 2020. The facilities have a total number of 30 health care providers managing Adolescents and young adults living with HIV. The health care providers were offered in-house training on how to use the app. The first testing was done by loading the AnnMac app to gadgets like phones and tablets offline, via Bluetooth or using a USB cable. The healthcare providers suggested that they would prefer the AnnMac mHealth application to accessible online so that one could easily download the application in real time. This suggestion lead to the registration of the AnnMac mHealth android application on Google play store.

Implementation rolling out of the AnnMac application

Rolling out of the app for evaluation was done was done to 15 facilities from February 2020 to July 2021 (18months). The 15 health care facilities were drawn from 4 of the 8 rural provinces of Zimbabwe. These are high volume sites with an average of 500 adolescents and young adults living with HIV were chosen after advice from the MoHCC Director of AIDS and TB program and the Adolescents and young adults' program officer. Statistics from these hospitals were indicating that this special group had poor health outcomes which include poor viral load suppression and opportunistic infections as major ones.

The first AnnMac training workshop was conducted in February 2020

The importance of the mHealth user training on how to use the AnnMac mHealth Android communication application was to sensitise and get pre-rollout comments from the health care providers of adolescents and young adults living with HIV. The health care professionals could easily use and introduce the app to clients, if they had understood the functions and accepted the mHealth application within specific

training workshops or through tutorials that are included within the application. Each participating health care facility received a tablet with the downloaded AnnMac mHealth android communication application. All the health care providers had cell phones and they all downloaded the AnnMac application to their gadgets. They mentioned that they preferred having the app on their phones so that they could practice using the app and study the documents at any time during their free time.

Outcome of the training workshop

The users accepted the AnnMac application and believed that it would assist in improving the health care outcomes of the adolescents and young adults living with HIV.

Agile Phase 6: Evaluation of the design and implementation of the AnnMac app.

Feedback meetings for monitoring evaluation reviews was done at 2 months post implementation and at 6 months. The information gathered was used to modify the AnnMac app.

Monitoring and review of the AnnMac application

In early April, after 2 months of using the AnnMac application, the health care providers as users requested to have COVID-19 information and other HIV and health communication via AnnMac application. The first national lockdown from the 31 of March 2020 had disturbed most communications within the healthcare system. The lockdown had movement restrictions and working restrictions and health care providers had limited information on how to continue saving this special group, adolescents and young adults living with HIV. The restrictions were a threat to the gains which had be gained over the past 16 years managing HIV. A quick literature review on healthcare providers' desired attributes of a mHealth application during pandemics like COVID-19 was done. The initial literature study on desired mHealth attributes came in handy. From April 2020 information on COVID-19 and other HIV care management addendums were share via the AnnMac application. The health care providers also mentioned fear because of the pandemic, motivational messages and encouragement were shared through the AnnMac application.

One of the most useful encouraging statement which was even later quoted in the comments was,

"*This is the greatest battle ever fought by our health generation. We need to join hands and fight this common enemy of us. If not us, then who?*"

Second AnnMac Review training

The second AnnMac review training was conducted in July 2020 six months after the initial roll out. The general outcome from the review training was pleasing as all the available functions were reported to be working well. One of the new recommendations done included the need of a feature to read PDF documents such as guidelines offline and easy downloading of the documents. This lead to the upload

of the AnnMac Version 2 on the 28th of August 2020. This was also taken as an opportunity to fix some issues to improve on app flexibility and compatibility issues, and fixed some bugs.

In low and medium income countries, mHealth apps are increasingly used for public health concerns; however, recent evidence has largely focused on app development, dashboards, or the before-and-after effects on awareness or coverage, [14]. Less evidence is available regarding end users' and decision makers' acceptance of and engagement with digital health technology [14]. Bridging this evidence gap is critical to embed digital technology into mainstream health systems, in this study the decision makers were part of the of the development team and they were being consulted at each and every stage. The Director of AIDS and TB program and The Psychosocial program officer were part of the student supervision team. In this study, we used the qualitative contributions and experiences of the health care providers in developing the real-time AnnMac mHealth application to improve the coverage and health care outcomes of the adolescents and young adults living with HIV.

