Leveraging mobile phone-based technologies to provide on-demand adolescent sexual reproductive health information in a resource-limited setting:

Kibra, Nairobi County

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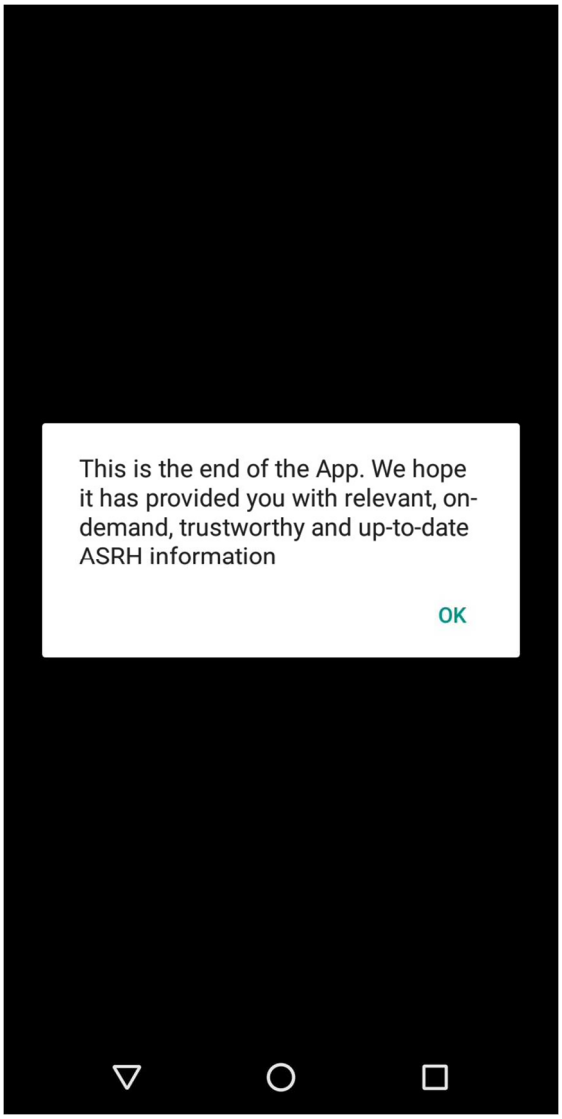
A thesis submitted for the degree of

Doctor of Network and Information Technologies

2022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Dedication

This thesis is dedicated to

Lucia my wife, Sarah, Ladan and Chislon my children

for their unconditional support in this journey.

Acknowledgement

I would like to acknowledge all the adolescent participants, their parents and guardians for making my research work a success. I am also very grateful to James Serembe, Josephine Ocham, Samwel Oninga and Noline Oudo for their dedicated field work and successfully working with adolescent participants at every stage of the study.

Thanks to my supervisors Drs. Carrion-Ribas and Perez-Navarro for all the support, encouragement, advice and guidance during my research. I am also very grateful to Dr. Irene Inwani and Prof. Ruth Nduati for their guidance and mentorship during the proposal development and research implementation.

I will forever be grateful to Lucia, my wife, for supporting and walking with me in this journey. I would like to mention my children Sarah, Ladan and Chislon who constantly inspired me to keep working on an intervention that meets the needs of young people like them.

Declaration

I declare that this research project is my original work.

Signed: _____

Name:_____Date: _____

This research project was submitted for examination with my approval as a University Supervisor.

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Abbreviations

ARH	Adolescent Reproductive Health
ASRH	Adolescent Sexual Reproductive Health
CTA	Cognitive Task Analysis
CW	Cognitive Walkthrough
DS	Design Science
ERC	Ethics Review Committee
FGDs	Focus Group Discussions
GCP	Good Clinical Practice
HCI	Human-Computer Interaction
Health-ITUEM	Health IT Usability Evaluation Model
IC	Informed Consent
ICT	Information and Communication Technology
ISO	International Organization for Standardization
KNH	Kenyatta National Hospital
LAR	Legally Approved Representative
LMICs	Low and Middle Income Countries
LTFU	Lost to Follow-up
MARS	Mobile Application Rating Scale
RCT	Randomized Control Trial
RMNCH	Reproductive, Maternal, Neonatal, and Child Health
SIM	subscriber identification module
SMSs	Short Message Services
SNOSE	Sequentially Numbered, Opaque Sealed Envelopes
SRH	Sexual and Reproductive Health
SRHC	Sexual and Reproductive Health Care

SSA	Sub-Saharan Africa
STI	Sexuality Transmitted Infection
TWG	Technical working Group
UNICEF	United Nations Children's Fund
USSD	Unstructured Supplementary Service Data
UX	User Experience
WHO	World Health Organization

Abstract

Adolescents transitioning from childhood to adulthood need to be equipped with reproductive health (SRH) knowledge, skills, attitudes, and values that empower them. The prevalence of pregnancy and STIs among adolescents in low and middle income countries leads us to believe adolescents don't have access to enough SRH information. The lack of SRH information may be due to cultural and societal attitudes towards adolescent sexual reproductive health. Innovative approaches, that are accessible, reliable, appropriate, and adolescent-friendly are required to address the adolescents SRH information needs.

We carried out a qualitative study to investigate adolescents' current information sources and their limitations. Then we explored the role technology, mainly mobile phones, could play among adolescents to meet their information needs. After gathering information needs and the role mobile phones could play, we applied a human-centered design (HCD) methodology to design, develop and field test a mobile app. To evaluate the potential impact of the mobile app on adolescent SRH outcomes, a randomized controlled trial (RCT) methodology was applied to investigate the app's ability to provide on-demand SRH information and improve SRH outcomes.

In the qualitative study, we found that preferred sources of SRH information by the adolescents were healthcare providers, parents, non-governmental organizations and the internet. Participants also believed a mobile phone-based app could improve their awareness and provide information in a confidential way. Due to the mobile phones commonly available in Kenya, Unstructured Supplementary Service Data (USSD) mobile phone technology was viewed as the most suitable mechanism for delivering information.

During the field usability test, 62 (54.9%) of the adolescents that were followed-up had used the app at least once, 32 (51.6%) were female participants. The app was described as 'very interesting' to use by 44 (70.9%) of the participants, 20 males and 24 females. The content was deemed to be either 'perfectly' or 'well targeted' on sexual reproductive health by 60 (96.7%) adolescents, and the app was rated 'best app' by 45 (72.6%) adolescents, 27 females and 18 males (p-value = 0.011).

In the RCT, 62 out of 109 adolescents (54.9%) used the USSD-based app at least once. The mean age by randomization group was 17.3 (SD 1.23) years for the control group and 17.3 (SD 1.12) years for the intervention group. There was a statistically significant difference in the total knowledge scores in the intervention group (mean 10.770, SD 2.012) compared with the control group (mean 10.170, SD 2.412) conditions (t=2.197; df = 179; p-value = 0.029). In relation to improved decision-making, 21.6% (29/134) of responses showed adolescents were able to identify STIs and were likely to seek treatment; 51.7% (15/29) of these were female. Ease of use was the most important feature of the app for 28.3% (54/191) of the responses.

The main contribution of this thesis is to show that SRH information should be provided to adolescents in a secure, confidential and anonymous manner. They require accurate and up-to-date SRH information to guide their decision-making and improve health outcomes. Mobile phones could offer an accessible, user-friendly and reliable delivery platform. The USSD mobile phone technology has great potential. A USSD-based app could be an appropriate tool for increasing SRH knowledge among adolescents in low-resource settings.

Access to mobile phones among adolescents in resource-limited settings is still a challenge. During the RCT, 47 adolescent participants failed to use the app due to lack of access to a phone. Phone ownership and access is determined by the economic status of an adolescent's family, other innovate ways of providing SRH information by using alternative technology options like internet which may be accessible to adolescents in these settings at cyber cafes could be explored.

1. Introduction

1.1 Adolescent Reproductive Health in Low and Middle Income Countries

Globally, by 2017, there were 1.3 billion people aged 15-24 years. Of these, over 226 million lived in Africa [1]. About 2 million adolescents are living with HIV and an estimated 1.6 million are living in Sub-Saharan Africa (SSA) [2]. In low and middle income countries (LMICs), almost 10% of girls become mothers by the age of 16, with the highest rates in SSA [3]. A substantial proportion of sexually-active adolescents do not know of any source to obtain contraception, get Sexuality Transmitted Infection (STI) treatment, or how to access social-psychological support services [4], [5].

In 2012, World Health Organization (WHO) identified universal access to Sexual Reproductive Health (SRH) as being a significant public health need requiring integration to national strategies and programs [6]. The WHO has also recognized SRH as fundamental to sustainable development of societies [7]. However, SRH services, especially for adolescents, are absent or of poor quality and underused in many LMICs. This is mainly because discussion on issues such as sexual intercourse and sexuality make people feel uncomfortable [8]. The adolescent phase of life (15 – 19 years) is viewed as a time of potential SRH risks. Adolescents' emerging SRH needs, cultural, social and health systems challenges they must content with as they seek SRH information of services increases the risk of poor health outcomes [9].

Preparing adolescents to a healthy sexual reproductive outcome still faces unique challenges, and to some extent, it is still contentious [10]. This is despite the adolescent age being a critical time to lay a good foundation for positive SRH outcomes. It is at the adolescent stage that attitudes and behaviors are formed, lifelong wellbeing is largely dependent on positive SRH outcomes [11]. Taboos surrounding discussions on SRH in most LMIC settings create constraints and barriers to meet the need [12]. Many young adolescents become sexually active without sufficient SRH information. For women, this also means that they have very little information to delay childbearing if they so desire [13].

To improve access to SRH information in LMICs, there is a need to use evidence-based interventions that are effective and carefully adapted to local cultures and contexts [4]. One study that used vouchers to make sexual and reproductive health care (SRHC) accessible to adolescents, appeared to have improved awareness of risky sexual behavior, resulting in increased contraceptive use [14]. Demand for SRH services in LMICs is a pointer to an unmet need by existing programs [15].

Adolescents in LMICs face obstacles to access SRH information. This is due to legal requirements of parental involvement. Adolescents also fear their confidentiality may be breach when accessing services. SRH services also lack age-appropriate information and education [16]. Due to lack of relevant SRH information, adolescents are exposed to risky behaviors leading to an increase in the number of cases of STIs and unplanned pregnancies. A study into the availability and access to SRH information found that there was preference to informal setup of information dissemination. Adolescents felt that existing services were “stressful”, this was due to fear of stigma and lack of confidentiality when receiving services. It is also challenging for adolescents just finding their way through the healthcare facility to access SRH services [17].

Worldwide, there are efforts to invest in strategies for effective SRH services. Such services need to be tailored to age groups, social contexts and adolescent-friendly services that are accurate, comprehensive and informative [18]. Adolescent-friendly access to SRH has gathered momentum through a number of approaches that raised awareness and provided much needed information [19]. In these efforts, technology innovations, including mobile phones and the Internet, present an enormous potential. The innovations could increase access to SRH information and, more importantly, in LMICs due to the spread of telecommunication infrastructure [20].

In the following sub-section, we will briefly discuss the use of mobile phones in LMICs. We will also show how mobile phones have improved access to healthcare in these countries.

1.2 Mobile Health in Low and Middle Income Countries

Over 5 billion people, about 83% of the world, can access mobile phone-based technologies [21]. In LMICs, access to mobile phones is estimated to be over 90% [22]. Modern mobile phones have a number of technical functions, such as voice, short message services (SMS) and USSD. The ability of mobile phones to process data and store files has been on an increase year-by-year. Mobile phones are now also able to connect to a client-server architecture making it possible to support the transmission and analysis of data in a variety of forms, including text, numerical, graphic, audio, and video files [23].

Mobile health (mHealth) is defined by WHO as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices” [24]. mHealth has provided healthcare providers, Government agencies and researchers with tools to improve health outcomes and make services accessible [25]. The mHealth interventions have had a positive impact, from improvement on quality of data collected in healthcare settings [26] to providing timely health information to adolescents and youth's health needs in LMICs [27].

Mobile phone technologies have been used to pass information to patients to promote treatment uptake [28] and also to monitor treatment adherence in real-time in different settings [29]. The

use of mobile phone technologies to improve quality of health services and also scale-up access has been received with great enthusiasm. The enthusiasm is driven by the potential benefits, availability of the technology and level of skills needed to use mobile phones [30]. mHealth has a great potential to transform public health systems by increasing access in remote areas and promoting a citizen-centred healthcare system. The mHealth integration has increased efficiency in the cost of service delivery, improved the ability to track disease and made it possible to have public health information in a timely way [31]. Figure 1 shows a feature phone. A feature phone has a small display screen, can perform basic tasks such as make a call, receive SMSs and interact using a USSD code. Such devices are commonly used in resource-limited settings, instead of smartphones which are much more expensive.

Figure 1: Image of a feature phone

This sub-section has shown how mobile phone technologies have impacted access to healthcare. In the following sub-section, we will discuss mobile phone's role in improving access to SRH services and information.

1.3 Sexual Reproductive Health and mHealth

Adolescents have found confidentiality, minimal time waiting, affordable and adolescent friendly access as factors mostly influencing their choice of SRH services [32]. Digital technologies, including the Internet, text messaging and social media sites, seem to have an impact on the adolescent communication landscape, the platforms offer potential tools to disseminate SRH information. One study using a technology-based intervention to improve access to SRH information indicated that this seemed to have had an impact on condom use, abstinence and increased users knowledge on STIs and pregnancy [33].

The ease of use of technology-based SRH interventions, their availability, confidentiality and the fact that adolescents can access information without parental or other adult supervision makes such interventions the choice of many adolescents [34], [35]. The technology-based interventions already seem to show positive outcomes. A study examining the use of the Internet to access health information by adolescents identified ease of access and confidentiality as key influencers of adolescents' choice of their source of SRH information. The convenient and interactive nature of Internet technologies have made it possible for the adolescents to access SRH information in a personalized manner and their information requests were provided in an individualized way [36], [37].

Improving access to SRH has been identified as the best strategy to prevent unintended pregnancy, abortion and STIs, including HIV. Interestingly, the use of mobile phones and social media apps is showing a promising potential to this strategy in resource limited settings [38]. Low cost technologies, including Short Message Services (SMSs) and WhatsApp (a social networking application), have been used to improve SRH knowledge and awareness in resource-limited settings. Mobile phone apps have also been used to organize training meetings in SRH, answer questions from group members and dispel myths on sexuality and pregnancy prevention [39], [40].

mHealth, the use of mobile phone technologies in the provision of public health services could offer on-demand SRH information to adolescents in a discreet, confidential, anonymous, novel, convenient and accessible manner [41], [42]. Research has demonstrated the potential of mhealth apps in resource-limited settings. Mobile phones are increasingly becoming affordable and can perform more tasks faster. Using mhealth interventions could have a higher impact with technologies including text messaging [43]. The WHO identifies mhealth apps as having a potential to increase access to SRH information and services especially in resource-limited settings [44]. Already, mhealth apps are showing great potential in offering user-friendly interventions [45].

In one study [46], a great potential was identified in terms of the use of technology to facilitate access to SRH information using a hotline number. The use of a toll-free number could potentially

address barriers, including cost, distance, waiting time, stigma and unfriendly staff. The hotline enabled healthcare staff to extend SRH services to the adolescents. Study participants found the hotline confidential, flexible and reliable since the information was adequate and of good quality. However, a South African qualitative study found that despite the potential of mHealth in information dissemination, projects have avoided the design and deployment of seemingly contentious SRH applications [47].

In Kenya, access and utilization of adolescents SRH services and information is provided in health facilities based on the adolescent's age. The Kenya adolescent sexual reproductive health policy directs that adolescents below 18 years cannot be provided with information or services on contraceptives. Parental involvement when adolescents are accessing SRH services may also be impacting outcomes. Poor health outcomes including a high number of adolescent pregnancies is an indication that the current model seems not to meet adolescents needs [16], [48], [49]. Kenya also has a high incidence of HIV among adolescents aged 15 to 24 years probably due to lack of adequate SRH information [50]. Strategies to implement mhealth applications in Kenya, a LMIC, are required to understand the most effective approaches for implementation and scale-up of mhealth interventions [51]–[53].

To guide the design and development of mHealth applications that meet user needs, effective evaluation processes are needed. The following sub-section will discuss several mHealth evaluation approaches.

1.4 Evaluating mHealth Applications

A specific criterion is required to evaluate mHealth applications. However, there is lack of agreed upon policy direction and clear guidelines to help healthcare providers and consumers evaluate mhealth applications. The criteria may evaluate user engagement, quality of the application to meet the user's needs and safety of the user. It could also evaluate the usability and clinical applications of the technology [54]. The evaluation may require development of a criterion based on risk, users and the integration of mobile applications to other systems. Other potential evaluation criteria of a mobile application could be designation of use, its level of development, security and privacy features, interoperability, usability and functionality [55].

In 2013, mHealth researchers and implementers developed an mHealth and Information and Communication Technology (ICT) Framework for reproductive, maternal, neonatal, and child health (RMNCH) [56]. The framework focused on intended users by identifying 12 mHealth applications and described how mHealth technologies would strengthen health systems across the RMNCH Continuum. The framework targeted to lay greater focus on the innovation achieving the objective of improving RMNCH outcomes. This is achieved by documenting uniqueness, commonalities and gaps of existing mHealth interventions thus enabling stakeholders to know applications that are available.

This framework strategically looked at the use of mobile phones to improve RMNCH outcomes by providing rational conceptual components in the technology application. This framework also identified 10 strategies to illustrate how effective mHealth solutions could contribute towards health systems achieving their goals in RMNCH. Strategy 4 of the framework focuses on decision support tools and systems that are automated and algorithm-based that could provide correct and relevant information based on user's input to improve health outcomes. Strategy 5 focus is on client education and behavior change communication aiming to provide targeted, timely health education and information through mHealth applications [57]. The study developed a mobile phone technology-based SRH app building on strategy 4 and 5 of the WHO mHealth and ICT framework [58].

One widely used tool to evaluate mhealth applications is the Mobile Application Rating Scale (MARS). The MARS as a multidimensional tool accesses functionality, engagement, aesthetics and information quality of the mhealth app [59]. To effectively access the 4 mentioned categories, the MARS uses a Likert scale of 1 – 5 (1-Inadequate, 2-Poor, 3-Acceptable, 4-Good, 5-Excellent). A "not applicable" option is also available for items not assessed based on the mHealth application under review. The tool in the last section has an "App-specific" category that evaluates the apps perceived impact on the users' knowledge, attitude and behavior change. Each category is calculated separately, the mean scores of each of the 4 categories make the mHealth app quality score. The scores can be interpreted by category or as an overall mean of the 4 categories. The MARS tool has shown excellent internal validity in the evaluation of mhealth apps [60].

To evaluate the functionality of mobile phone applications, specific standards have been set. The International Organization for Standardization (ISO) defines functionality of a system as the "degree to which the set of functions covers all the specified tasks and user objectives, provides the correct results with the needed degree of precision and facilitates the accomplishment of specified tasks and objectives" [61, p. 2011]. Evaluating the functionality of a mobile phone application involves testing if the application and each individual function works correctly [62, p. 2011].

A system evaluated as effective is predictable and can be made available to many users since it meets the needs of the envisioned users [63]. The Health IT Usability Evaluation Model (Health-ITUEM) was developed as a framework to guide evaluation of technology-based systems and has been used in several mHealth applications. The Health-ITUEM model guided the usability and user experience evaluation of the current research. Figure 2 shows the Health-ITUEM model. The figure shows how an information technology application can be designed to be usable and user friendly. From an objective point of view, the application should be efficient and effective. From a subjective perspective, the application should be easy to use, useful to the user, is not error prone and meets the user's information needs by being flexible to each user [64].