Final Database Design version

With extra capacities such as searchable and sortable areas and multiple improved reporting features, the system was integrate current maintenance information in the legacy database into a fresh improved database. The database of the system was able to import and export data from / to other apps.

In order to meet both research objectives, structured data stored in the database was searchable and sortable. As such, the names of the database areas correspond to all areas included in the User Data Entry Module as shown in the figure 3 below:

User interface

There are a number of user interface options as recommended by users during the designing and development. The interface included frequently asked questions and answers, Clinical updates, Offline guidelines, Read later option, "Whats app" group joining and comment section as shown on the figure 4 below:

3. Results And Discussion

Design science Phase 3: Evaluation results and discussion of the experiences and impact of the AnnMac app by the HCPs (users)

Overview

The study results initially revealed the gaps in the mode of communication and workshop training system which was in use. It further designed, developed and pilot implemented an AnnMac application artifact. Lastly was the evaluation of the AnnMac application user experiences and impact by the HCPs who were the users.

Results on PRA on communication and training workshop system

The HCPs raised some policy and AaYALHIV management follow-up issues as contributing factors to poor AaYALHIV health management outcomes. Lack of training and resources (90%). Poor community involvement (100%). District level supportive supervision to hospitals on children disclosure (100%). The lack of attention to children disclosure in the national health sector targets, and especially its absence in district disclosure level targets (100%) which results in the exclusion of disclosure supervision, and the lack of awareness in the district management team about HIV disclosure. Poor disclosure in childhood usually affect AaYALHIV adherence and relationships resulting in poor HIV management outcomes.

Review analysis on the results from the communication and workshop training system was done and the results appeared not very favourably. Only one cadre HIV focal person from bigger facilities and Nurse in charge from smaller facilities attends all the training workshops (100%). There is challenge in dissemination of the information to other HCPs (100%). Maximum time for the training workshop average 10 minutes (95%). Guidelines and reference materials are usually given to the HCP attending the workshop and some took them as their personal resources (98%). There is shortage of reference information (100%). Consultancy and reference not in real time (100%). There is no follow up after the trainings to check on sharing of information and implementation (100%). There is no feedback to comment on the system (100%).

Results on designing, development and pilot implementation

The mhealth application was designed, developed and pilot implemented and is readily available on Google store for download. The application name is AnnMac MedScieTech. The link to the *AnnMac MedscieTec link-is* https://play.google.com/store/apps/details?id=com.app.annmac. The user interface and *AnnMac MedscieTec website* is http://annmacmed.co.zw. The **designing and *development of the mobile application*** was done by September 2019. . The Application testing was done from September 2019 to January 2020. The app was registered on Google play store in January 2020 and **can be accessed free of charge** on Google play store. The Implementation was done from February 2020- July 2021. AnnMac developer online information is displayed as shown on the figure 5 below:

The mHealth application was named AnnMac MedScieTec application. It was named after the student's first name (Annah) and maiden name (Machakata) hence the name AnnMac and the MedScieTec part was named after the Chinhoyi University of Technology, Medical Science and Technology department where the researcher was a student. This was necessitated by the fact that it needed a unique name for the website and registration on Google play store for patent rights registration and easy search. The findings of this study show that the application is widely accepted because of its conveniences that it brings and also that it is user friendly as per measured by the 138 participants (HCPs) evaluation results. Most users (HCPs) agreed that the AnnMac application was user-friendly (94%), was functional / practical in terms of helping you do your job better (96%).

White and black box testing results

Application testing was done from September 2019 to January 2020

White box testing

White box testing is software testing technique in which internal structure, design and coding of the software were tested to verify flow of input-output and to improve design, usability and security. The white box testing of the AnnMac application focused on the internal structure, design and coding of the software and the artefact passed. Google play store also tested the artefact for bugs and it was found to be meeting the google online requires as a health training and education artefact.

Black box testing results

The black box testing of the AnnMac application focused on its functional, non-functional and regression components was done. The functionality, non-functionality was done by the participants and the artefact passed. The regression was done using the feedback on the need for offline documents which changed the application to version 2 and it passed.

Results per steps in designing and developing of the AnnMac app

[15] Niemoller et al. (2016) five critical success factors (SF) for an enduring implementation of mHealth applications outcomes:

SF1: Technology choice – Build on convening technology and user knowledge

A crucial contribution to the successful implementation was made through the choice of appropriate mobile devices. Factored in the development of mHealth applications, the services can now be provided on available mobile phones, tablet and laptops with an android software including offline pdfs with tailor made information for adolescents and young adults living with HIV and AIDS, National HIV management guidelines and clinical updates.

SF2: User-oriented design – Take special background into account

The development approach in the application design considered the users (healthcare providers) as central in designing, developing, pilot implementation and evaluation of the AnnMac application. Special background check was taken into account, only Ministry of Health and Child Care (MoHCC) communication documents did not need approval before being uploaded on the AnnMac application. The documents that did not originate from the MoHCC, which were from stakeholders, needed approval from the MoHCC first before being uploading on the AnnMac application. For the variety of demands, a reliable functionality required a close cooperation between designer and user hence the feedback mode platform with phone number to phone or "Whats app" messages. An online comment section and feedback session was created to cater for non-emergency communication between designer and users.

SF3: Simplicity – Focus on reachable goals instead of providing a holistic approach

A comprehensive medical care for an entire population especially adolescents and young adults living with HIV demands diverse applications to fit the heterogeneous requirements and user groups. Hence the development of the AnnMac mHealth application with guidelines, clinical updates, frequently asked questions and answers were the main features of the application. Holistic approach sets goals that were difficult to achieve and has the detriment of high complexity were avoided [13] (Niemoller et al, 2017). From IS perspective, a focus on the most important functionalities and an agile approach was found beneficial.

SF4: Exploitation of synergies – Provide interoperability between applications

In national projects, synergies between different applications can be useful as cited by Niemoller et al. (2016). For example, information needed for medical emergency services for adolescents and young adults living with HIV management during the COVID-19 pandemic were addressed by the communication of the relevant COVID-19 topics in awareness and management services. The interoperability between services maximized the benefits for the user and developer of the applications as the application was also used in dissemination COVID-19 information as shown on the figure 6 below:

SF5: Strong partnerships for sustainability – Integrate partners to the mHealth project

The Agile design model brought together various experts and healthcare providers (users) resulted in promoting partnership and sustainability of the application. The business and IT team all had ownership of the application

The user and the adolescents and young adults living with HIV which were the beneficiaries of the service knowledge which is now readily available in real-time, promotion of the national project and the connection to an existing national guidelines and clinical updates. There is a promising cooperation in active AnnMac mHealth application project including local medical authorities like Ministry of Health and Child Care, Nurses Council and the Biomedical Research and Training Institute(BRTI), telecommunication companies, network operators and Non-Governmental Organizations [14] (mHealth Alliance, 2013).

Experience and Impact Evaluation

All three approvals were received, from the CUT research committee, Ministry of Health and Child Care (MoHCC) and Medical Research Council of Zimbabwe (MRCZ).

One of the most useful encouraging statement which was quoted in the online comments was,

"This is the greatest battle ever fought by our health generation. We need to join hands and fight this common enemy of us. If not us, then who?"

User experiences with the AnnMac android mobile application

Evaluation of the health care providers experience and impact of the developed AnnMac application from the perspective of healthcare provider showed high level of success. The statistical analysis included

138 healthcare providers offering HIV management to AaYALHIV at the 15 health facilities between April 2020 and July 2021.

Table 1 results shows the number of healthcare providers offering HIV management to AaYALHIV at the 15 health facilities between April 2020 and April 2021. Of these 138 study participants, 74(54 %) were females and 64(46%) were males. Majority of the study participants were in the age-band 30-39 years 66 (48%), followed by 34(25%) in the age-band 40-49 years, 26(19%) in the age-band 20-29 years and lastly 12(8%) in the age-band 50+ years.