User experience and user experience evaluation of mobile phone application also guides the design and development process. User experience (UX) is defined by ISO as “person’s perceptions and responses resulting from the use and or anticipated use of a product, system or service” [65, p. 2019]. The UX encompasses users' perception and feeling in the interaction with technology. Mobile phone devices interact with the environment, face the challenges of connectivity, their display screen is limited, processing power is limited and the data entry methods have a number of limitations. Functionality, context and user input form part of what determines user experience [66].

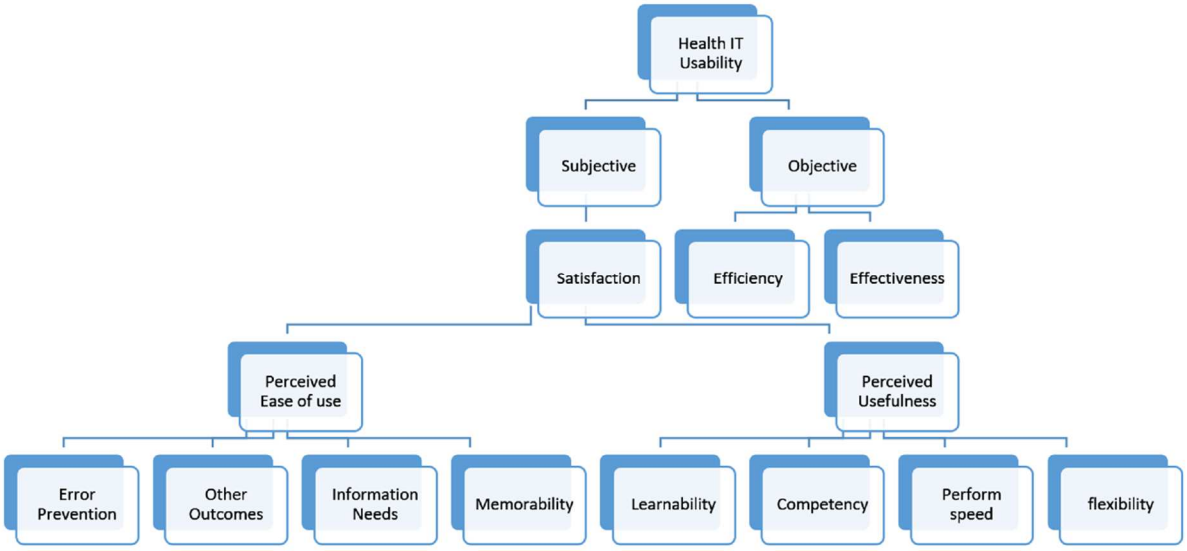

Figure 2: The health IT usability evaluation model [64]

Tools to evaluate UX have not always been adequate, requiring efforts to make UX evaluation strategies understandable, manageable and measurable. The evaluation methods could use a pre-defined template applying psycho-physiological measurements, an experience sampling method or expert evaluation [67], [68]. The goal of UX evaluation is to understand if the developed application will achieve its intended goal [69]. The scope of UX evaluation incorporates how human responses will be measured including pleasure and the circumstances within which these would be quantified during the anticipated use and reflection on use. Research has found that a mixed method approach to UX evaluation that includes observation of system logging data and user insights is an important way to collect user data [70].

At this point we have seen the importance of mHealth apps in providing health interventions and how we can evaluate such apps. It is also key to know the reality of the study setting, in the next sub-section, we will briefly discuss Kibra the study setting where the study was carried out.

1.5 Study Setting

Kibra is a suburb in Nairobi County with an estimated population of about 2.5 million people. It is “famous” for being the largest slum dwelling in African and among the largest in the world. Kibra has a number of the Kenya ethnic groups living here. Healthcare services in Kibra are mostly supported by non-governmental organizations. Most of the Kibra residents live below the poverty line hardly surviving [71]–[73]. Figure 3 below shows the location of Kibra in Nairobi County.

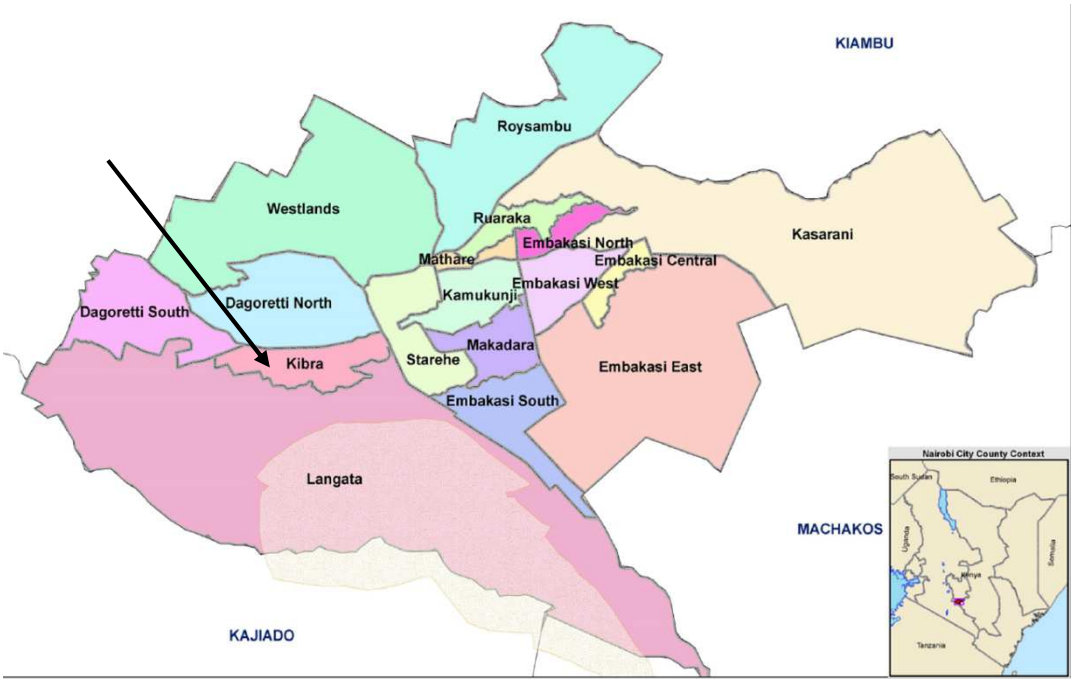

Figure 3: A map of Nairobi County showing the location of Kibra

Nairobi is the capital city of Kenya 1,680 metres above sea level and is located in Eastern Africa. The Nairobi County is made up of the city and its srroundings which is approximately 696 km^2. The population of Nairobi is estimated to be 4.3 million with 730,403 aged between 10 – 19 years [74]–[76]. Until recently, the Kibra informal settlement was called Kibera.

In Kibra, adolescent’s SRH information needs are unmet. This is due to societal and cultural norms [77]. Efforts are needed to increase access to SRH information in the Kibra setting [78]. The burden of STIs among adolescents in Kenya, Kibra included, underscores the need to develop interventions that are adolescent-friendly and accessible [79]. Adolescents aged between 15-19 years were recruited from multiple villages in this area. Figure 4 shows the 12 villages in Kibra.

The following sub-section will now discuss the design science approach to the development of the mHealth application in our study.

Figure 4: A map of Kibra showing the 12 villages

1.6 Design Science

Design Science (DS) is a research strategy promoting the creation of an artifact to solve a real-life problem [80]. This research strategy could consist of building and evaluating the artifact through models or prototypes [81]. DS plays an important role in the development and management of ICTs. It may involve development of decision support systems, governance strategies or information system change interventions [82].

Research has found that DS and human-centred design (HCD) of information systems (IS) have a lot in common. A major outcome of combining DS and HCD is enabling designers to develop user-centric applications that meet end user needs [83]–[85]. Since DS research framework is iterative in nature, it seamlessly integrates with HCD methodology an approach that documents user feedback to improve the final artifact. The improvements make the end product desirable, effective and meets the end user's needs [86].

This study adopted a DS-based HCD approach to the design, development and prototyping of a mobile phone-based application. In the following sub-section, we are going to briefly discuss the HCD methodology.

1.7 The Human-Centred Design Methodology

HCD is also known as "user-centred design (UCD)". The HCD methodology is "an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques". The methodology enhances user satisfaction, efficiency of the developed artifact thus effectively meeting the user's need [65].

The interactive processes of HCD were initially defined in the International Organization for Standardization (ISO) 13407 [87]. The ISO standard on HCD aimed to define processes that

would be followed to ensure use-centered development of products and services [88, p. 13407], [89]. Zhang T and Dong H (2008) proposed a conceptual model of HCD that combined Maslow's hierarchy of needs model and Küthe's "design and society" model. The proposed model attempted to marry psychology and sociology in order to design products and services that cared more towards human needs [90].

Although the HCD methodology has its origin in the engineering field, in the recent past, it has found relevance in the healthcare industry. In applying social innovation in global public health to both a social need and a social problem, the HCD approach has seen greater application. This is due to the focus on empathy, context, ideation and iteration in the design and development of health interventions [91]. Applying a mixed-methods approach, the HCD lifecycle emphasizes on how the end product will meet the needs of the envisioned users [92].

A HCD framework for a variety of mhealth interventions exists. Although the framework varies based on the target intervention, a common set of methods inform this process. The guiding principles include;

- gathering a multidisciplinary team,
- stakeholder engagement and
- conducting ideation sessions to inform the iterative steps of the design process [93]

Research has shown that It is very important to engage users by applying a HCD methodology when developing an mhealth intervention in resource-limited settings [94].

Developing interventions to meet SRH needs can be challenging and requires an innovative approach. The HCD approach has been found to be very helpful by providing a rigorous process that makes it possible to better understand the needs and also design the most effective intervention [95]. For the HCD process to be effective, it needs to be guided by three iterative phases namely; background analysis, usability testing, and field testing [96].

The ultimate end goal of applying the HCD methodology in the design and development of a mHealth application was informed by the desire for behavior change among adolescent participants. The next sub-section will discuss the behavior change framework in health interventions.

1.8 The Behavior Change Framework

Healthcare services and information is aimed at encouraging the general population to adopt behaviors minimizing poor health outcomes. Designing a health intervention that will inform behavioral changes is complex since only limited information is available on how best to achieve

results. The behavioral change framework aims to establish which is the best strategy to design an intervention, the content of the intervention and the target population [97].

Research has shown that technology-based health interventions have great potential to lead to behavior change. SMS texting, social media sites and applications have created opportunities to engage adolescents. This has enabled adolescents get health information leading to behavior change [98]. The theory-based behavior change model has had great success in healthcare interventions, this model lays greater emphasis on the target population participating the design process [99]. The health belief model (HBM) forms the theory-based behavior change model to design interventions in healthcare [100],

The HBM is a cognitive framework that views people as rational beings that make health decisions based on acquired knowledge. This model presupposes that a person will make a given health decision if the knowledge in their possession makes them believe that this decision could prevent illness or improve health outcomes as shown in figure 5 [101]. In adolescent SRH, the HBM has successfully been used to assess the effectiveness of SRH interventions in resource-limited settings [102], [103]. Due to the HBM ability to evaluate adolescent SRH interventions, we applied this model in our research.

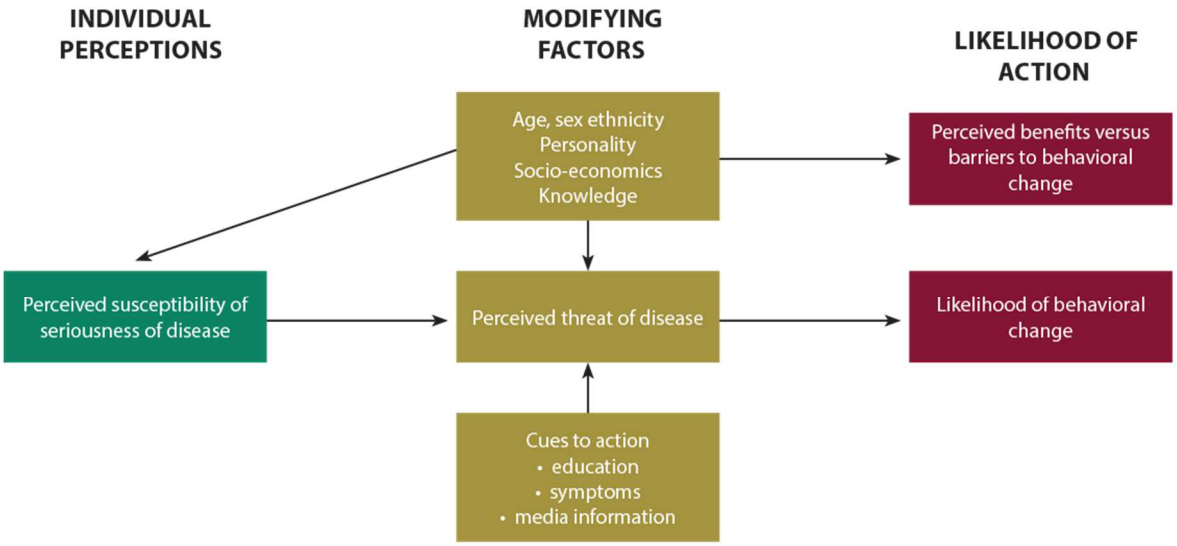

Figure 5: The health belief model

The thesis document is presented in the format explained in the following subsection.

1.9 The Document Structure

The thesis document is divided into seven chapters. Chapter one has already presented the literature review of adolescent SRH needs in resource-limited settings. This chapter has also showed the potential benefits of using mobile phone technologies to provide adolescents with SRH information. Chapter one explains the mHealth evaluation process that was used in the study and concludes by discussing a design science-based methodology applying a HCD approach to building mHealth interventions.

Chapter two presents the study objectives and hypothesis. In chapter three, the study methodology is presented. Chapter 3 explains in detail the three phases of the HCD approach to designing the mobile phone app and the subsequent field testing.

The results are presented in chapter four, five and six. The results are divided by each HCD phase. Published work (for chapter 5 the paper has been submitted to a journal and we are awaiting review) from each phase of the HCD approach is presented at the end of each chapter of the results section.

The last chapter, chapter 7 presents the study conclusions and lessons learnt to inform future research work. The references and appendices form the last two sections of the document.

2. Objectives

2.1 Objectives

The main objective of the current work is:

From a human-centred design methodology, design a mobile phone application to improve access to SRH information among adolescents in a resource-limited setting.

The secondary objective is:

Based on the WHO mHealth and ICT framework, evaluate the ability of the mobile app to provide correct, relevant SRH information leading to user education and behavior change communication.

The objectives will be guided by the following specific objectives:

- To identify adolescents SRH information access needs, document existing sources and the preferred mobile phone technology to disseminate adolescent SRH information.
- To design and develop a mobile phone technology-based intervention to provide on-demand adolescent SRH information and evaluate its functionality, usability and user experience.
- To conduct an outcome evaluation on the adolescent knowledge, attitudes, practice and SRH health outcomes.

2.2 Hypothesis

The hypothesis is: “It is acceptable and feasible to use a mobile phone-based technology to improve access to Adolescent Sexual Reproductive Health Information in a resource-limited setting.”

3. Methods

3.1 Mobile App Design

In our research, we applied the HCD methodology in the design, development and piloting of a mobile phone-based app providing sexual reproductive health (SRH) information to adolescents.

3.2 Study Area Description

The study was carried out in the Kibra informal settlement in Nairobi County. The research team worked closely with Community-based organizations that have adolescent programs in the area. The study area has been discussed in detail in subsection 1.5 of the document.

3.3 Methodology

Guided by the HCD methodology, we applied the iterative phases of gathering user requirements, development, usability and field testing of the mHealth intervention. The three iterative phases are described in the following subsections.

3.3.1 Background Analysis

An exploratory study was carried out. The aim was to identify current sources of SRH information for adolescents in Kibra. We focused on the role technology played including the internet, social media, television and radio in the access of SRH information. A qualitative study approach was applied. Specific elements of the qualitative study are discussed below.

For the qualitative study, focus group discussions (FGDs) based on World Health Organization approved questions on adolescent SRH were carried out [104]. The FGDs lasted 30 – 45 minutes and they took place in April 2019 at the study site at the African Inland Church Kibra. Although Swahili and other local languages are commonly used in Kibra, all participants preferred to use English in the discussions. In total, 12 focus group discussions were held divided by gender and age group: 3 for females between 15 and 17 years old; 3 for males between 15 and 17 years old; 3 for 18 and 19-year- old females; and 3 for 18 and 19-year-old males. A focus group discussion guide (Appendix 2) was used by the moderator to guide discussions. An audio recording was made of each FGD.

Adolescents were contacted by two community mobilizers experienced in working with adolescents in Kibra. A targeted non-probabilistic sampling methodology was used. Events or venues in the 12 villages of Kibra that attracted adolescents were identified, at which the

community mobilizers contacted potential participants and briefly explained study procedures individually or in small groups of three to five adolescents.

An FGD recruitment script (Appendix 1A) was used to explain the study procedures to individuals aged between 15 and 17 years old. Those agreeing to participate were then requested to bring a parent or guardian to the study site on a given day for the study procedures to be explained in detail. If the adolescent still wished to participate, the consenting and assenting process were administered.

For adolescents 18 years and over, a focus group discussion recruitment script (Appendix 1B) was used to explain their potential participation in the study. They were then referred to the study site location where study procedures were explained in detail and the consenting process administered. Depending on participant's age an assent (Appendix 6B) or consent form (Appendix 6C) was signed before starting the FGDs. To collect the participant's demographics, a participant profile form (Appendix 5) was used.

3.3.2 Usability Testing

A prospective research study design was used to evaluate the usability and user experience of the mobile app prototype. The alpha usability testing evaluated the apps functionality and information content, as well as the usability and user experience of the app. The usability and user experience testing was guided by a customized mobile application rating scale (MARS) (section 1.4). The MARS demonstrated excellent internal consistency ($\alpha = .90$) and interrater reliability intra-class correlation coefficient ($\alpha = .79$) [105]. The study team customization only included rephrasing questions in section F of the MARS to relate to the SRH.

The alpha usability testing took place in August 2019. Participants were enrolled in the first week then followed-up at the end of August 2019. A recruitment script (Appendix 1C or Appendix 1D depending on age) was used to explain the study procedures and potential benefits to the adolescents. The enrolled participants accessed the app for a 1-month period. The MARS (Appendix 3) was administered at the end of the month of use. Depending on participant's age an assent (Appendix 6E) or consent form (Appendix 6F) was signed before starting the 1-month alpha usability testing. To collect the participant's demographics, a participant profile form (Appendix 5) was used.

The field usability testing took place between October 2019 and January 2020. Participants were enrolled early October then followed-up from December 2019 to January 2020. A recruitment script (Appendix 1C or Appendix 1D depending on age) was used to explain the study procedures and potential benefits to the adolescents. The enrolled participants accessed the app for a 3-month period. The MARS (Appendix 3) was administered at the 3-month use. Depending on participant's age an assent (Appendix 6E) or consent form (Appendix 6F) was signed before

starting the 1-month alpha usability testing. To collect the participant's demographics, a participant profile form (Appendix 5) was used.