Of the 138 study participants, 48 (35%) had 5-9 years' experience working in the health sector, followed by 33 (23%) who had 10-14 years of experience working in the health sector, this was followed by 31 (22%) with 0-4 years' experience working in health care sector, 19 (14%) had 15-19 years working experience in the health sector, and only 8 (6%) had more than 20+ years of working in the health sector. Majority of the study participants, 60 (43%) had 5-9 years' experience offering HIV management to AaYALHIV, 43 (31%) had 0-4 years of experience offering HIV management to AaYALHIV, 23 (17%) had 10-14 years of experience offering HIV management to AaYALHIV, 11 (8%) had 15-19 years of experience working with AaYALHIV and only 1 (1%) had 20+ years of experience offering HIV management to AaYALHIV as shown in the table 1 below:

In this study, 75% of the health care providers were nurses. Most HCPs agreed that the AnnMac application was aligned with their job description (90%). 91% of the HCPs perceived the AnnMac app. to be easy to follow and use. Previous studies on mhealth also note that the interventions should be simple and provide high ease of use to the user (Niemoller et al 2016, Ventuneac et al 2020). The health care providers' impression before using the AnnMac application and after using the AnnMac application from 77% to 97%. This was most probably due to technical support they received from the AnnMac developers. 86% of the health care providers ranked the AnnMac application with 4 stars out of 5.

In addition, the health care providers agreed that the AnnMac app in the healthcare outcomes of the AaYALHIV, helped you improve of Quality of Life (97%). 97% of the health care providers were helped to deal with AaYALHIV and 90% were helped in understanding the dynamics of AaYALHIV. 93% rated highly that the AnnMac app helped them in delivering individually tailored messages. 94% of the HCPs agreed that the AnnMac app must also give access to AaYALHIV. The high rate of the adoption of the AnnMac app is in line with previous studies which show that the perceived benefits of the technology, such as improved quality of care/health outcomes, easier access to care for existing patients, and quality of clinician-patient relationship are top predictors of adoption [15-17] (Mourad, 2012, Khamphasaeng et al 2019, Whiteley, 2018).

4. Conclusion And Future Study Recommendations

The study results above has confirmed that innovation in scientific IT influence the capacity of HCPs in improving HIV management outcomes in AaYALHIV as evaluated by the HCPs (users). According to the evaluation results from the HCPs the designing, development, testing and implementation of the AnnMac

was successful. The study confirmed that AnnMac app. can be utilized to improve the quality of care or to downsize health care expenditure to both client and the Healthcare system. The study also confirmed that AnnMac application can be utilised to improve the quality of care resulting in improved quality of life for AaYALHIV.

The AnnMac m-health android based communication application enabled the healthcare providers to have ease of access to and follow set National HIV management guidelines, clinical updates and standard operation procedure manuals It gave HCPs access to HIV management expects and peers, and to disseminate accurate and relevant information to AaYALHIV. The online application helped health care providers communicate and engage with AaYALHIV using relevant manuals guidelines, standard operation procedure, algorithms and tailor made messages or information. The online application enabled health care providers manage AaYALHIV healthcare progress in improving their HIV management resulting in improved adherence to antiretroviral therapy and viral load suppression among patients.

The recommendations for future research are that it should focus on being able to identify and evaluate promising eHealth interventions/ mobile android based healthcare provider communication tool to improve HIV management outcomes and on investigating whether the clinical context perspective articulated in this paper contributes to making better evaluations. The principles have been generalized in order to promote understanding and discussion among evaluators and product owners, and to ensure creativity in the design process.

Declarations

To be used for health informatics journals

Funding

No funding was received for this study.

Ethics approval and consent to participate

A protocol was submitted to the Medical Research Council of Zimbabwe.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

N/A

Consent for publication

Authors agreed for the material to be published

Code Availability

N/A

Authors' contributions

"AR undertook the entire study as part of her doctoral studies with Chinhoyi University of Technology. KC assessed the thesis and paper and was the principal supervisor for the project. SC was the assistant supervisor for the project bringing much experience in the field of information technology. BD advised the first author on critical issues on the application of m-health interventions in HIV and AIDS Care. OM also advised the first author on critical issues on the application of m-health interventions in HIV and AIDS Care."