3.3.3 Field Testing in a Randomized Control Trial

Through a randomized control trial (RCT), the USSD-based app was evaluated on its ability to influence adolescent's knowledge, attitudes and practices relating to SRH health awareness using evaluation of the knowledge of SRH information questionnaire (Appendix 7). Content provided in the app was based on validated adolescent sexual health information (Appendix 8), created through Avert's Young Voices, a project that developed materials and content on adolescent sexual health through a co-creation process with adolescents from South Africa, Lesotho, Zambia, Zimbabwe and Malawi [106]. Avert's Young Voices is an initiative offering educative videos and other learning materials targeting adolescents contending with issues on sex and relationships. The information is presented in "Fact sheet" format and sample questions for discussion, the presentation makes it easier for adolescents to understand and apply lessons learnt to their context [107].

After the app had passed the usability testing a field testing was carried out. The adolescent participants were enrolled in October 2019 and followed up in December 2019 and January 2020. The field testing was to evaluate the success of the app in providing correct, relevant, and on-demand information. At enrollment, a recruitment script (Appendix 1C or Appendix 1D depending on age) was used to explain the study procedures and potential benefits to the adolescents.

Each eligible adolescent provided a cellphone number for either their own phone or that of a parent, guardian, or sibling. Depending on participant's age an assent (Appendix 6G) or consent form (Appendix 6H) was signed before starting the 3-month field testing. Figure 7 shows the participant flow during the field testing. To collect the participant's demographics, a participant profile form (Appendix 5) was used.

3.4 Recruitment

Participants were mobilized from the 12 villages; community mobilizers approached potential participants at social halls, sports events and other social activities that attracted 15- to 19-year-olds. Study procedures were explained individually or to small groups of 3 to 5 adolescents using a study recruitment script (Appendix 1A or Appendix 1B or Appendix 1C or Appendix 1D depending on age and stage of the study). Those adolescents who were interested in the study were referred to the study venue.

For the field testing, a minimum sample of 226 adolescents was required to attain a 95% confidence interval. The Kenya adolescent Reproductive Health and development policy implementation assessment Report projected adolescents aged 15–19 years accessing SRH

services to be about 8% [108]. The 8% was used to calculate the minimum sample per randomization group as shown in figure 6. Thus, the sample size of 300 adolescents enrolled had 74 more participants than the minimum sample calculation. The additional participants ensured that sample strength would be maintained even with loss at follow-up. The study used Sequentially Numbered, Opaque Sealed Envelopes (SNOSE), an affordable and effective method for randomizing participants [109]. Having passed screening for eligibility, adolescents picked a sealed envelope from a box. Each envelope contained the randomization group and an assigned participant identification number. The randomization list was generated using a web tool [110].

$$\frac{N = Z^2 \times P(1-P)}{d^2}$$

Where:
Z – 1.96 (95% confidence interval)
P – Estimated access to ASRH services = 0.08
d – Margin of error (precision error) = ±5%

$$\frac{n = 1.96^2 \times 0.08 \times 0.92}{0.05^2}$$

Substituting into the formula: n = 113

Figure 6: Minimum sample calculation for field testing participants.

3.5 Inclusion and Exclusion Criteria

For the background analysis, an adolescent should have been aged between 15 and 19 years, and living in Kibra. Each adolescent was required to have the capability to fulfill the age-based assent and consent process.

For the usability and field testing, an adolescent must:

- have lived in Kibra for at least 3 months;
- be aged between 15 – 19 years;
- be willing to take part in the study; and
- have access to a feature phone or smartphone.

Based on the adolescent's age, a written assent or consent was obtained from each participant.

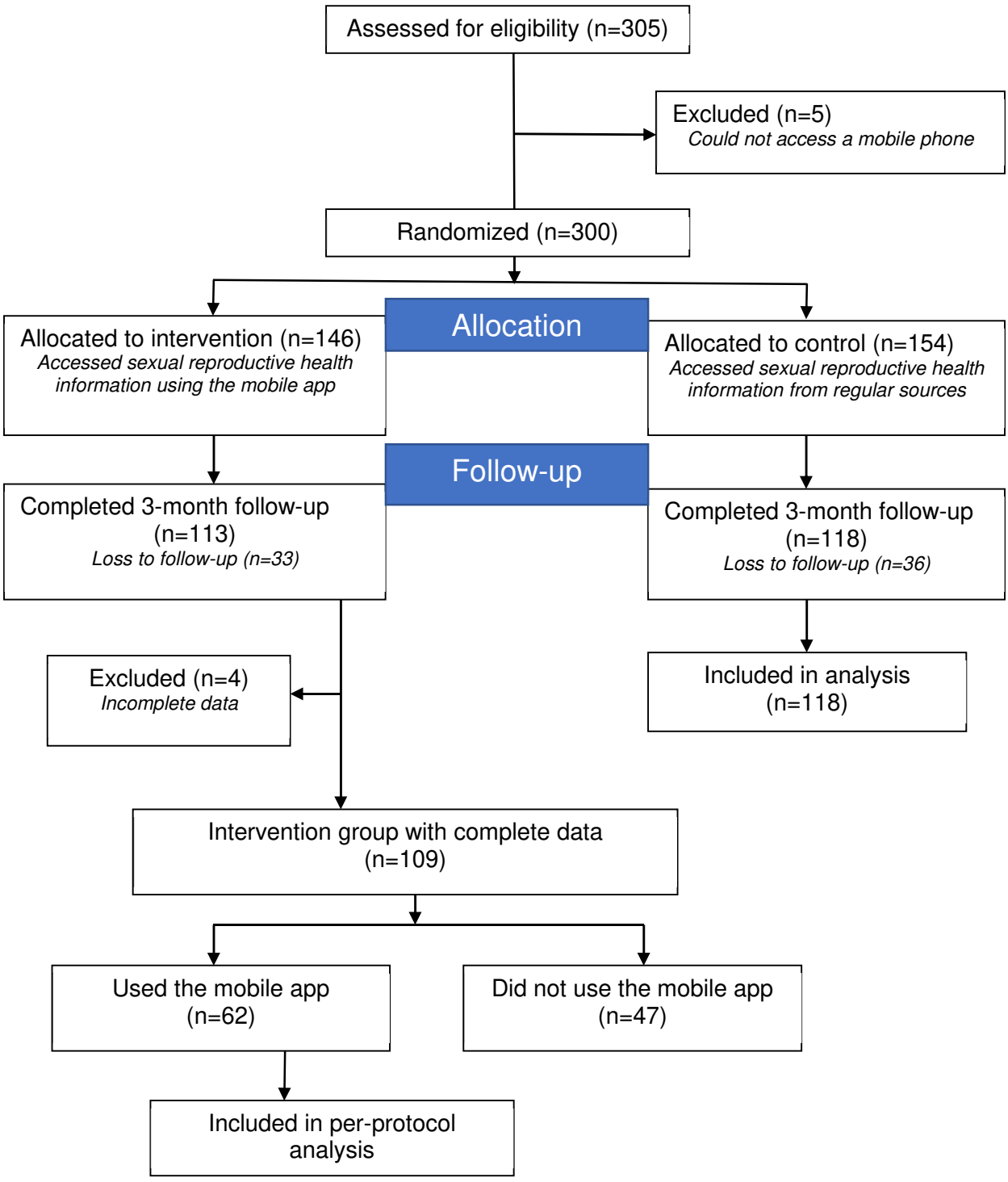

Figure 7: Field testing participant flow

3.6 Data Management, Storage and Analysis

For the FGDs, audio recordings of the discussions were transcribed. A total of 3 transcripts were generated from each age and gender group, then merged to form a single transcript. These final documents were analysed using AtlasTi® version 7. Themes and keywords were coded into the analysis process. A final report code with quotes in word processing and a spreadsheet document with quantitative outputs were generated from the AtlasTi® analysis. The qualitative and quantitative output was used to identify current adolescent SRH information sources and their limitations. Particular emphasis was given to the role played by technology in meeting information needs, especially the use of mobile phones. After merging the transcripts by age and gender, phrases relating to the identified themes were reviewed. Figure 6 shows the study flow for the qualitative study.

For the usability testing, descriptive statistics were applied to the participant characteristics, MARS and user experience evaluation. For application rating scale scores, standard deviation was used to measure the spread. A Chi square test of independence was carried out on the user experience evaluation outcomes. A p-value of < 0.05 was deemed to be statistically significant. A Cronbach alpha test [111] was used to provide a measure of the internal consistency of the MARS during the alpha and field testing.

For the field testing, a paired samples t-test was conducted to compare knowledge score data. The t-test attempted to show if there were differences in knowledge scores between the intervention and control group at the 3-month follow-up visit. The longitudinal continuous outcome scores were analyzed across time points (baseline and endline) in order to understand the effect of variation in the outcome scores. The Paired Samples t-test would compare the means of the intervention and control groups. The continuous outcome that was normally distributed. The threshold for statistical significance for all analyses was set at a p value of <0.05. This analysis was performed on the knowledge scores data.

For the use and perception of the mobile phone app questionnaire data that was part of the field testing, descriptive statistics were used to access the adolescents' knowledge, awareness and potentially improved decision making in relation to SRH. A Chi-square test was used to assess any differences by age group, with a p value of < 0.05 regarded as significant. The data was analyzed using R for statistical computing.

All study data was stored securely in password protected electronic files and folders. The study data was only assessable to the investigator. Paper, electronic and audio records generated in the study were kept in locked cabinets and only authorized electronic storage. All electronic data was backed up on flash memory on a weekly basis in encrypted format, the study data backups were stored by the investigator.

3.7 Ethical Considerations

The study research protocol will be submitted to the Ethics Review Committee (ERC) at Kenyatta National Hospital (KNH) for review and approval (Appendix 9). All study activities awaited the written approval of the ERC. The investigator ensured protection of human subjects at all stages of the study, any changes to the protocol, informed consent forms were submitted for review and approval.

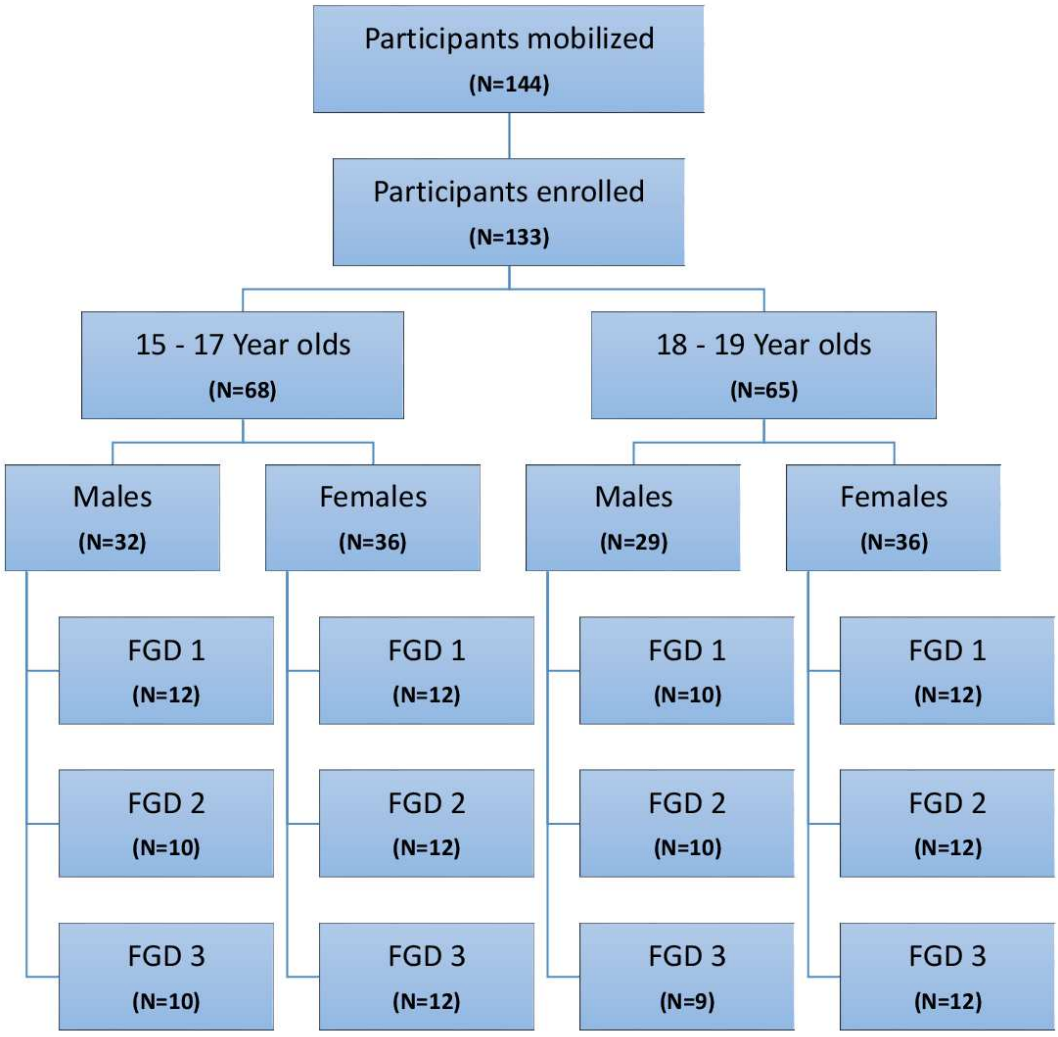

Figure 8: Participant flow during the qualitative study

4 Results: Background Analysis

In this results section, the qualitative study outcomes are presented. The qualitative work findings, discussion and conclusion will be presented. This work has been published in the International Journal of Sexual Health.

4.1 Overview of Study Findings

A total of 133 participants were recruited into the study. They had a median age of 17 years, 54.0% (72) of the participants were female and 91.0% (121) of the participants were students, and 79.7% (106) were in Secondary School (see table 1).

The recruitment process is shown in figure 8. Each focus group discussion had between 9 and 12 participants. The focus group discussions were carried out on the 8th, 10th and 12th April 2019 and each moderator-guided session lasted 30 to 40 minutes. The main outputs and some of the most relevant comments made by participants are reviewed in the following paragraphs.

THEME I: Preferred sources of adolescent sexual and reproductive health information

Subtheme I: Healthcare settings

There are a number of adolescent-friendly facilities in the community and adolescents do access these services. Healthcare settings as a source of information were more often referred to by older adolescents. Below are a few comments on this source of information:

“There are some organizations… some girls working in those organizations, for example at Carolina for Kibra [adolescent-friendly health service provider] you can just go and get information” (female, 18 years)

“Such information can be gotten from healthcare facilities, when you go to Voluntary Counselling and Testing (VCT) for a test [HIV test], you will be counselled depending on your sexual reproductive health needs” (male, 18 years)

The adolescent participants indicated that they were able to access SRH information and services in adolescent-friendly health facilities in their community. It can also be seen that the adolescent-friendly facilities were known to the adolescents’ due the awareness activities in the community by the healthcare providers.

Table 1: Demographic characteristics of participants in the qualitative study

	All % (n)	Male % (n)	Female % (n)
	100 (133)	46 (61)	54 (72)
Median age (IQR)	17 (15 - 18)	17 (16 - 18)	17.5 (15 - 18)
Education			
None	0.7 (1)	1.6 (1)	0 (0)
Primary	12 (16)	1.6 (1)	20.8 (15)
Secondary	79.7 (106)	83.6 (51)	76.4 (55)
College	6 (8)	13.1 (8)	0 (0)
University	1.5 (2)	0 (0)	2.8 (2)
Village			
Kambi muru	5.2 (7)	1.6 (1)	8.3 (6)
Karanja	5.2 (7)	1.6 (1)	8.3 (6)
Katwekera	20.3 (27)	27.9 (17)	13.9 (10)
Kianda	25.6 (34)	32.8 (20)	19.4 (14)
Kisumu Ndogo	9.8 (13)	8.2 (5)	11.1 (8)
laini saba	0.8 (1)	0 (0)	1.4 (1)
Lindi	0.8 (1)	0 (0)	1.4 (1)
Makina	5.2 (7)	4.9 (3)	5.6 (4)
Olympic	12.8 (17)	9.8 (6)	15.3 (11)
Raila	5.2 (7)	6.6 (4)	4.2 (3)
Sarangombe	1.5 (2)	0 (0)	2.8 (2)
Soweto	7.5 (10)	6.6 (4)	8.3 (6)
Occupation			
None	3.0 (4)	1.6 (1)	4.2 (3)
Student	91.7 (122)	88.5 (54)	94.4 (68)
Self-employed	4.5 (6)	8.2 (5)	1.4 (1)
Employed	0.8 (1)	1.6 (1)	0 (0)

Subtheme II: Parents

The participants, particularly younger adolescents, rely on their parents to provide SRH information. However, a few felt their parents avoided certain topics or did not provide enough detail. Below are quotes from the adolescents on this source of information:

“As adolescents, there are some things that our parents don’t tell us and if they did, it was not directly but in a coded way” (male, 15 years)

“Parents are a reliable source of sexual reproductive health information, because they care about us in a lot of things” (female, 16, years)

"When parents want to talk to you on sexual reproductive health and realized you are not comfortable; they may not tell you what they want to tell you. So such information I don't think is accessible from parents" (male, 19 years)

"I will go to my mum, she is very understanding; she explains to me slowly and in a way that I understand" (female, 18 years)

"Because, our parents are shy so h/she doesn't provide all the information" (female, 15 years)

A number of adolescents rely on their parents to provide SRH information because they trust them and believe they have their best interest at heart. However, the adolescent participants felt that their parents shy away from sensitive SRH topics which make the adolescents look for the information elsewhere.

Subtheme III: Non-governmental organizations

Community-based non-governmental organizations provide SRH information for adolescents in Kibra. The organizations are not necessarily healthcare facilities, but "safe" spaces where adolescents can meet and interact with counselors providing health information. At times, those peer mentor counselors also visit adolescents in the community. Some of the comments on this source of information are listed below:

"There are community-based organizations, you can visit their facilities if you have any questions on adolescent reproductive health you will be able to get answers" (female, 18 years)

"I would say the most important source are the non-governmental organization (NGO) seminars, they get adolescents from the village and start to talk to them on many topics on sexual reproductive health issues. It is not like our parents who choose what they want to tell us, in the NGO seminars, they say things as they are…." (male, 16 years)

Kibra being an informal setting, the number of NGOs is high. The NGOs provide many services including healthcare. The NGO's are an important source of SRH information in Kibra, their staff conduct community outreaches offering adolescents information in a way the adolescents find friendly and well detailed. The SRH information provided is relevant to both, male and female adolescents.

Subtheme IV: Internet

A number of the participants rely on the internet for SRH information, most often to compliment other sources of information. A number of illuminating comments by the adolescents are listed below:

"I rely on a health counselor to get sexual reproductive health information, when I feel that the information given is not enough; I do research on Google" (male, 19 years)

“As for me, I will get the information from social media where I have to search because I am sure I will get everything I need” (female, 19 years)

“With internet as a source of sexual reproductive health information, let us say you are suspecting you have a sexually transmitted infection, you search on the internet; you search for the matching symptoms to know if you have it or you don’t” (male, 19 years)

Adolescents participants indicated that they rely on the internet as a source of SRH information, due to the huge amount of SRH information available in internet. Search engines make it easier to search for SRH information, the search results also include images on symptoms of sexually transmitted infections that adolescents can easily understand.

THEME II: Limitations of current sexual reproductive health information sources.