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Tables
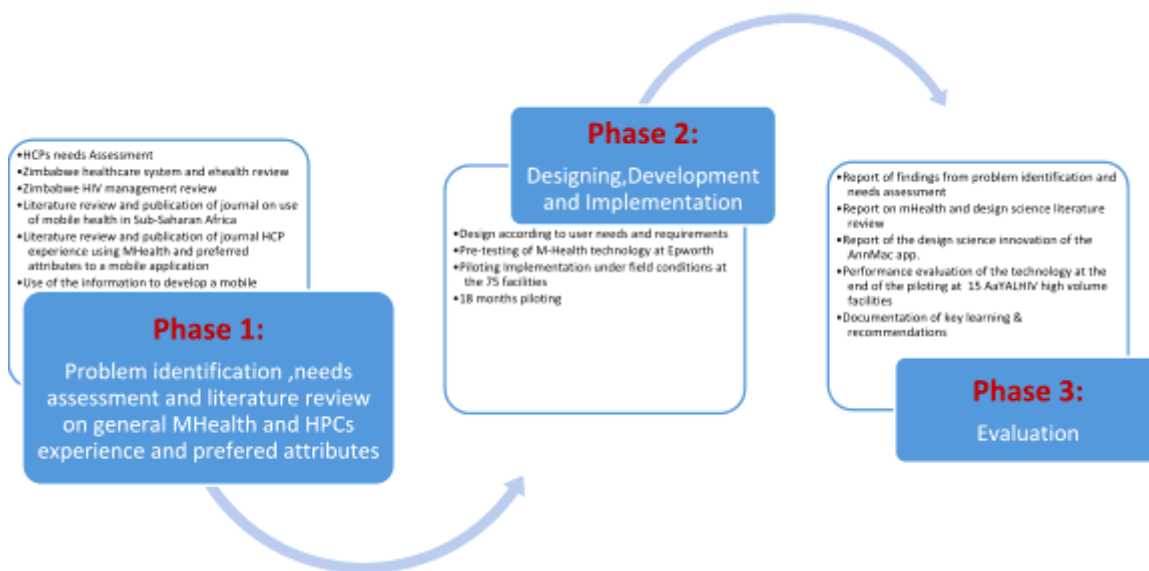
Table 1 is available in the Supplemental Files section.

Figures

Figure 1

The research Phases for AnnMac application, Source: **Adopted and modified from Wieringa, 2014**
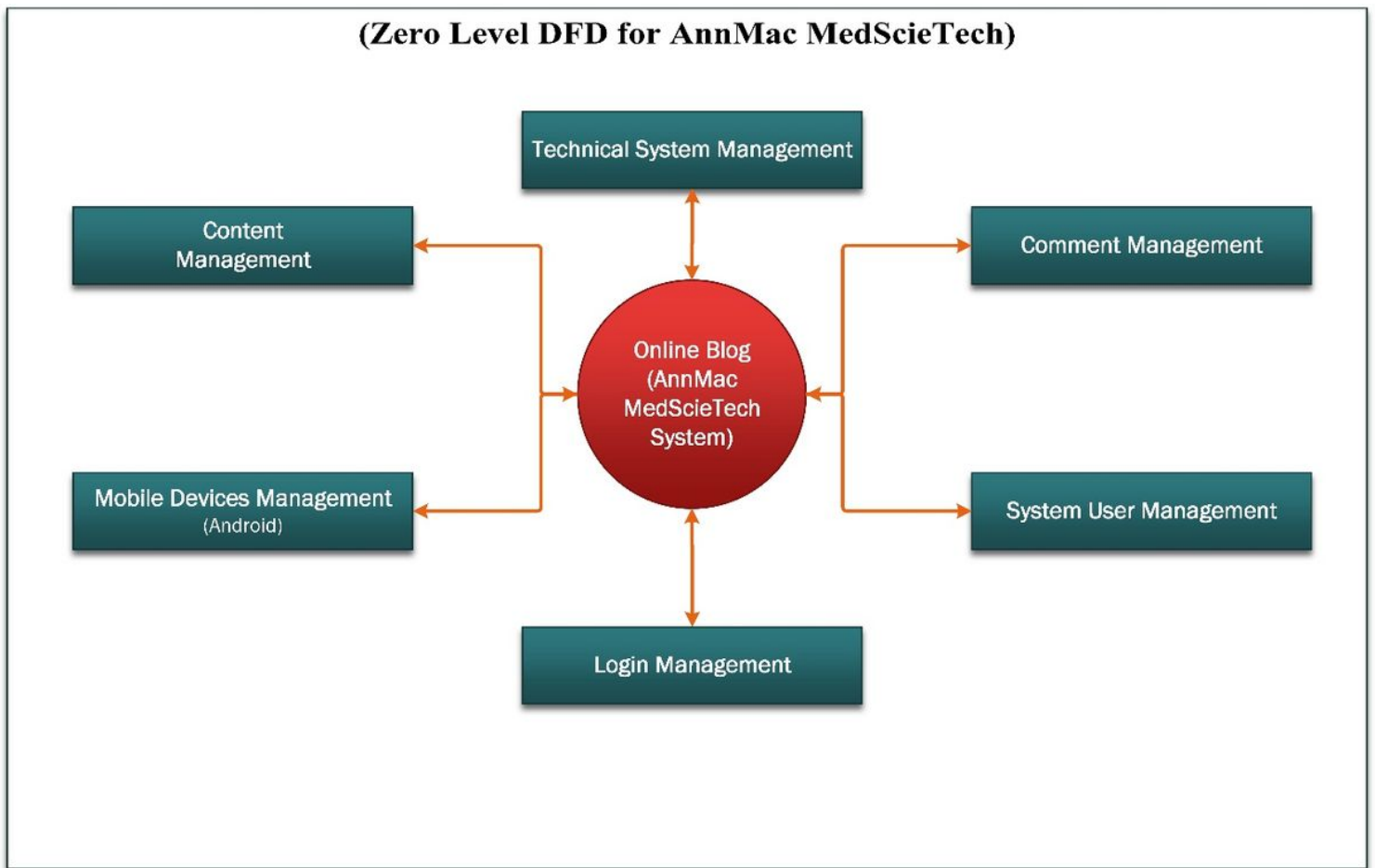
Figure 2