Subtheme I: Adequacy of current information sources

The adolescents feel their current sources of SRH information do not adequately meet their needs. Issues include not being able to access information on-demand, a lack of facts to assess the accuracy of information and a general lack of provision for boys. Below are some of the adolescents’ comments on the inadequacy of reproductive health information:

“We should now start dealing with boys and fewer issues of girls, girls are getting more services and information on sexual reproductive health. Chances of the girls being raped will be reduced because the boys will be empowered and knowledgeable” (male, 16 years)

“[when we visit healthcare facilities] the time spent is never enough to explain sexual reproductive health matters and even when they explain, one does not understand” (male, 17 years)

“Not all the social media information is true, the best thing to do is just look for a health organization providing reproductive health services” (female, 18 years)

“Some of us don’t get information because many of our peers’ cheat you and so we prefer going to get it ourselves” (female, 16 years)

“For me it is No, most of the youth-friendly healthcare centers have sexual reproductive health services that are fit for girls and nothing motivating for the boys.” (male, 19 years)

A number of male study participants feel that available adolescent SRH information and services target females. The SRH service providers need to look into the best way to attract male adolescents and meet their expectations. The adolescents also have to contend with sources of SRH information they find not to be trustworthy, like their peers and social media.

Subtheme II: Confidentiality and privacy concerns

Adolescents want their SRH information needs to be met, but have concerns about their privacy being breached; they are also afraid of being "judged" based on their information requests or needs. Below are some of the adolescents' comments and concerns:

"You see sometimes if you are afraid and you have harsh parents you will not go and ask them some questions so you will go to the internet, because sometimes if you ask them, some parents will punish you" (female, 19 years)

"When we are looking for sexual reproductive health information on the internet, this remains between you and the internet and no one will know of it" (female, 18 years)

"Yeah, like there are some questions you cannot ask a parent, like they are private and you can't talk, so when you Google you just find answers directly" (female, 18 years)

"For example going to the chief's place [adolescent-friendly health facility in a government building], there we even fear. What if we got a place where one can ask questions and get answer without physically meeting the person answering you. Like a hotline?" (male, 19 years)

Confidentiality is a determinant of how adolescents will seek and access SRH information. Adolescents fear being "judged" by their parents or other community members when they access a health facility to seek SRH information or services. Privacy and confidentiality seem to be the reason adolescent look for SRH information on the internet.

Subtheme III: Abstinence, unwanted pregnancies, STIs and drugs

Younger adolescents, especially girls, often wish to abstain from sex due to the negative impact of teenage pregnancy, or be empowered with information on available contraceptive options to reduce the risk of early pregnancy and STIs. The adolescents would also like more information on STIs, such as HIV. Drug use and how this could negatively impact their reproductive health outcomes is also concerns:

"Because I need to know more ….. being told to abstain you, are not explaining how to do it" (female, 16 years)

"Because if one is not taught about abstinence, you will not know, where to abstain and how to abstain" (female, 15 years)

"Peer mentors [from community-based non-governmental organizations] visit us in the village and teach us sexual reproductive health issues, as you teach us we understand, as we understand we abstain from sex" (female, 17 years)

"I went to see a healthcare provider [in an adolescent-friendly clinic], they told me if you don't want to abstain from your girlfriend, then use protection" (male, 19 years)

"For us to avoid this sexually transmitted infections, as adolescent girls, we need to abstain because there is time for everything" (female, 18 years)

"When adolescents hear an advert about a HIV meeting, they all go there and pay attention" (male, 18 years)

"In school, teachers taught us and explained to us something about the effects of drugs and how this could affect our judgement, then we all understand" (male, 15 years)

Due to the fear of unwanted pregnancies and sexually transmitted infections, a number of adolescent participants are interested in information that would enable them abstain from sex. The adolescents are also concerned about drug use and its effects to the adolescent's SRH outcomes.

THEME III: Technology's role in meeting reproductive health information needs

Subtheme I: Convenient, on-demand and confidential

Technology, including internet search engines, social media and mobile phones, have been useful tools in meeting the adolescents' SRH information requirements. These technology options are convenient, can be used whenever needed and enhance confidentiality. Below are some of the adolescents' comments on the role played by technology in meeting their information needs:

"The internet is good to look for adolescent reproductive health information because it showcases images of, let's say, the features of sexually transmitted infections if you have then you can know which ones" (male, 19 years)

"When using mobile phones to access sexually reproductive health information, one will receive information relatively in good time" (male. 15 years)

"Yes mobile phone can improve access, if I have a problem and do not want anyone to know about, I will text, for example, if I have a sexually transmitted infection, I will type a text 'what is wrong?' then the text response will help me" (female, 16 years)

"If you have a sexual reproductive health problem and used your phone to access information no other person will know and It is good because it is private" (female, 15 years)

"If I use a mobile app, I will be able to get sexual reproductive health information, then I don't need to visit any place to get the information. Without a mobile app, I need to go looking for the information" (male, 16 years)

"You cannot visit adolescent friendly healthcare facilities at night, you just have to use the mobile app phone [proposed intervention]" (male, 19 years)

Due to the user-friendliness of mobile phone technologies, a number of adolescents feel that SRH information made available via mobile phones could improve access. The adolescents can easily access on-demand SRH information when needed without breaching their confidentiality.

Subtheme II: Unstructured Supplementary Service Data (USSD) technology preference

A number of mobile phone technology options were discussed by the focus groups. Most participants favored a USSD-based mobile app, due perhaps to not being able to afford a smartphone or not having a phone of their own. Users feel USSD is more capable of preserving privacy. Below are some of the adolescents' comments that captured key points:

"I think I will prefer to use USSD, because for example, I don't have a smartphone and I can use USSD on this phone" (male, 18 years)

"I will consider the USSD option [the user doesn't need to install anything] because my phone does not have space, and I want to keep my space for WhatsApp because it helps me reach many people" (male, 19 years)

"[Using USSD] One can borrow a phone, use and return to the owner and the owner will not trace what you were doing with his phone" (male, 15 years)

"It will be okay to use USSD, because of its confidentiality as it does not keep any trace of what you were searching and return to the phone owner" (male, 16 years)

"That will be very good because even if I don't have a phone, I can get from my friend and ask my questions. So that will boost my access to information and no one will know who asked the questions" (female, 15 years)

"It will be convenient to access sexual reproductive health information at home rather than visiting the adolescent friendly organizations situated in different parts of Kibra" (female, 18 years)

Due to the convenience and ease-of-use of the USSD technology, most of the adolescents preferred USSD to provide SRH information. The USSD technology is interactive, can be provided without charge to the adolescents and works on both, feature phones and smartphones.

4.2 Sexual Reproductive Health Information Needs

The adolescent participants identified five SRH topics of interest about which they would need information segmented by gender. Information on abstinence, pregnancy prevention, sexual relationships, sexually transmitted infections and adolescent-friendly health services is needed. Stratified by age, the adolescents need up-to-date information on how to find adolescent-friendly services (33.3%), pregnancy prevention (30.0%) and sexually transmitted infections (30.0%) as shown on figure 9. Information on abstaining from drugs seem not to be of interest to adolescents 18 years and above. This could be due a Kenyan law that requires alcohol and other legal drugs to be sold to persons 18 years and above. Adolescents 15 – 17 years were not interested with information on sexual relationships. This could be due to societal expectations and emphasis on sexual abstinence before marriage.

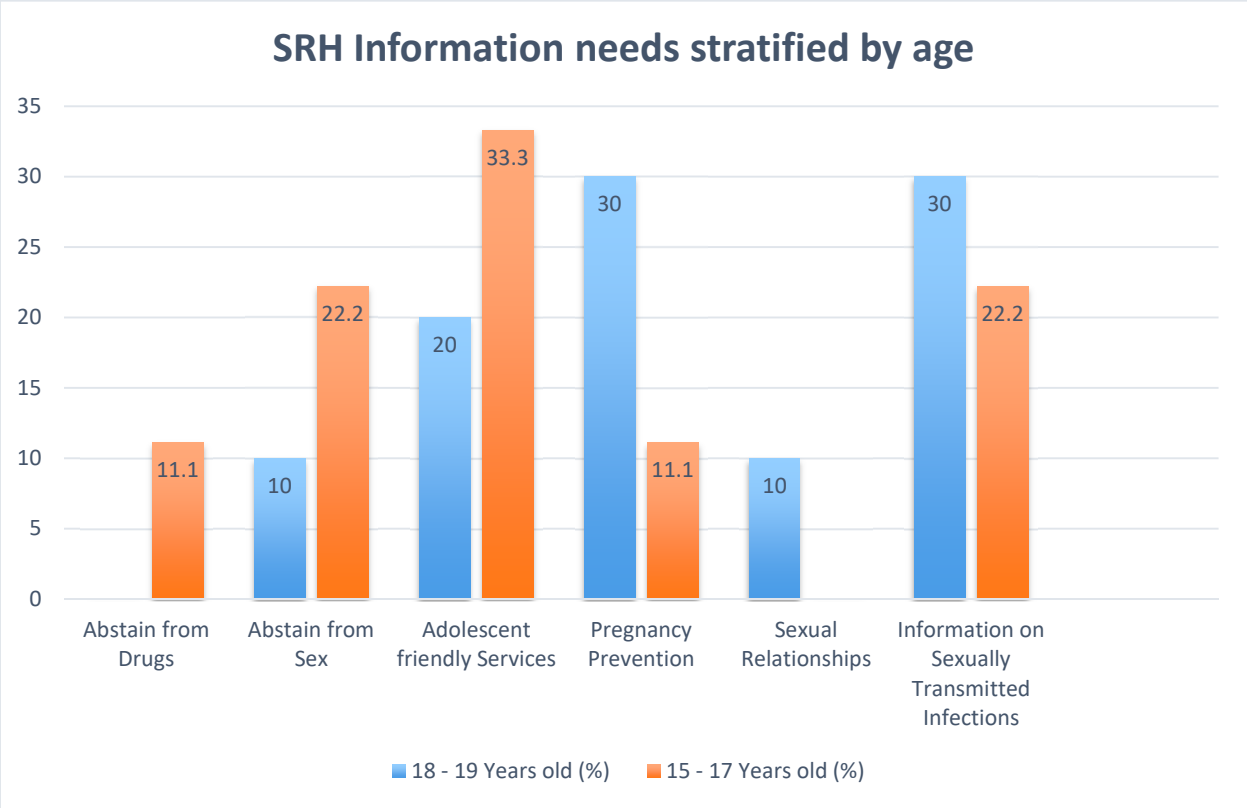

Figure 9: SRH information needs stratified by age

The adolescents' information needs varied slightly by gender and age. Girls above 18 years greatest need is information on sexual relationships while girls 15 to 17 years old need information on how to abstain from sex. Boys above 18 years need information on sexually transmitted infections while boys 15 – 17 years old need information on adolescent-friendly health services as shown on figure 10.

4.3 Discussion

Adolescents in resource-limited settings like Kenya face unique challenges accessing SRH information. This is due to multiple factors that include healthcare provider attitude, cultural factors and lack of confidentiality [48]. Limited access to SRH information makes adolescents and especially girls very vulnerable leading to poor outcomes like teenage pregnancies and STIs [112]. To meet the SRH needs of our study population, we carried out an exploratory study to: 1) identify the current information sources and their limitations and 2) explore the potential role of mobile phones to meet the SRH information needs.

A validated FGD guide (Appendix 2) based on WHO acknowledged questions on adolescent SRH was used. By the end of this sub-study, 144 adolescents were mobilized and 133 enrolled to the study. The research findings outlined three themes namely, preferred sources of information, limitations of current sources and role of technology in meeting SRH information needs.

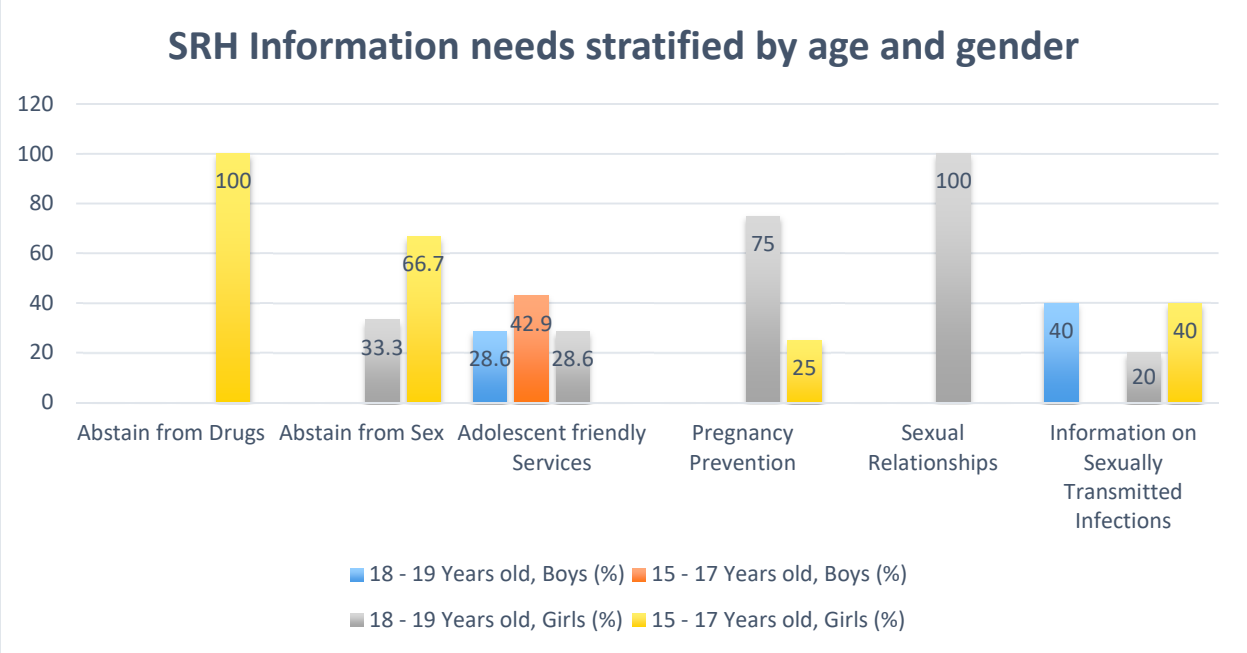

Figure 10: SRH information needs stratified by age and gender

On the preferred sources of SRH information, healthcare providers (HCPs) were an important, trusted and knowledgeable source. As one research shows [113], adolescents seem to feel comfortable talking to HCPs about their SRH needs. However, some of the HCPs seem to be a barrier to success access to SRH information due to their attitude. Adolescent-friendly services are preferred [114].

Parents are preferred as a source of SRH information by a number of adolescents. This is based on the belief by adolescents that their parents have their best interest at heart and would provide trustworthy SRH information. Adolescents and especially girls as one study found [115], despite

cultural factors, discussed issues around SRH with their mothers. Parents need to be empowered so that they are able to provide up-to-date, accurate SRH information [116].

On limitation of the current sources of SRH information, privacy and confidentiality concerns seem to have a big bearing to how adolescents access the information. Adolescents don't want to be "judged" or their ability to make SRH choices to be put into question. Research has shown that adolescents will access SRH services where they feel respected and their privacy is assured [117].

Technology and especially mobile phones have changed how adolescents access information and interact. Our study findings show that adolescents prefer to access information on SRH on mobile phones. The mobile phones would be convenient, easy and can be accessed on-demand. Adolescents preferred the Unstructured Supplementary Service Data (USSD) that works on both feature and smart phones. In the adolescent's view, USSD would enhance their confidentiality, could work on any phone and no audit trail is left on the device. Other researchers have also found the potential benefits on mobile phone technologies on adolescent SRH information access [118]. Mobile phone-based health interventions can be easily scaled, work in resource-limited settings positively impacting health outcomes [119].

The adolescent participants indicated they needed information on: abstinence for those below 18 years, contraceptives for those 18 years and above, sexual relationships, symptoms of STIs, adolescent friendly services and how to abstain from drugs. A WHO report in 2018 identified adolescents as a heterogeneous group whose SRH needs keep changing based on their life's circumstances and stage in life [120]. Customized SRH interventions that meet adolescents needs and context are required, the needs will vary by age or gender.

In this study we documented current SRH information sources used by adolescents in Kibra, existing information gaps and how technology, including the internet, social media and mobile apps, provide access to information. This research was designed to determine adolescents' perspectives, the information they need and the challenges they face in accessing information.
It can be seen from our results that significant sources of adolescent SRH information were healthcare providers, parents, non-governmental organizations and the internet. The information sources accessed varied by age.

Healthcare providers were an important source of adolescent SRH information [121]. Although healthcare providers were considered knowledgeable and trustworthy, there were a number of barriers. Social norms, a taboo on adolescent SRH, concerns about confidentiality and the possibility of judgmental attitudes appeared to hinder access to this source.

Parents were an important source of information for younger adolescents but this role diminishes with age when peers and others become preferred sources, as was determined in the study by Muhwezi et al [122]. Older adolescents had less communication about SRH issues with their parents, possibly due to decreasing levels of parental connectedness [123]. The research showed

that older adolescents prefer other sources of information, perhaps feeling their parents may not be as knowledgeable or detailed as alternative sources [103].

A cross-sectional study by Dessie et al showed that delaying sex can improve adolescent sexual health outcomes [124]. Our study was able to show that adolescent girls were keen to abstain from sex to minimize the risk of sexually transmitted infections, early pregnancies and other effects of risky sexual behavior. Long-Middleton et al showed that reasons for abstinence varied from fear and lack of opportunity to beliefs and values [125]. Alhassan and Dodoo found that fear of STIs and pregnancy could motivate adolescents to abstain from sex, as can religious conviction. Parental guidance was also an important factor in sexual abstinence [126].

Mirroring the findings of Kaneshiro & Salcedo (2015), the older adolescents in our study were keen to access services to prevent teenage pregnancies, which were mostly unwanted and unplanned, and negatively impact adolescents' lives [127]. Knowledge and awareness of contraceptives among adolescents were affected by social norms and cultural gender roles [128]. It was highly important to increase awareness and knowledge of available contraceptive options and services [129], and contraceptive interventions needed to be adapted to local culture and context [130].

As the study findings showed, technology plays a role as a source of SRH information. Participants currently used the internet and social media but the adolescents felt that mobile phone technologies could improve access to accurate, reliable and on-demand information. USSD was the preferred mobile phone technology for disseminating information. USSD is a low-cost option that allows two-way communication. The mobile phone user dials a 3 to 7-digit code based on the provider's service, which then connects to a two-way interactive communication referred to as a "session" [131].

It is important to note that USSD is the only technology capable of operating in both feature phones and smartphones: WhatsApp, Facebook and Instagram, which could have broader penetration in other settings, only work on smartphones. The preference for USSD showed that many of the target population did not own a smartphone [132]. A number of adolescents in the study also indicated their devices did not have the space to install new phone apps.

USSD technology had already been used in a number of settings to provide and support healthcare interventions [133]–[135], and provide public health information in resource-limited settings [136]. The technology enabled a user to access an interactive user interface that is simple, user-driven and user-friendly. The content could also be customized to each setting and context.

Adolescents had an unmet need of adolescent-friendly healthcare facilities providing SRH services and information. This agreed with the findings by Ayehu et al [4] and Mutea et al [48], fear of being judged, breach of privacy and the taboo associated with adolescents seeking SRH services still persist. Information on pregnancy prevention was also needed by both, girls 15 to 17 years old and girls above 18 years. Our findings agreed with those of Nash et al [137] regarding

a higher burden on girls due to unplanned or unwanted pregnancies, girls needed information on contraceptives or abstinence.