The AnnMac design wireframe (2018)

Figure 3

The System overview used to develop the AnnMac Application, Adopted modified from, (Chib, 2013)
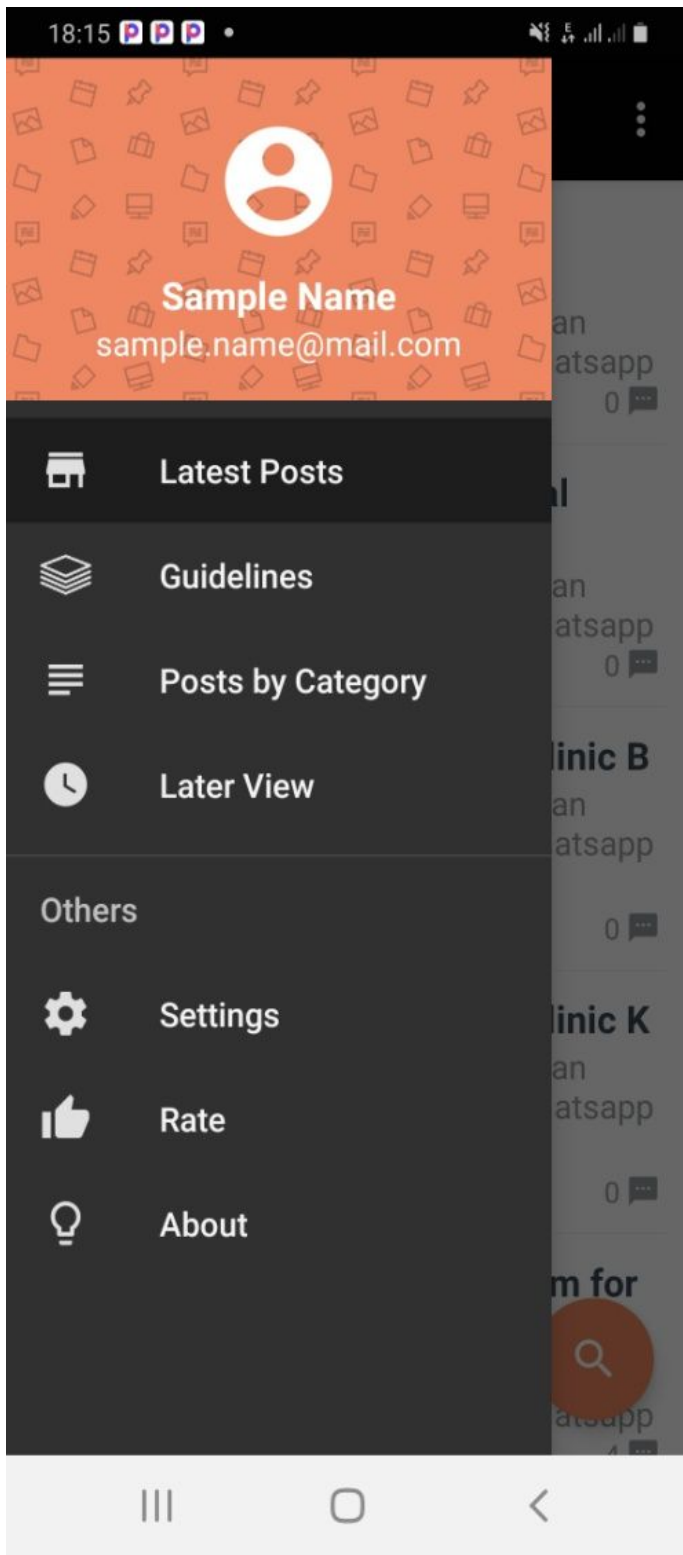
Figure 4