Adolescents, and especially girls 15 to 17 year-olds, needed information on how to abstain from drugs. None of the previously cited studies seemed to have identified this need. The study participants felt that use of drugs seemed to impair their judgement on SRH issues leading to bad outcomes. The adolescents requested to be provided with information on how identify drug use problems and provide referral pathway for any identified problems.

A technical paper by UNESCO in 2019 [138], found that adolescents aged 15 to 24 years searched online for SRH information on sexually transmitted infectious and sexual relationships among other related topics. These findings agreed with our finding that information on sexually transmitted infections is needed by adolescents in this age group by both, boys and girls.

4.4 Conclusions

Healthcare providers and parents are important sources of information. Adolescents view healthcare providers as knowledgeable and expect them to offer user-friendly services. These services need constant review and improvement to meet adolescents' expectations. Parents need to continue to provide factual SRH information, as adolescents expect their parents to be able to offer reliable and trustworthy information to guide their decision making.

Interventions to increase awareness among adolescents about dangers relating to unprotected sex and drug use should be provided. User-friendly, on-demand information provided in an anonymous way could improve awareness and empower adolescents to make informed decisions, thereby improving their reproductive health outcomes. According to our participants, mobile phone apps have the potential to provide SRH information to adolescents.

Most of our participants favored the use of USSD. This technology works on any mobile phone, no installation is needed and no audit trail is left on the device, thereby enhancing confidentiality. The USSD service can be provided as a pre-paid service, which enables adolescents to access information without cost.

4.5 Publication

INTERNATIONAL JOURNAL OF SEXUAL HEALTH
https://doi.org/10.1080/19317611.2021.1918311

An Exploratory Study of Current Sources of Adolescent Sexual and Reproductive Health Information in Kenya and Their Limitations: Are Mobile Phone Technologies the Answer?

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ABSTRACT

Purpose: The prevalence of pregnancy and sexually transmitted infections among adolescents in low and middle-income countries leads us to believe that sexual and reproductive health (SRH) information needs are still unmet. This paper investigates current sources and their limitations and then explores the role technology could play. *Methods:* In an exploratory qualitative study themes identified; (1) preferred sources of SRH information; (2) their limitations; (3) the role of technology in meeting their needs. *Results:* Mobile phone-based apps could improve awareness and provide information in a confidential way. *Conclusions:* Adolescents have an unmet need that vary by age and gender. Mobile phones could offer accessible, user-friendly platform.

ARTICLE HISTORY
Received 6 November 2020
Revised 7 April 2021
Accepted 10 April 2021

KEYWORDS
Adolescents; reproductive health; mobile phones

Introduction

In low and middle-income countries, almost 10% of girls become mothers by the age of 16, with the highest rates in Sub-Saharan Africa (Ahinkorah et al., 2019). A substantial proportion of sexually-active adolescents are not aware of any source of contraception, health facilities providing sexually transmitted infection (STI) treatment or how to access psychosocial support services (Ayehu et al., 2016; Newton-Levinson et al., 2016).

As lifelong wellbeing is highly dependent on positive sexual and reproductive health (SRH) outcomes, adolescence is a critical time to lay the foundations for positive and informed choices (de Castro et al., 2018; Denno et al., 2015). Many adolescents become sexually active without sufficient health information, particularly in relation to contraception (Darroch et al., 2017). The provision of evidence-based interventions that are effective and carefully adapted to local cultures and contexts is required to improve access to SRH information (Bilal et al., 2015).

Taboos surrounding discussions about adolescent SRH in most resource-limited settings create constraints and barriers to meeting adolescents' needs (Agbemenu et al., 2018). In these settings, attempts to prepare adolescents for healthy sex lives face unique challenges, and to some extent, are still contentious (Bankole & Malarcher, 2010). Digital media, including the internet, text messaging, and social media, have dramatically altered the landscape of communication, especially among adolescents. These technology-based modes of communication offer potential platforms to engage adolescents and improve their access to SRH information (Waldman & Stevens, 2015).

With growing adolescent demand for easily accessible, credible, trustworthy, and confidential SRH information, mobile phone technologies are

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Supplemental data for this article is available online at https://doi.org/10.1080/19317611.2021.1918311.

a viable option. Low-cost technologies, including short message services (SMS) and Telegram and WhatsApp (social networking applications), have been used to improve SRH knowledge and awareness in resource-limited settings. WhatsApp has been used to organize information seminars in SRH, answer questions from group members and dispel myths about sexuality and pregnancy prevention (Fletcher et al., 2018; Ipas, n.d.; Olsen et al., 2018; Shiferaw et al., 2018; Uddin et al., 2017).

The above examples, among others, demonstrate the potential of mobile phone technologies for conveniently providing health services. Mobile phone apps could offer on-demand information about SRH to adolescents in a discreet, confidential, anonymous, novel, convenient and accessible manner (Merrill et al., 2013; Peter et al., 2015). Nevertheless, smartphone-based technologies such as WhatsApp are only an option if the target population has access to smartphones with the capabilities to run this type of app. Thus, it is important to know and understand the technology available to a target population before developing interventions.

Mobile phone-based interventions in adolescent SRH in resource-limited settings are becoming more common as the user-friendliness of this technology has increased, and evidence shows that mobile phones are effective in delivering knowledge and realizing behavior change (Ippoliti & L'Engle, 2017). Mobile phones make it possible to develop demand-driven, culturally-relevant and user-friendly adolescent SRH content (Nuwamanya et al., 2018). Adolescents are more comfortable using interactive apps on mobile phones than text- or voice-based services to access SRH information, as noted by Alhassan et al. (2019).

Background and literature review

A number of barriers to the provision of SRH information to adolescents exist. Lack of priority, societal, cultural and religious factors negatively impact the provision of SRH services that meet the adolescents needs (Morris & Rushwan, 2015). Research shows that there is a need to provide accurate, culturally appropriate and relevant SRH information to adolescents consistent with their values systems. Relevant policy is also required to ensure that SRH information is available and easily accessible to adolescents (Mosavi et al., 2014).

For girls, who seem to bear the heaviest burden, effective information, education, and communication (IEC) materials on SRH are needed. The role of the community as an enabler to making it easier for adolescents to access information on prevention of early pregnancies and the lasting impact of poor SRH outcomes cannot be over emphasized (Nash et al., 2019). Healthcare providers have an important role to play in the dissemination of SRH information to adolescents. Their nature of work offers the needed knowledge, skillset, and opportunities to deliver evidence-based SRH information to adolescents (Santa Maria et al., 2017).

In Kenya, adolescents comprise 24% of the country's population, this large population has great implications on health services provision in-country. Accessing adolescent SRH information faces a number of challenges. The National Adolescent Reproductive Health (ARH) policy (2015) estimates that approximately 18 percent of adolescents (15–19 years) have children. Most of the unplanned pregnancies are due to inaccessibility of adolescent reproductive healthcare information and services. Political, cultural and religious barriers negatively impact provision of adolescent SRH information and services. To address this, the ARH policy targets to "enhance equitable access to high quality, efficient and effective adolescent friendly SRH information and services." The national ARH policy also aims to enhance SRH status of adolescents, to increase access, the policy explores how to facilitate digital platforms increase access to SRH information (Ministry of Health, n.d.).

This underscores the need for adolescent-friendly, accessible and nonjudgmental provision of adolescent SRH services. Negative healthcare provider attitude, social cultural factors and lack of privacy and confidentially continue to negatively impact adolescent SRH seeking behavior (Mutea et al., 2020). Public health facilities in Kenya provide HIV testing, STI screening and treatment and health education to adolescents.

Family planning services are only offered to adolescents above 18 years (Robert et al., 2020).

Access to mobile phones and internet has expanded greatly in Kenya, there is also an increase access to internet broadband and low-priced smartphones (Ipas, n.d.); however, it's not possible to know how many adolescents have access to or own mobile phones. This is because purchasing a phone is closed linked to the purchase of a subscriber identification module (SIM) card sold only to adults 18 years and above with a national identification card. The use of mobile phone-based voice and SMS services is a common phenomenon by people who own mobile phones. It is estimated that 97% of internet users in Kenya access it on mobile devices. The use of mobile money is also common among mobile phone users (GeoPoll, n.d.).

The exploratory study is guided by the health brief model a widely used behavior change framework. The health brief model is incorporated into healthcare interventions to enable healthcare service consumers increase their knowledge leading to behavior change (Green et al., 2020). Behavior change is achieved if the proposed intervention is targeted and has potential benefits to the users (Jones et al., 2015). This study is intended to identify adolescents' current SRH information sources, existing information gaps and the role of technology in accessing this information. The main objective is to determine the mechanism for accessing SRH information that adolescents in Kenya prefer, addresses current barriers and is feasible. A secondary goal is to identify the main information that adolescents require.

Methodology

This study is exploratory research (Liu, 2008; Reiter, 2013) to identify current sources of SRH information for adolescents in Kenya, with particular focus on the role played by technology, including the internet, social media, television, and radio. This study will also identify more efficient mechanisms for sharing SRH information with adolescents.

A qualitative approach is taken, based on focus groups of adolescents between 15 and 19 years old. Specific elements of the methodology are discussed in the following sections.

Study site

The study was carried out in Kibra, a suburb in the city of Nairobi, Kenya. Kibra consists of formal housing estates and a large informal settlement organized into 12 villages. The informal settlements are often referred to as the largest slum in Africa (Kibera UK, n.d.), with approximately 2.5 million residents. Intervillage ethnic differences relating to the history of the area exist, and people migrating from rural areas prefer to settle close to their fellow tribespeople.

Kibra was a preferred study site due to a number of reasons; the population in Kibra is made up of most of the Kenyan ethnic groups. There are also cultural and religious differences in this suburb that would enable the research team better understand the barriers and challenges of accessing adolescent SRH information. A number of families in Kibra rely on low-paying jobs, which have a bearing to accessibility and availability of smartphones in the community. Thus, the situation in Kibra represents most peri-urban and rural settings in Kenya. In selecting Kibra as a study site, the study team would be able to identify feasible mobile phone technologies that can be leveraged on to provide SRH information to adolescents in most parts of Kenya.

Inclusion and exclusion criteria

The inclusion criteria were adolescents aged between 15 and 19 years and living in Kibra. Each adolescent was required to have the capability to fulfill the age-based assent and consent process.

Sample collection

Adolescents were contacted by two community mobilizers experienced in working with adolescents in Kibra. A targeted nonprobabilistic sampling methodology was used. Events or venues in the 12 villages of Kibra that attracted adolescents were identified, at which the community

mobilizers made contact with potential participants and briefly explained study procedures individually or in small groups of three to five adolescents.

A focus group discussion recruitment script (Supplementary Appendix 1A) was used to explain the study procedures to individuals aged between 15 and 17 years old. Those agreeing to participate were then requested to bring a parent or guardian to the study site on a given day for the study procedures to be explained in detail. If they still wished to participate, the consenting and assenting process was administered.

For adolescents 18 years and over, a focus group discussion recruitment script (Supplementary Appendix 1B) was used to explain their potential participation in the study. They were then referred to the study site location where study procedures were explained in detail and the consenting process administered.

Focus groups discussion

The focus group discussions were based on World Health Organization approved questions on adolescent SRH ("WHO | Asking young people about sexual and reproductive behaviours," 2014). Although Swahili and other local languages are commonly used in Kibra, all participants preferred to use English in the discussions. In total, 12 focus group discussions were held divided by gender and age group: three for females between 15 and 17 years old; three for males between 15 and 17 years old; three for 18- and 19-year-old females; and three for 18- and 19-year-old males. A focus group discussion guide (Supplementary Appendix 2A) was used by the moderator to guide discussions. An audio recording was made of each discussion.

Data management and analysis

Audio recordings of the discussions were transcribed. A total of three transcripts were generated from each age and gender group, then merged to form a single transcript. These final documents were uploaded to AtlasTi® version 7 for analysis. Themes and keywords were coded into the analysis process. A final report code with quotes in word processing and a spreadsheet document with quantitative outputs were generated from the AtlasTi® analysis. The qualitative and quantitative output was used to identify current adolescent SRH information sources and their limitations. Particular emphasis was given to the role played by technology in meeting information needs, especially the use of mobile phones. After merging the transcripts by age and gender, phrases relating to the identified themes were reviewed. The initial analysis report identified 479 quotations, and the phrases that best captured thoughts in each sub-theme were selected and analyzed. A number of these are included in this paper.

Ethical consideration

The study protocol was reviewed and approved in March 2019 by the Kenyatta National hospital/ University of Nairobi Ethics committee. The approved study protocol number is P707/10/2018.

Limitations

Participants in this study were those who attended venues or events frequented by adolescents in Kibra, thus adolescents that do not patronize these places were excluded. The data also shows that one in every four participants came from the village of Kianda because of its proximity to the study site. Kibra is a low-income slum neighborhood with minimal access to and ownership of mobile phones. This points to the fact that the results may not generalizable or representative of adolescents throughout Kenya. Further research in other settings is needed to confirm these outcomes.

Results

A total of 133 participants were recruited into the study. They had a median age of 17 years, 54.0% (72) of the participants were female and 91.0% (121) of the participants were students, and 79.7% (106) were in secondary school (see Table 1). The recruitment process is shown in Figure 1. Each focus group discussion had between 9 and 12 participants. The focus group

discussions were carried out on the 8th, 10th, and 12th April 2019 and each moderator-guided session lasted 30–40 minutes.

Table 1. Participants demographic profile.

Variable	All % (*n*)	Male % (*n*)	Female % (*n*)
Participants	100 (133)	46 (61)	54 (72)
Median age (IQR)	17 (15–18)	17 (16–18)	17.5 (15–18)
Education			
None	0.7 (1)	1.6 (1)	0 (0)
Primary	12 (16)	1.6 (1)	20.8 (15)
Secondary	79.7 (106)	83.6 (51)	76.4 (55)
College	6 (8)	13.1 (8)	0 (0)
University	1.5 (2)	0 (0)	2.8 (2)
Village			
Kambi muru	5.2 (7)	1.6 (1)	8.3 (6)
Karanja	5.2 (7)	1.6 (1)	8.3 (6)
Katwekera	20.3 (27)	27.9 (17)	13.9 (10)
Kianda	25.6 (34)	32.8 (20)	19.4 (14)
Kisumu Ndogo	9.8 (13)	8.2 (5)	11.1 (8)
laini saba	0.8 (1)	0 (0)	1.4 (1)
Lindi	0.8 (1)	0 (0)	1.4 (1)
Makina	5.2 (7)	4.9 (3)	5.6 (4)
Olympic	12.8 (17)	9.8 (6)	15.3 (11)
Raila	5.2 (7)	6.6 (4)	4.2 (3)
Sarangombe	1.5 (2)	0 (0)	2.8 (2)
Soweto	7.5 (10)	6.6 (4)	8.3 (6)
Occupation			
None	3.0 (4)	1.6 (1)	4.2 (3)
Student	91.7 (122)	88.5 (54)	94.4 (68)
Self-employed	4.5 (6)	8.2 (5)	1.4 (1)
Employed	0.8 (1)	1.6 (1)	0 (0)

The main outputs and some of the most relevant comments made by participants are reviewed in the following paragraphs.

THEME I: Preferred sources of adolescent sexual and reproductive health information

Subtheme I: Healthcare settings

There are a number of adolescent-friendly facilities in the community and adolescents do access these services. Healthcare settings as a source of information were more often referred to by older adolescents. Below are a few comments on this source of information:

> There are some organizations … some girls working in those organizations, for example at Carolina for Kibra [adolescent-friendly health service provider] you can just go and get information. (Female, 18 years)

> Such information can be gotten from healthcare facilities, when you go to Voluntary Counselling and Testing (VCT) for a test [HIV test], you will be counselled depending on your sexual reproductive health needs. (Male, 18 years)

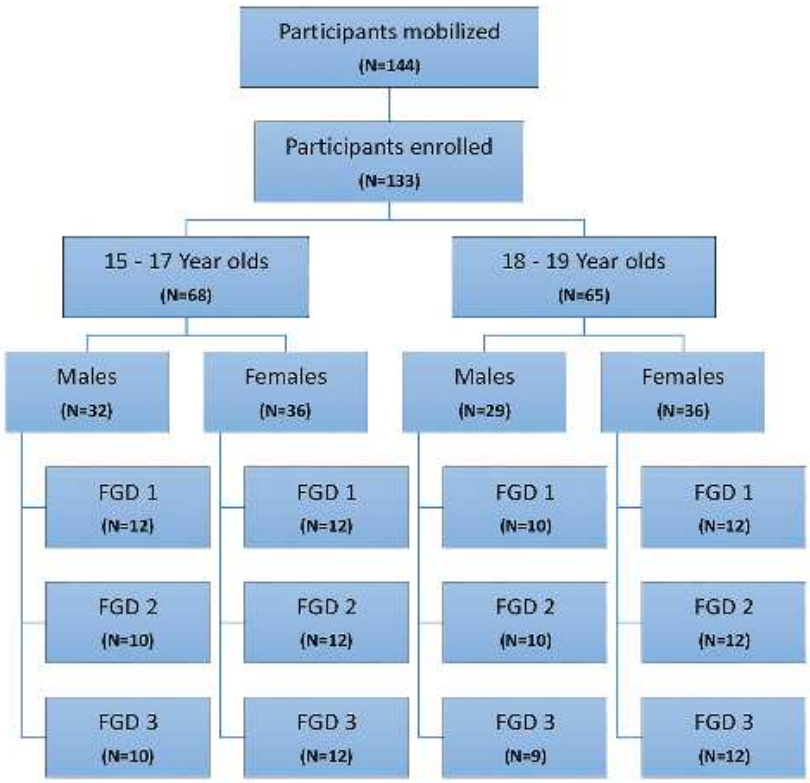

Figure 1. Study flow chart.

The adolescent participants indicated that they were able to access SRH information and services in adolescent-friendly health facilities in their community. It can also be seen that the adolescent-friendly facilities were known to the adolescents' due the awareness activities in the community by the healthcare providers.

Subtheme II: Parents

The participants, particularly younger adolescents, rely on their parents to provide SRH information. However, a few felt their parents avoided certain topics or did not provide enough detail. Below are quotes from the adolescents on this source of information:

> As adolescents, there are some things that our parents don't tell us and if they did, it was not directly but in a coded way. (Male, 15 years)

> Parents are a reliable source of sexual reproductive health information, because they care about us in a lot of things. (Female, 16, years)

> When parents want to talk to you on sexual reproductive health and realized you are not comfortable; they may not tell you what they want to tell you. So such information I don't think is accessible from parents. (Male, 19 years)

> I will go to my mum, she is very understanding; she explains to me slowly and in a way that I understand. (Female, 18 years)

> Because, our parents are shy so h/she doesn't provide all the information. (Female, 15 years)

A number of adolescents rely on their parents to provide SRH information because they trust them and believe they have their best interest at heart. However, the adolescent participants felt that their parents shy away from sensitive SRH topics which make the adolescents look for the information elsewhere.

Subtheme III: Non-governmental organizations

Community-based non-governmental organizations provide SRH information for adolescents in Kibra. The organizations are not necessarily healthcare facilities, but "safe" spaces where adolescents can meet and interact with counselors providing health information. At times, those peer mentor counselors also visit adolescents in the community. Some of the comments on this source of information are listed below:

> There are community-based organizations, you can visit their facilities if you have any questions on adolescent reproductive health you will be able to get answers. (Female, 18 years)

> I would say the most important source are the non-governmental organization (NGO) seminars, they get adolescents from the village and start to talk to them on many topics on sexual reproductive health issues. It is not like our parents who choose what they want to tell us, in the NGO seminars, they say things as they are …. (Male, 16 years)

Kibra being an informal setting, the number of NGOs is high. The NGOs provide many services including healthcare. The NGO's are an important source of SRH information in Kibra, their staff conduct community outreaches offering adolescents information in a way the adolescents find friendly and well detailed. The SRH information provided is relevant to both, male and female adolescents.

Subtheme IV: Internet

A number of the participants rely on the internet for SRH information, most often to compliment other sources of information. A number of illuminating comments by the adolescents are listed below:

> I rely on a health counselor to get sexual reproductive health information, when I feel that the information given is not enough; I do research on Google. (Male, 19 years)

> As for me, I will get the information from social media where I have to search because I am sure I will get everything I need. (Female, 19 years)

> With internet as a source of sexual reproductive health information, let us say you are suspecting you have a sexually transmitted infection, you search on the internet; you search for the matching symptoms to know if you have it or you don't. (Male, 19 years)

Adolescent participants indicated that they rely on the internet as a source of SRH information, due to the huge amount of SRH information available in internet. Search engines make it easier to search for SRH information, the search results also include images on symptoms of sexually transmitted infections that adolescents can easily understand.

THEME II: Limitations of current sexual reproductive health information sources

Subtheme I: Adequacy of current information sources

The adolescents feel their current sources of SRH information do not adequately meet their needs. Issues include not being able to access information on-demand, a lack of facts to assess the accuracy of information and a general lack of provision for boys. Below are some of the adolescents' comments on the inadequacy of reproductive health information:

> We should now start dealing with boys and fewer issues of girls, girls are getting more services and information on sexual reproductive health. Chances of the girls being raped will be reduced because the boys will be empowered and knowledgeable. (Male, 16 years)

> [when we visit healthcare facilities] the time spent is never enough to explain sexual reproductive health matters and even when they explain, one does not understand. (Male, 17 years)

> Not all the social media information is true, the best thing to do is just look for a health organization providing reproductive health services. (Female, 18 years)

> Some of us don't get information because many of our peers' cheat you and so we prefer going to get it ourselves. (Female, 16 years)

> For me it is No, most of the youth-friendly healthcare centers have sexual reproductive health services that are fit for girls and nothing motivating for the boys. (Male, 19 years)

A number of male study participants feel that available adolescent SRH information and services target females. The SRH service providers need to look into the best way to attract male adolescents and meet their expectations. The adolescents also have to contend with sources of SRH information they find not to be trustworthy, like their peers and social media.

Subtheme II: Confidentiality and privacy concerns

Adolescents want their SRH information needs to be met, but have concerns about their privacy being breached; they are also afraid of being "judged" based on their information requests or needs. Below are some of the adolescents' comments and concerns:

> You see sometimes if you are afraid and you have harsh parents you will not go and ask them some questions so you will go to the internet, because sometimes if you ask them, some parents will punish you. (Female, 19 years)

> When we are looking for sexual reproductive health information on the internet, this remains between you and the internet and no one will know of it. (Female, 18 years)

> Yeah, like there are some questions you cannot ask a parent, like they are private and you can't talk, so when you Google you just find answers directly. (Female, 18 years)

> For example going to the chief's place [adolescent-friendly health facility in a government building], there we even fear. What if we got a place where one can ask questions and get answer without physically meeting the person answering you. Like a hotline? (Male, 19 years)

Confidentiality is a determinant of how adolescents will seek and access SRH information. Adolescents fear being "judged" by their parents or other community members when they access a health facility to seek SRH information or services. Privacy and confidentiality seem to be the reason adolescent look for SRH information on the internet.

Subtheme III: Abstinence, unwanted pregnancies, STIs and drugs

Younger adolescents, especially girls, often wish to abstain from sex due to the negative impact of teenage pregnancy, or be empowered with information on available contraceptive options to reduce the risk of early pregnancy and STIs. The adolescents would also like more information on STIs, such as HIV. Drug use and how this could negatively impact their reproductive health outcomes is also concerns.

> Because I need to know more .... being told to abstain you, are not explaining how to do it. (Female, 16 years)

> Because if one is not taught about abstinence, you will not know, where to abstain and how to abstain. (Female, 15 years)

> Peer mentors [from community-based non-governmental organizations] visit us in the village and teach us sexual reproductive health issues, as you teach us we understand, as we understand we abstain from sex. (Female, 17 years)

> I went to see a healthcare provider [in an adolescent-friendly clinic], they told me if you don't want to abstain from your girlfriend, then use protection. (Male, 19 years)

> For us to avoid this sexually transmitted infections, as adolescent girls, we need to abstain because there is time for everything. (Female, 18 years)

> When adolescents hear an advert about a HIV meeting, they all go there and pay attention. (Male, 18 years)

> In school, teachers taught us and explained to us something about the effects of drugs and how this could affect our judgement, then we all understand. (Male, 15 years)

Because of the fear of unwanted pregnancies and sexually transmitted infections, a number of adolescent participants are interested in information that would enable them abstain from sex. The adolescents are also concerned about drug use and its effects to the adolescent's SRH outcomes.

THEME III: Technology's role in meeting reproductive health information needs

Subtheme I: Convenient, on-demand and confidential

Technology, including internet search engines, social media and mobile phones, have been useful tools in meeting the adolescents' SRH information requirements. These technology options are convenient, can be used whenever needed and enhance confidentiality. Below are some of the adolescents' comments on the role played by technology in meeting their information needs:

> The internet is good to look for adolescent reproductive health information because it showcases images of, let's say, the features of sexually transmitted infections if you have then you can know which ones. (Male, 19 years)

> When using mobile phones to access sexually reproductive health information, one will receive information relatively in good time. (Male, 15 years)

> Yes mobile phone can improve access, if I have a problem and do not want anyone to know about, I will text, for example, if I have a sexually transmitted infection, I will type a text 'what is wrong?' then the text response will help me. (Female, 16 years)

> If you have a sexual reproductive health problem and used your phone to access information no other person will know and it's good because it is private. (Female, 15 years)

> If I use a mobile app, I will be able to get sexual reproductive health information, then I don't need to visit any place to get the information. Without a mobile app, I need to go looking for the information. (Male, 16 years)

> You cannot visit adolescent friendly healthcare facilities at night, you just have to use the mobile app phone [proposed intervention]. (Male, 19 years)

Because of the user-friendliness of mobile phone technologies, a number of adolescents feel that SRH information made available via mobile phones could improve access. The adolescents can easily access on-demand SRH information when needed without breaching their confidentiality.

Subtheme II: Unstructured Supplementary Service Data (USSD) technology preference

A number of mobile phone technology options were discussed by the focus groups. Most participants favored a USSD-based mobile app, due perhaps to not being able to afford a smartphone or not having a phone of their own. Users feel USSD is more capable of preserving privacy. Below are some of the adolescents' comments that captured key points:

> I think I will prefer to use USSD, because for example, I don't have a smartphone and I can use USSD on this phone. (Male, 18 years)

> I will consider the USSD option [the user doesn't need to install anything] because my phone does not have space, and I want to keep my space for WhatsApp because it helps me reach many people. (Male, 19 years)

> [Using USSD] One can borrow a phone, use and return to the owner and the owner will not trace what you were doing with his phone. (Male, 15 years)

> It will be okay to use USSD, because of its confidentiality as it does not keep any trace of what you were searching and return to the phone owner. (Male, 16 years)

> That will be very good because even if I don't have a phone, I can get from my friend and ask my questions. So that will boost my access to information and no one will know who asked the questions. (Female, 15 years)

> It will be convenient to access sexual reproductive health information at home rather than visiting the

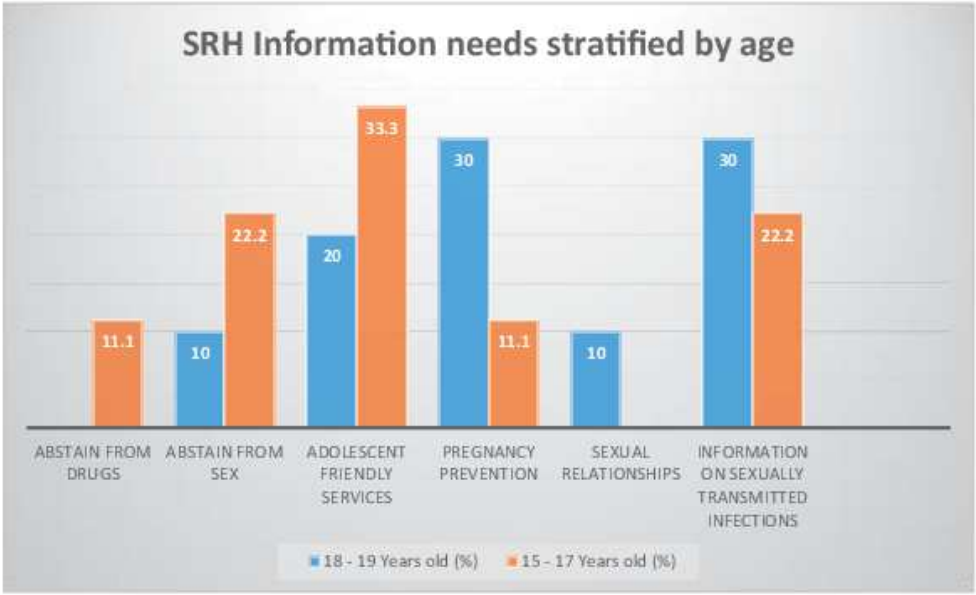

Figure 2. SRH information needs stratified by age.

adolescent friendly organizations situated in different parts of Kibra. (Female, 18 years)

Because of the convenience and ease-of-use of the USSD technology, most of the adolescents preferred USSD to provide SRH information. The USSD technology is interactive, can be provided without charge to the adolescents and works on both, feature phones and smartphones.

Sexual reproductive health information needs

The adolescent participants identified five SRH topics of interest about which they would need information segmented by gender. Information on abstinence, pregnancy prevention, sexual relationships, sexually transmitted infections and adolescent-friendly health services is needed. Stratified by age, the adolescents need up-to-date information on how to find adolescent-friendly services (33.3%), pregnancy prevention (30.0%) and sexually transmitted infections (30.0%) as shown on Figure 2.

The adolescents' information needs varied slightly by age and age. Girls above 18 years greatest need is information on sexual relationships, whereas girls 15–17 years old need information on how to abstain from sex. Boys above 18 years need information on sexually transmitted infections, whereas boys 15–17 years old need information on adolescent-friendly health services as shown on Figure 3.

Discussion

In this study we have documented current SRH information sources used by adolescents in Kibra, existing information gaps and how technology, including the internet, social media and mobile apps, provide access to information. This research was designed to determine adolescents' perspectives, the information they need and the challenges they face in accessing information.

It can be seen from our results that significant sources of adolescent SRH information were healthcare providers, parents, non-governmental organizations and the internet. The information sources accessed varied by age.

Healthcare providers are an important source of adolescent SRH information (Dittus et al., 2018). Although healthcare providers are considered knowledgeable and trustworthy, there are a number of barriers. Social norms, a taboo on adolescent SRH, concerns about confidentiality and the possibility of judgmental attitudes appear to hinder access to this source.

Parents are an important source of information for younger adolescents but this role diminishes with age when peers and others become preferred

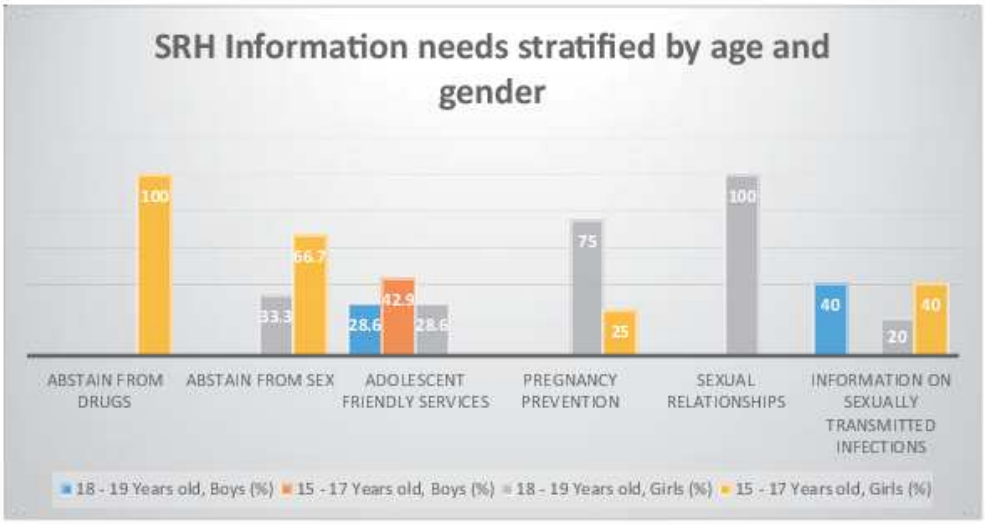

Figure 3. SRH information needs stratified by age and gender.

sources, as was determined in the study by Muhwezi et al (Muhwezi et al., 2015). Older adolescents have less communication about SRH issues with their parents, possibly due to decreasing levels of parental connectedness (Kusheta et al., 2019). Research shows that older adolescents prefer other sources of information, perhaps feeling their parents may not be as knowledgeable or detailed as alternative sources (Dessie et al., 2015).

A cross-sectional study by Dessie et al. has shown that delaying sex can improve adolescent sexual health outcomes (Eggers et al., 2017). Our study shows that adolescent girls are keen to abstain from sex to minimize the risk of sexually transmitted infections, early pregnancies and other effects of risky sexual behavior. Long-Middleton et al. have shown that reasons for abstinence vary from fear and lack of opportunity to beliefs and values (Long-Middleton et al., 2013). Alhassan and Dodoo found that fear of STIs and pregnancy can motivate adolescents to abstain from sex, as can religious conviction. Parental guidance is also an important factor in sexual abstinence (Alhassan & Dodoo, 2020).

Mirroring the findings of Kaneshiro and Salcedo (2015), the older adolescents in our study are keen to access services to prevent teenage pregnancies, which are mostly unwanted and unplanned, and negatively impact adolescents' lives (Kaneshiro & Salcedo, 2015). Knowledge and awareness of contraceptives among adolescents is affected by social norms and cultural gender roles (Capurchande et al., 2016). It is highly important to increase awareness and knowledge of available contraceptive options and services (Ganle et al., 2019), and contraceptive interventions need to be adapted to local culture and context (Lopez et al., 2016).

As this study shows, technology plays a role as a source of SRH information. Participants currently use the internet and social media but the adolescents felt that mobile phone technologies could improve access to accurate, reliable and on-demand information. USSD was the preferred mobile phone technology for disseminating information. This is a low-cost option that allows two-way communication. The mobile phone user dials a three to seven digit code based on the provider's service, which then connects to a two-way interactive communication referred to as a "session" (Google Patents, n.d.).

It is important to note that USSD is the only technology capable of operating in both feature phones and smartphones: WhatsApp, Facebook and Instagram, which could have broader penetration in other settings, only work on smartphones. The preference for USSD shows that many of the target population do not own a smartphone (Ipas, n.d.). A number of adolescents

in the study also indicated their devices did not have the space to install new phone apps.

USSD technology has already been used in a number of settings to provide and support healthcare interventions (Barjis et al., 2013; Osae-Larbi, 2016; Wang et al., 2008) and to provide public health information in resource-limited settings (Amoakoh et al., 2019). The technology enables a user to access an interactive user interface that is simple, user-driven and user-friendly. The content can also be customized to each setting and context.

Adolescents have an unmet need of adolescent-friendly healthcare facilities providing SRH services and information. This agrees with the findings by Ayehu et al. (2016) and Mutea et al. (2020), fear of being judged, breach of privacy and the taboo associated with adolescents seeking SRH services still persist. Information on pregnancy prevention is also needed by both, girls 15–17 years old and girls above 18 years. Our findings agree with those of Nash et al. (2019) regarding a higher burden on girls due to unplanned or unwanted pregnancies, girls need information on contraceptives or abstinence.

Adolescents, and especially girls 15–17 years, need information on how to abstain from drugs. None of the previously cited studies seem to have identified this need. The study participants felt that use of drugs seem to impair their judgment on SRH issues leading to bad outcomes. The adolescents requested to be provided with information on how identify drug use problems and provide referral pathway for any identified problems.

A technical paper by UNESCO in 2019 (UNESCO Brief, n.d.), found that adolescents aged 15–24 years searched online for SRH information on sexually transmitted infectious and sexual relationships among other related topics. These findings agree with our finding that information on sexually transmitted infections is needed by adolescents in this age group by both, boys and girls.

Conclusions

Healthcare providers and parents are important sources of information. Adolescents view healthcare providers as knowledgeable and expect them to offer user-friendly services. These services need constant review and improvement to meet adolescents' expectations. Parents need to continue to provide factual SRH information, as adolescents expect their parents to be able to offer reliable and trustworthy information to guide their decision making.

Interventions to increase awareness among adolescents about dangers relating to unprotected sex and drug use should be provided. User-friendly, on-demand information provided in an anonymous way could improve awareness and empower adolescents to make informed decisions, thereby improving their reproductive health outcomes. According to our participants, mobile phone apps have the potential to provide SRH information to adolescents.

Most of our participants favored the use of USSD. This technology works on any mobile phone, no installation is needed and no audit trail is left on the device, thereby enhancing confidentiality. The USSD service can be provided as a pre-paid service, which enables adolescents to access information without cost.

Acknowledgments

We would like to acknowledge the adolescent participants, their parents and guardians and the community mobilization team for their role in making the research a success.

Conflict of interest statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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5 Results: Usability Testing

In this results section, we present the app development and usability test outcomes. This work has now been published by the BMC Medical Research Methodology journal.

5.1 Mobile Phone App Development

We developed a mobile phone app prototype. A human-centered design (HCD) approach (section 1.7) guided the iterative process of the mobile app development. Using the previously identified adolescent sexual reproductive health information needs, content on abstinence, contraceptives, sexually-transmitted infections, sexual relationships and drug use was developed into a paper-based format. This content was then reviewed by 2 adolescent reproductive health experts for its accuracy, relevance, and age appropriateness for the targeted adolescent participants. The 2 experts were Dr. Irene Inwani and Prof. Ruth Nduati, researchers with many years of experience working in adolescent reproductive health in Kenya and co-investigators in this study.

The experts reviewed the structure and wording used to ensure information could easily be understood by adolescents. They also ensured that the content by age group was permissible by government policy. For example, it is illegal to provide information on contraceptives to anyone under 18 in Kenya, therefore information on abstinence was made available to participants under 18. Once the content had been reviewed and agreed upon it was customized into the Echomobile® platform, a telco service provider with presence in Kenya. This provider offers a cloud-based web platform capable of providing a USSD channel to automate personalized communications at scale.

5.2 Overview of Study Findings

The final paper-based version of the adolescent reproductive health content (Appendix 8) was programmed into the web-based interface provided by Echomobile® for the USSD platform. To open the app, users dialed a 7-digit code on a mobile phone, which then prompted them to input a pre-assigned PIN linked to their cellphone number. When the users were authenticated, they selected their gender and age on subsequent screens before selecting a sexual reproductive health topic of interest. The users then interacted with screen-by-screen content guided by their input. A selection of the mobile app interactive screens is shown on Figure 11. Adolescent users could select sexual reproductive health topics of interest and access information. Figure 12 shows how a user accessed content on sexual relationships.