The **interface home information page on** AnnMac Application **online**, screenshot, 2022
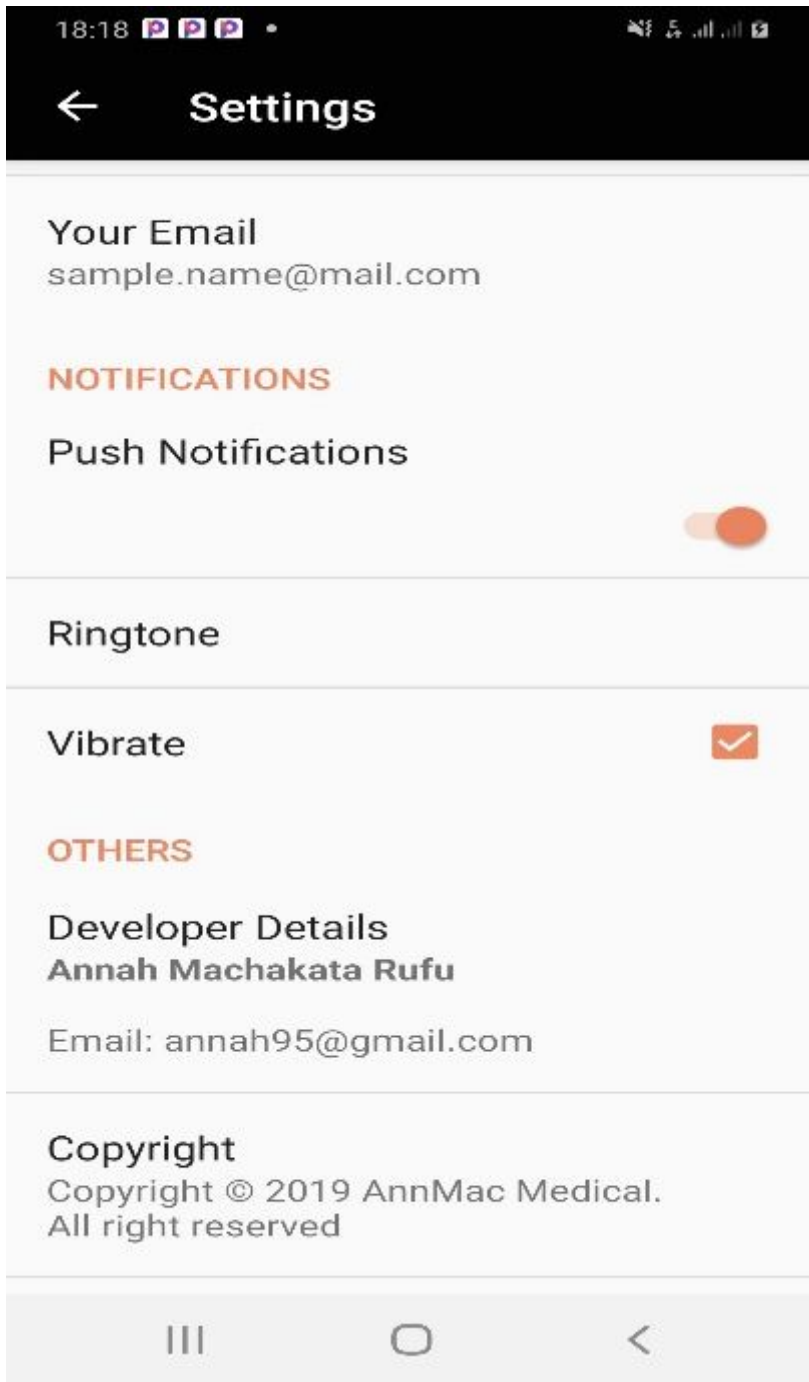
Figure 5

The **Google play store registration information** on AnnMac application online, screenshot, (2022)
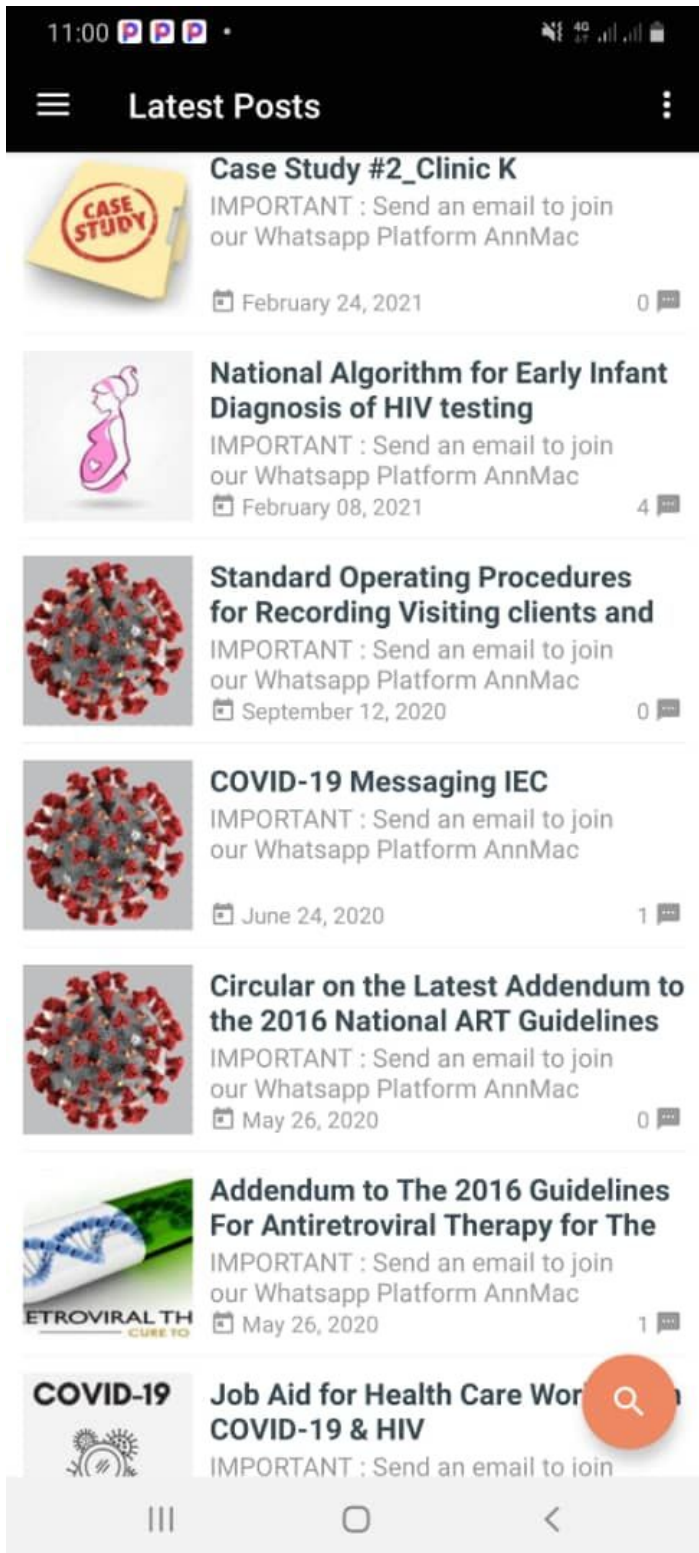
Figure 6

The *COVID information on* AnnMac application, screenshot (2022)

Supplementary Files

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- Tab01.png