For the alpha usability testing, participants were required to dial a 7-digit USSD code on either a feature phone or smartphone., The users were then taken through authentication and selection of gender and age. Table 3 shows the demographic characteristics of the adolescents who were successfully followed up and had used the app at least once during the 1-month period of alpha usability testing. The median age of participants was 15 years for the under 18 and 18 years for

the 18 and above group. All attended secondary school. Of the 38 adolescents enrolled, 12 were successfully followed up, only 9 had used the app at least once during the 1-month period. Only survey questions applicable to the USSD app were analyzed. Questions on app customization, sharing, app description on Playstore, buttons and icons were excluded.

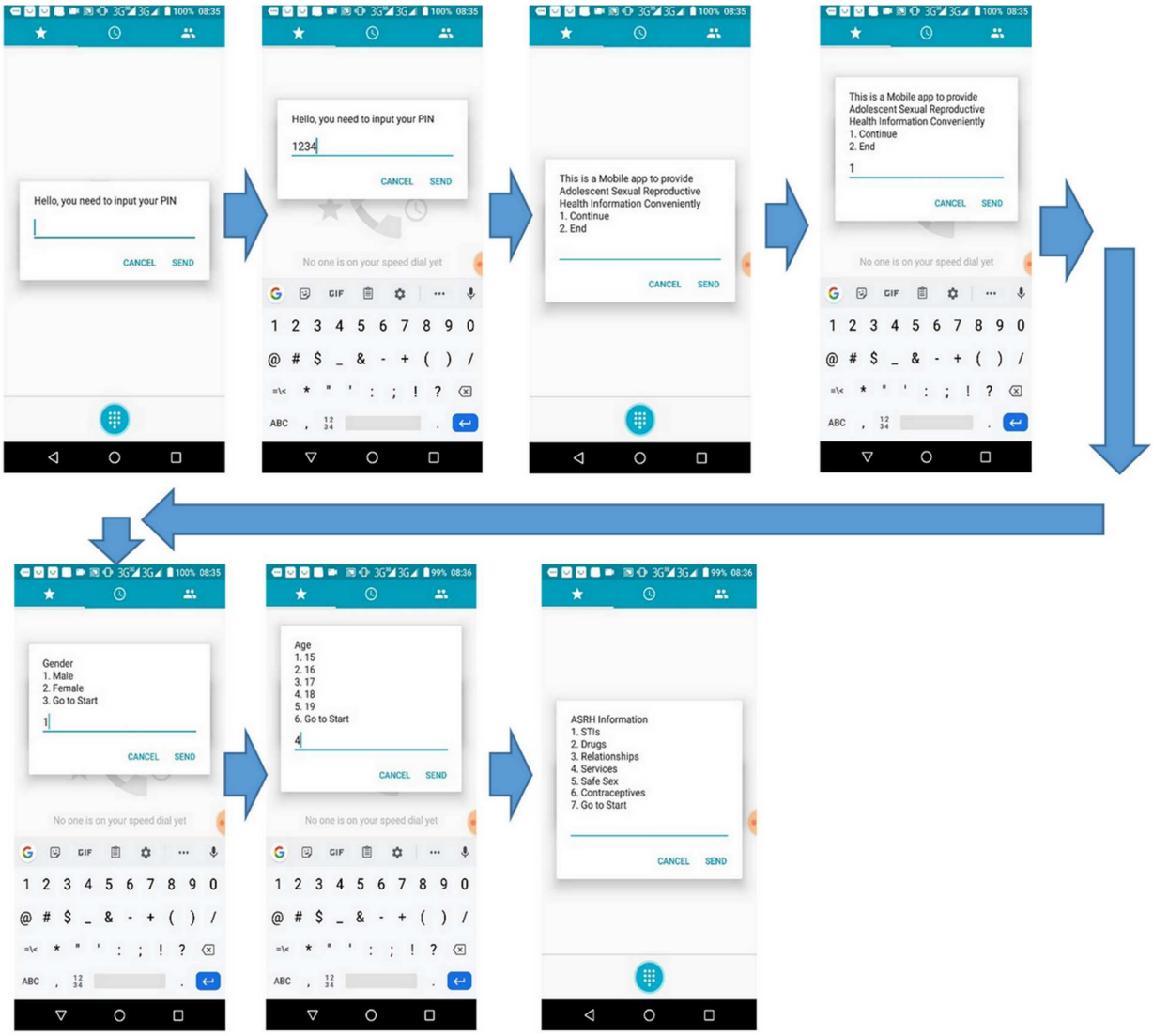

Figure 11: A flow chart diagram showing a step-by-step interaction of by a user connecting to the USSD app

Table 2: Demographic characteristics of participants who used the app during alpha usability testing

	Under 18 *n* (%)	**18 and above *n* (%)**	***p*-value**
Participants	7 (77.8)	2 (22.2)	
Age median, (SD) (Range)	15.0, (0.53) (15 – 16)	18.0, (0.00) (18 – 18)	0.029
Gender			
Male	3 (100)	0 (0)	0.777
Female	4 (66.7)	2 (33.3)	
Education			
Primary	0 (0)	0 (0)	0.096
Secondary	7 (77.8)	2 (22.2)	
College	0 (0)	0 (0)	
University	0 (0)	0 (0)	
Occupation			
Student	7 (77.8)	2 (22.2)	0.096
None	0 (0)	0 (0)	

Participants feedback during alpha usability testing on engagement, functionality, aesthetics, and quality of information provided by the mobile app is shown in Table 4. The MARS was scored 1 to 5 with 1 being the lowest score and 5 the highest. The highest scores were attained on engagement of the app with a mean score of 4.4, and functionality with a mean score of 4.3. The MARS consisted of 15 items and the value for Cronbach's Alpha for the survey was $\alpha = .83$. Under the aesthetics, information on layout, the "arrangement and size of buttons/icons" and graphics "the quality/resolution of graphics used for buttons/icons/menus/content" were excluded from the final analysis. The research team noted that these features were not applicable to the USSD app, the app contains no buttons, icons or graphics. Since no issues were identified during the alpha testing of the app, nothing was changed before the field testing.

Once the alpha usability test had been completed and performance of the app validated, field usability testing was carried out. Participants had to dial a 7-digit USSD code on either a feature phone or smartphone, before being taken through authentication and selection of gender and age. Once in the app, the users had a list of options to choose from based on their information needs. For the field testing, 146 adolescents were enrolled, 113 were followed-up, and 109 provided complete study data. Among these, 62 had used the app at least once in the 3-month period. The demographic characteristics of participants who used the app during the field usability testing are shown in Table 5. This p-values checked potential statistically significant difference in demographic characteristics between participants under 18 years and above 18 years. The mobile application rating scale scores for the field usability testing are shown in Table 6. Only survey questions applicable to a USSD app were analyzed. Questions on app customization, sharing, app description on Playstore, buttons and icons were excluded.

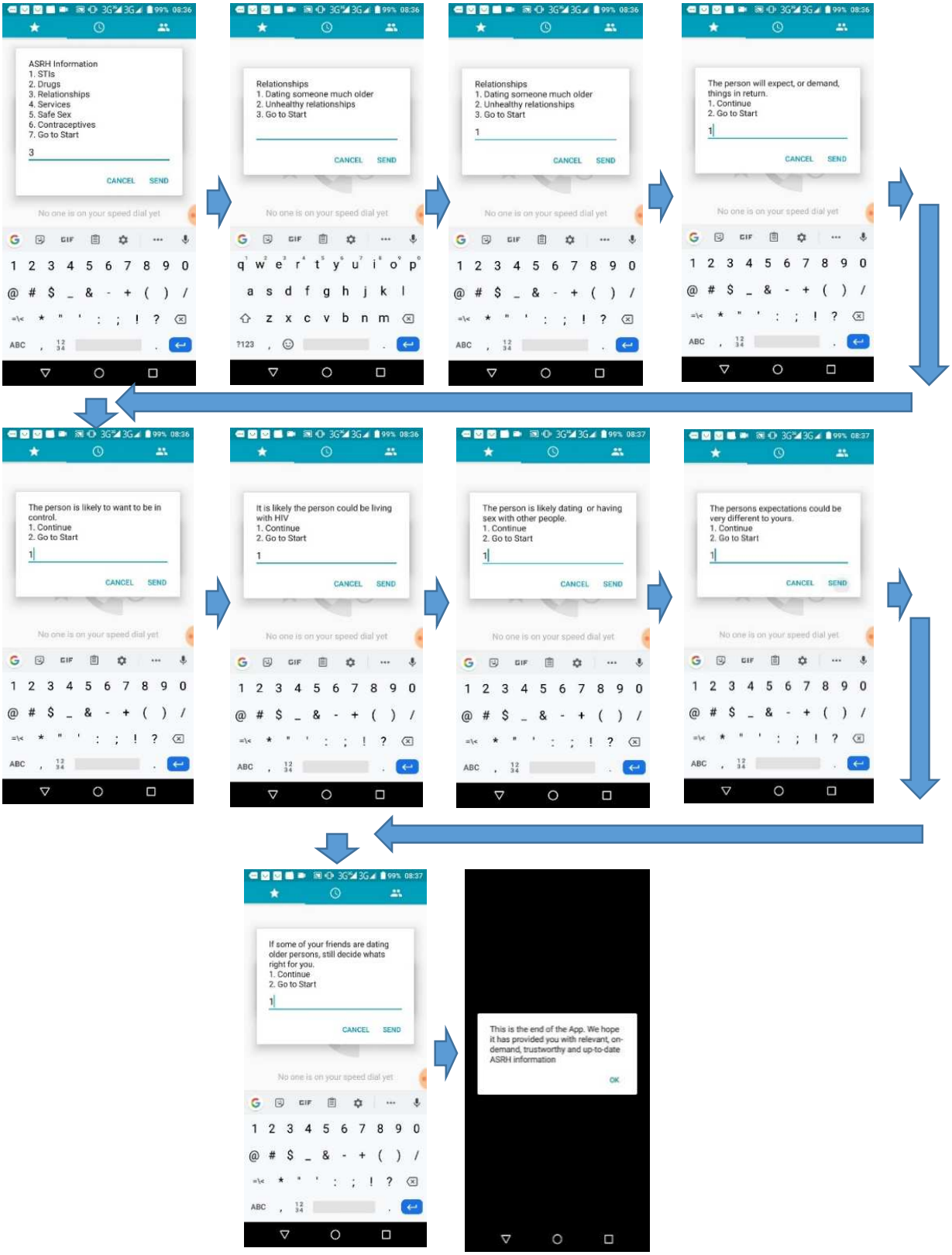

Figure 12: A step-by-step interaction by a user accessing information on sexual relationship on the USSD app

Table 3: Mobile application rating scale scores for the alpha usability testing

Mobile Application Rating Scale Score	**Mean (SD)** (Range)
Engagement	
Entertainment	4.1 (0.93) (2)
Interest	4.6 (1.00) (3)
Interactivity	4.2 (1.30) (4)
Target group	4.6 (0.73) (2)
Mean score	**4.4 (0.82) (2.7)**
Functionality score	
Performance	4.1 (1.27) (3)
Ease of use	3.8 (1.09) (4)
Navigation	4.8 (0.44) (1)
Gestural design	4.4 (0.73) (2)
Mean score	**4.3 (0.73) (2.3)**
Aesthetics score	
Visual appeal	3.3 (1.50) (4)
Mean score	**3.3 (1.50) (4)**
Information score	
Goals	4.0 (1.00) (2)
Quality of information	4.7 (0.70) (2)
Quantity of information	3.8 (1.30) (4)
Mean score	**4.1 (0.73) (2.4)**
App quality mean Score	**4.0 (0.74) (2.3)**

Table 4: Demographic characteristics of participants who used the app during field usability testing

	Below 18 *n* (%)	**18 and above *n* (%)**	***p*-value**
Participants	33 (53.2)	29 (46.8)	
Age (median, SD) (Range)	17.0, (0.79) (15 – 17)	18.0, (0.44) (18 – 19)	1.102
Gender			
Male	17 (56.7)	13 (43.3)	0.786
Female	16 (50.0)	16 (50.0)	
Education			
Primary	6 (85.7)	1 (14.3)	0.111
Secondary	26 (51.9)	28 (48.1)	
None	1 (100)	0 (0)	
University	0 (0)	0 (0)	
Occupation			
Student	32 (52.5)	29 (47.5)	1.000
None	1 (100)	0 (0)	

During the field usability testing, engagement of the app attained a mean score of 4.3 (0.44). The functionality mean score was 4.6 (0.38), with navigation and gestural design ratings within the functionality score attaining a mean score of 4.8 (0.43) and 4.8 (0.35) respectively. The overall mean score for information was 4.4 (0.31), with quantity of information attaining 4.6 (1.11) and quality of information 4.5 (0.71). The value for Cronbach's Alpha for the field testing was $\alpha = .54$. It is important to note that, 109 adolescents were successfully followed up after the 3-month period. However, only 62 had used the USSD app at least once. The usability testing interview was only administered to adolescent participants who had used the app at least once during the 3-month period. Table 7 shows participants' feedback on the app's characteristics. Only options selected by users are included in this table.

The adolescents found the app entertaining, with 43.6% (27) of the users indicating the app was fun to use. Most of the users, 70.9% (44), found the app very interesting. The adolescents deemed the app content to be appropriately directed, with 54.8% (34) users indicating it was perfectly targeted. Only 3.2% (2) of the users felt the content was not well targeted or inappropriate. On the accuracy of app features, 72.5% (45) of the adolescents felt the features were perfect and did not experience any bugs. The adolescents were able to learn how to use the app swiftly, with 72.6 % (45) finding this easy. Regarding the app's interaction, 85.5% (53) of the adolescents found the content consistent and intuitive across all screens.

Over 90% of the adolescents found the content provided in the app relevant to their sexual reproductive health needs. Gender differences were not significant. The content was comprehensive according to 87.1% (54) of the adolescents. Notably, at least one in every two participants, 54.8% (34), indicated they would recommend the app to other adolescents. The app was rated highly, with 72.6% (45) of users describing it as the 'best app' for providing adolescent sexual reproductive health information.

Table 5: Mobile application rating scale scores for the field usability testing

Mobile Application Rating Scale Score	Mean (SD) (Range)
Engagement	
Entertainment	3.8 (0.93) (4)
Interest	4.7 (0.46) (1)
Interactivity	4.0 (1.17) (4)
Target group	4.5 (0.56) (2)
Mean score	**4.3 (0.44) (1.7)**
Functionality score	
Performance	4.5 (0.97) (3)
Ease of use	4.2 (0.44) (1)
Navigation	4.8 (0.43) (2)
Gestural design	4.8 (0.35) (1)
Mean score	**4.6 (0.38) (1.7)**
Aesthetics score	
Visual appeal	4.3 (0.57) (2)
Mean score	**4.3 (0.57) (2)**
Information score	
Goals	4.1 (0.84) (2)
Quality of information	4.5 (0.71) (3)
Quantity of information	4.6 (1.11) (4)
Mean score	**4.4 (0.60) (2.3)**
App quality mean Score	**4.4 (0.31) (1.5)**

Although 45.2% (28) of users ‘strongly agreed’ the app could increase awareness of sexual reproductive health information, there were important gender differences within this category. While 66.7% (20) of male participants ‘agreed’ the app could increase awareness, less than half the female users, 43.7% (14), ‘agreed’. The majority of female participants, 56.3% (18), ‘strongly

agreed' the app could increase awareness. On increasing knowledge, 59.7% (37) of users 'agreed' the app was likely to increase knowledge on sexual reproductive health.

Table 6: User experience evaluation of the mobile application during field usability testing

App characteristics	All *n* (%)	Male *n* (%)	Female *n* (%)	*p*-value
Times used app - median (SD)	4 (9.9)	3 (8.1)	6 (10.9)	0.534
Is the app fun/entertaining to use?				
Dull	1 (1.6)	1 (3.3)	0 (0)	0.708
Fun enough to entertain user	27 (43.6)	12 (40.0)	15 (46.9)	
Moderately fun and entertaining	15 (24.2)	8 (26.7)	7 (21.8)	
Highly entertaining and fun	19 (30.6)	9 (30.0)	10 (31.3)	
Is the app interesting to use?				
Mostly uninteresting	1 (1.6)	0 (0)	1 (3.1)	0.4
Moderately interesting	17 (27.4)	10 (33.3)	7 (21.9)	
Very interesting	44 (71.0)	20 (66.7)	24 (75.0)	
Is the app content appropriate for you as an adolescent?				
Acceptable but not targeted. May be inappropriate/unclear/confusing	2 (3.2)	1 (3.4)	1 (3.1)	0.974
Well targeted, with negligible issues	26 (41.9)	13 (43.3)	13 (40.6)	
Perfectly targeted, no issues found	34 (54.9)	16 (53.3)	18 (56.3)	
How accurately do the app features and menus work?				
Some functions work, but lagging or contains major technical problems	5 (8.1)	3 (10.0)	2 (6.2)	0.953
App works overall. Some technical problems need fixing	6 (9.7)	3 (10.0)	3 (9.4)	
Mostly functional with minor/negligible problems	6 (9.7)	3 (10.0)	3 (9.4)	
Perfect/timely response; no technical bugs found	45 (72.5)	21 (70.0)	24 (75.0)	
How easy is it to learn how to use the app?				
Easy to learn how to use the app	45 (72.6)	21 (70.0)	24 (75.0)	0.876
Able to use app immediately; intuitive; simple	17 (27.4)	9 (30.0)	8 (25.0)	
Are interactions consistent and intuitive across all screens?				
Mostly consistent/intuitive with negligible problems	9 (14.5)	3 (10.0)	6 (18.7)	0.537
Perfectly consistent and intuitive	53 (85.5)	27 (90.0)	26 (81.3)	
Is app content correct, well written, and relevant to Adolescent Sexual Reproductive Health?				
Barely relevant	2 (3.2)	2 (6.7)	0 (0)	0.237
Moderately relevant	2 (3.2)	0 (0)	2 (6.2)	
Relevant	23 (37.1)	12 (40.0)	11 (34.4)	
Highly relevant, appropriate, coherent, and correct	35 (56.5)	16 (53.3)	19 (59.4)	

Is the content comprehensive and concise?				
Minimal Information	4 (6.5)	2 (6.7)	2 (6.3)	0.237
Insufficient	1 (1.6)	0 (0)	1 (3.1)	
OK but not comprehensive or concise	3 (4.8)	3 (10.0)	0 (0)	
Comprehensive and concise; contains links to more information and resources	54 (87.1)	25 (83.3)	29 (90.6)	
Would you recommend this app to people who might benefit from it?				
There are very few people I would recommend this app to	3 (4.8)	0 (0)	3 (9.4)	0.274
There are several people whom I would recommend it to	6 (9.7)	3 (10.0)	3 (9.4)	
There are many people I would recommend this app to	19 (30.7)	8 (26.7)	11 (34.4)	
I would recommend this app to everyone	34 (54.8)	19 (63.3)	15 (46.8)	
What is your overall rating of the app?				
Average	6 (9.7)	6 (20.0)	0 (0)	**0.011**
Above average	11 (17.7)	6 (20.0)	5 (15.6)	
Best app	45 (72.6)	18 (60.0)	27 (84.4)	
This app is likely to increase awareness of the importance of addressing Adolescent Sexual Reproductive Health?				
Agree	34 (54.8)	20 (66.7)	14 (43.7)	0.119
Strongly agree	28 (45.2)	10 (33.3)	18 (56.3)	
This app is likely to increase knowledge of Adolescent Sexual Reproductive Health?				
Neutral	1 (1.6)	1 (3.3)	0 (0)	0.262
Agree	37 (59.7)	20 (66.7)	17 (53.1)	
Strongly agree	24 (38.7)	9 (30.0)	15 (46.9)	
This app is likely to change attitudes toward improving Adolescent Sexual Reproductive Health?				
Agree	43(69.4)	20 (66.7)	23 (71.9)	0.866
Strongly agree	19 (30.6)	10 (33.3)	9 (28.1)	
This app is likely to increase intentions to address Adolescent Sexual Reproductive Health?				
Agree	44 (81.0)	21 (70.0)	23 (71.9)	1
Strongly agree	18 (29.0)	9 (30.0)	9 (28.1)	
Use of this app is likely to encourage further help seeking on Adolescent Sexual Reproductive Health?				
Disagree	1 (1.6)	1 (3.3)	0 (0)	0.418
Agree	41 (66.1)	18 (60.0)	23 (71.9)	
Strongly agree	20 (32.3)	11 (36.7)	9 (28.1)	
Use of this app is likely to reduce problems in Adolescent Sexual Reproductive Health?				
Agree	41 (66.1)	20 (66.7)	21 (65.6)	1
Strongly agree	21 (33.9)	10 (33.3)	11 (34.4)	

Users also felt that the app could change attitudes toward adolescent sexual reproductive health, with 69.4% (43) agreeing that a change in attitude would improve service provision and uptake. The app was envisioned to potentially increasing the uptake of interventions providing adolescent sexual reproductive health by 81.0% (44) of participants. On whether the app would encourage help-seeking behavior by adolescents on reproductive health issues, 66.1% (41) of participants agreed. A reduction in adolescent sexual reproductive health problems through use of the app was predicted by 66.1% (41) of participants.

A number of user experience evaluation components attained substantially different scores from male and female users. On the overall rating of the app, 72.6% (45) rated the app as the 'best app': of these, 84.4% (27) were female users compared to 60.0% (18) male, with a *p*-value=0.011. On the USSD app increasing awareness of addressing adolescent sexual reproductive health, 56.3% (18) of the female users 'strongly agreed' compared to 33.3% (10) male users. On the likelihood of the app increasing knowledge on sexual reproductive health, 46.9% (15) of female users 'strongly agreed', but only 30.0% (9) of male users.

5.3 Discussion

From a human-centered approach, we designed, developed and prototyped a USSD-based mobile app. Research has shown that adolescents want to be engaged in the design, development and prototyping of mobile apps that are used to monitor and manage their healthcare needs [139]. In this study, feedback from the adolescent participants was applied at every stage of the app development. The participants identified their sexual reproductive health information needs, alpha tested the initial app prototype and participated in field usability testing. Usability testing is a critical step in the development of an effective and engaging mobile app capable of impacting users' health outcomes [140]. As their information and design requests were considered, the participants found that the USSD app effectively provided sexual reproductive health information.

In our study, the users found the mobile app engaging and easy to navigate. The information provided was of high quality, age-group specific and in the right quantity. Feroz et al [141] found that mobile apps could be highly effective for providing adolescents with reproductive health information in resource-limited settings. This is due to the barriers adolescents face when accessing SRH services at the health facilities. Mobile app users in Feroz's study felt the intervention provided support and connectedness, especially if the app provided targeted communication containing new knowledge, reminders and/or suggestions about health issues [142]. Information provided by the USSD app in our study was found to be individualized, appropriate and relevant to the participants' sexual reproductive health information needs.

The participants may have found that the USSD app enhanced confidentiality, a feature that influences how an adolescent will access sexual reproductive health information. Healthcare workers may take on a policing role guided by their own or socially-sanctioned standards. Technology-based reproductive health information sources, including the internet, are adolescents preferred options [143], [144]. The USSD app enabled the adolescents to access

sexual reproductive health information in a confidential way. No audit trail was left on the mobile phone when the USSD sessions ended. Using the study mobile app, the adolescents could access information when needed/required without fear of being judged. It is important to note that there is no local installation, and no trace is kept in the phone after using the USSD app, any SRH information the adolescent accessed remains confidential improving the user's confidence in the app.

The USSD mobile phone app had content that was accurate and its functionality was free of technical problems. The app was easy to use and the content consistent and intuitive across all interaction screens. As Steinberg et al [145] showed, mobile phone apps designed to provide adolescents with information should have functionality features that improve user experience and enable users to search content by topic, making it easier to access the required information. The adolescents in our study found the USSD app easy to use and quickly learnt how the app worked, navigating through the content with ease.

Adolescent participants in the study found the USSD app effective for providing sexual reproductive health information. Guilamo-Ramos et al [146] showed that adolescent users are motivated to use technology-enabled access to reproductive health information due to its accessibility and wide coverage of topics that can be personalized to each user. The USSD app was deemed very appropriate to all the adolescents and could work toll-free on all types of phones. As the app met their sexual reproductive health information needs, the participants were prepared to recommend it to their peers.

The adolescents found the USSD app user-friendly. The USSD technology provides an interactive, user-friendly and simple tool for delivering health information using mobile phones. This technology has been used to build highly promising mobile phone-based clinical decision support systems for healthcare providers [136], USSD was also used to pilot a well-received mobile app enabling users to locate healthcare facilities in their vicinity [147].

As Canavarro et al [148] determined, girls bear the greatest burden when unable to access accurate and up-to-date reproductive health information. Adolescent pregnancy can lead to dropping out of school, early marriage and/or rejection by family members. This may explain why more female participants in this study deemed the USSD app the 'best app' (p-value = 0.011) than male participants. Female participants also 'strongly agreed' the USSD app could increase awareness and knowledge of adolescent sexual reproductive health issues.

Although there are few apps in Playstore and Appstore on adolescent reproductive health, they only work on Android or iOS smartphones. Many adolescents in resource-limited settings including Kenya and specifically Kibra, our study site location may not easily access smartphones. This was confirmed by our qualitative work [149] during the exploratory stages of gathering the adolescents' SRH information needs . USSD is a low cost application that works on both smartphones and feature phones was the option of choice by the adolescent participants.

In alpha usability testing, research has found that a sample of 10 participants is able to identify over 80% of issues with an application at alpha usability testing stage [150]. In our study, 9 of the 38 participants were successfully followed-up attaining 90% of the minimum requirements. Adolescent research studies face unique challenges on recruitment, retention and follow-up [151]. In our study, after the alpha usability testing, we requested the ethics review board to offer the adolescents a gift voucher on successful follow-up. During the field testing, 113 (75%) adolescents were successfully followed-up. Innovate approaches need to be continuously undertaken to improve retention in adolescent studies.

In our study we used the MARS for the usability testing, other studies have used the System Usability Scale (SUS) to measure the usability of mobile apps. The SUS is a 10-question tool used to measure subjective usability [152]. In one setting that evaluated the reliability of a translated SUS assessing mobile apps, the reliability test showed a Cronbach alpha value of .85 indicating the SUS is a reliable tool for usability assessment of mobile apps [153]. The MARS measures a significant number of mobile apps quality dimensions and has also been validated in more mhealth apps [154]. Usability testing has also been used to test mhealth apps for other health needs and conditions. In one study, usability testing was used to evaluate an mhealth app that provided information on how to manage chronic conditions to persons living with HIV. From the usability testing, the researchers were able to get useful feedback that made the mhealth app usable and ready for future efficacy testing [155]. In another study, usability testing evaluated mhealth apps in pediatric obesity. The findings of the study identified the importance of thorough evaluation and collection of evidence in mhealth apps for best practice [156].

5.4 Limitations

Although 62 adolescent participants used the app at least one during the 3-month period meeting the minimum sample required, the study findings could have had more confidence if all participants in the intervention group used the app. This study targeted adolescents that could access a mobile phone, adolescents not able to access a mobile phone were screened out. Further research could be carried out to find out how adolescents not able to access a mobile phone could access SRH information.

On participant selection, adolescents were mobilized from youth program venues where 15 to 19 year olds visited. Adolescents who did not visit these places were not enrolled creating a potential selection bias. Relating to the selection bias, what was identified as SRH information needed by the adolescents was based on the sample of adolescents enrolled. A subset of adolescents in Kibra that was not enrolled could have had different SRH information needs. Content provided in the USSD app may have been biased to the needs of enrolled participants. Studies exploring multiple participant mobilization strategies need to be explored to ensure all adolescent get a chance to participate in research studies thus informing interventions.

Although the USSD technology works on feature phones, most feature phone devices have smaller display screens. Adolescents using feature phones may have faced challenges of being able to view the information displayed on their screens. One way we attempted to address this

was to keep the statements short and precise. The most effective solution to this limitation is for the adolescents to use a device with a larger display screen.

5.5 Conclusions

Adolescents need information on sexual reproductive health, they also want to be meaningfully involved in the design and development process of interventions intended to meet their SRH information needs. Being involved at every stage of the app design and development in this study, participants found both the content and USSD app very appropriate. The USSD app worked on their feature phones and they could access the services toll-free. Their privacy was protected by the absence of an audit trail.

The USSD mobile phone technology is ideal for resource-limited settings, as users in these areas may only be able to access feature phones, have to share a phone and/or be unable to pay for services. The USSD technology works seamlessly on both feature phones and smartphones. No information is saved on the phone when using USSD, thus maintaining confidentiality even on shared phones. The service can be pre-paid by the provider. For future work, with availability of resources, we aim to scale-up prototyping and testing the mobile app with adolescents in different parts of Kenya and the Africa region. Expanding the USSD-based technology providing SRH information to adolescents living in underprivileged settings could have positive life-long impact on the adolescents' reproductive health.

5.6 Publication

Macharia *et al.*
BMC Medical Research Methodology (2022) 22:213
https://doi.org/10.1186/s12874-022-01689-4

BMC Medical Research Methodology

RESEARCH Open Access

Developing an Unstructured Supplementary Service Data-based mobile phone app to provide adolescents with sexual reproductive health information: a human-centered design approach

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Abstract

Background: Adolescent pregnancies and sexually-transmitted infections continue to impact 15 – 19-year-olds across the globe. The lack of sexual reproductive health information (SRH) in resource-limited settings due to cultural and societal attitudes towards adolescent SRH could be contributing to the negative outcomes. Innovative approaches, including mobile phone technologies, are needed to address the need for reliable adolescent SRH information.

Objective: The study aimed to co-design a Unstructured Supplementary Service Data (USSD) based mobile app prototype to provide confidential adolescent SRH information on-demand and evaluate the mobile app's usability and user experience.

Methods: A human-centered design methodology was applied. This practice framework allowed the perspectives and feedback of adolescent users to be included in the iterative design process. To participate, an adolescent must have been 15 to 19 years old, resided in Kibra and would be able to access a mobile phone. Adolescents were enrolled for the alpha and field testing of the app prototype at different time-points. The Mobile Application Rating Scale (MARS) a multidimensional mobile phone evaluation tool was used to access the functionality, engagement, aesthetics and quality of information in the app. Responses from the MARS were reported as mean scores for each category and a mean of the aggregate scores making the app's quality score. The MARS data was also evaluated as categorical data, A Chi square test of independence was carried out to show significance of any observed differences using cumulative and inverse cumulative distribution functions.

Results: During the usability test, 62/109 (54.9%) of the adolescents that were followed-up had used the app at least once, 30/62 (48.4%) of these were male participants and 32/62 (51.6%) female. On engagement, the app had a mean score of 4.3/5 (SD 0.44), 4.6/5 (SD 0.38) on functionality, 4.3/5 (SD 0.57) on aesthetics and 4.4/5 (SD 0.60) on the quality of information. The overall app quality mean score was 4.4/5 (SD 0.31). The app was described as 'very interesting' to use by 44/62 (70.9%) of the participants, 20/44 males and 24/44 females. The content was deemed to be either

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'perfectly' or 'well targeted' on sexual reproductive health by 60/62 (96.7%) adolescents, and the app was rated 'best app' by 45/62 (72.6%) adolescents, 27/45 females and 18/45 males, with a *p*-value = 0.011.

Conclusions: Adolescents need on-demand, accurate and trusted SRH information. A mobile phone app is a feasible and acceptable way to deliver adolescent SRH information in resource-limited settings. The USSD mobile phone technology shows promise in the delivery of much needed adolescent SRH information on-demand..

Keywords: Adolescent health, Reproductive health, Mobile phones, Human-centered design

Introduction

Adolescent pregnancies continue to negatively impact girls across the globe, with around 12 million girls aged 15 – 19 years giving birth annually in the developing world [1]. Information on sexual reproductive health [2] and contraception is lacking in majority of resource-limited settings [3]. Although girls bear the most significant impact, boys also lack information and services on reproductive health. Inability to access reproductive health information and services may be a contributing factor to unwanted pregnancies and sexually-transmitted infections among adolescents [4].

The World Health Organization (WHO) considers adolescent pregnancy a public health concern due to its impact on the health of both newborn and mother [5, 6]. In a number of countries, complications arising from giving birth as an adolescent are a leading cause of death [7]. Sexually-transmitted infections among adolescents are increasing, despite the mounting burden on health systems, there has been little research into effective prevention and treatment strategies [8]. Due to the high levels of sexually-transmitted infections among adolescents, there is a need to develop and customize information and educational resources to provide relevant, accessible and up-to-date sexual reproductive health information [9].

Many adolescents access sexual reproductive health information from their peers, parents and technology-based sources, including the social media and internet [10]. Choice of information sources on reproductive health has been found to have a substantial impact on adolescent health outcomes. The large number of unwanted pregnancies, sexually-transmitted infections and mental health related issues indicate current sources don't meet the adolescents' information needs [11]. Research has shown that adolescents prefer evidence-based information on sexual reproductive health delivered through innovative approaches. The information should be targeted and adapted to the adolescents' norms and context [12].

To show how important adolescent reproductive health is as a public health issue, the world health organization (WHO) in 2018 launched a document entitled "WHO recommendations on adolescent sexual and reproductive health and rights". The document aimed to "provide an overview of sexual and reproductive health and rights issues that may be important for the human rights, health and well-being of adolescents (aged 10–19 years) and the relevant WHO guidelines on how to address them in an easily accessible, user-friendly format".

The human-centered design (HCD) methodology is "an approach to interactive systems development that aims to make systems usable and useful by focusing on the users" [13]. In recent years, the HCD approach to the design of social innovations in global health is on the increase. This is due to the approach focusing on empathy and context in the ideation and iterative design of a health intervention [14]. The HCD lifecycle emphasizes the need to develop a product that meets the needs of the envisioned users [15]. As research shows [16], applying the HCD methodology in the design and development of an mhealth intervention is very important. In our study, three phases of the HCD methodology were applied namely; gathering user needs, content review by subject experts and carrying out alpha and field testing of the app.

In our formative qualitative study to gather the adolescents SRH information needs [17], we identified their current sources, limitations of these sources and the potential role of mobile phone technologies could play in meeting their SRH information needs. Adolescents need information on adolescent-friendly services, sexually-transmitted infections, contraceptives, sexual relationships, abstinence, and drug use. Among mobile phone technologies, the adolescents prefer a technology that enhances privacy, is toll-free, provides information on demand, and works on both feature phones and smartphones [18–20]. The Unstructured Supplementary Service Data (USSD) technology met the adolescents' user requirement. The technology works in both feature phones and smartphones, nothing is saved on the phone enhancing confidentiality. No installation was required and the services could be provided toll-free.

The USSD is a mobile phone technology that has a similar format to short message services (SMSs). However, USSD offers a messaging service that doesn't save any data on the user's device [21]. Already, the USSD technology has been used to enable healthcare workers interact with patients on-demand. For example, in Zimbabwe

a resource-limited setting, the USSD technology was used to provide health tips to the general public [22]. In Uganda, the USSD technology was used for health data reporting enhancing accuracy, timeliness and completeness of healthcare data [23].

In this study we aimed to co-design and develop a mobile app prototype to provide adolescents with confidential reproductive health information on demand and evaluate its usability and user experience. The study was guided by a human-centered design approach.

Materials and methods

Mobile phone technology development

A mobile phone app prototype was developed. A human-centered design (HCD) approach guided the iterative process of the mobile app development. The HCD approach is a practice framework that allows users' perspectives and feedback to be included in the design, development and prototyping of a health intervention [24].

Using the previously identified adolescent sexual reproductive health information needs, content on abstinence, contraceptives, sexually-transmitted infections, sexual relationships and drug use was developed into a paper-based format. This content was then reviewed by 2 adolescent reproductive health experts for its accuracy, relevance, and age appropriateness for the targeted adolescent participants. The 2 experts were I.I. and R.N., researchers with many years of experience working in adolescent reproductive health in Kenya and co-investigators in this study.

The experts reviewed the structure and wording used to ensure information could easily be understood by adolescents. They also ensured that the content by age group was permissible by government policy. For example, it is illegal to provide information on contraceptives to anyone under 18 in Kenya, therefore information on abstinence was made available to participants under 18.

Once the content had been reviewed and agreed upon it was customized into the Echomobile® platform, a telco service provider with presence in Kenya. This provider offers a cloud-based web platform capable of providing a USSD channel to automate personalized communications at scale. The USSD technology is a mobile phone standard that runs on feature phones and smartphones running Android or iOS operating system without any installation, technical development or customization. Only the SRH content was reviewed by content experts and then customized to the USSD platform. On the USSD platform, nothing is saved on the device, all interaction is saved on a backend Echomobile® server. On the other hand, USSD apps can work in Android and iOS and feature phones without installation. However, it is important to note, that Android and iOS are very rare in the target population.

Study design

A prospective research study design was used to evaluate the usability and user experience of the mobile app prototype. The study was a two-step process: alpha testing and field usability testing. The recruitment, inclusion, exclusion criteria and mobile app access for these two processes is presented in the following sections.

Participant recruitment

Adolescents were mobilized from the 12 villages in Kibra by two community workers with experience working in youth programs in the area. Kibra is a suburb in the city of Nairobi Kenya with an estimated population of 2.5 million residents. Inter-village ethnic differences exist related to historical, migration and settlement trends. The mobilization targeted events, venues, sport events and other youth programs in the community that attracted 15 – 19-year-olds. Study procedures were explained to all potential participants using a recruitment script, individually or in small groups. Adolescents showing an interest in the study were referred to the recruitment site for screening and potential enrollment. During the alpha testing, all the 38 adolescents mobilized to the study met the eligibility criteria and were enrolled. For the field testing, a total of 305 adolescents were screened and 300 met the eligibility and were enrolled. The Kenya adolescent reproductive health and development policy implementation assessment report projected adolescents aged 15–19 years accessing SRH services to be about 8%. The 8% was used for sample calculation. The sample of 300 was 74 participants more than the minimum sample calculation so that sample strength was still achieved if there was loss to follow-up. For the 300 enrolled, 146 were randomized to use the mobile app for a 3-month period. The adolescents in the intervention group accessed SRH information on the mobile app prototype, nothing was provided to adolescents in the control group. Figure 1 below shows participant enrollment for the field testing.

Inclusion and exclusion criteria

To be eligible an adolescent must: 1) have lived in Kibra for at least 3 months; 2) be aged between 15 – 19 years; 3) be willing to take part in the study; and 4) have access to a feature phone or smartphone. Based on the adolescent's age, a written assent or consent was obtained from each participant before study procedures were administered. Both boys and girls meeting the inclusion criteria participated in the study.

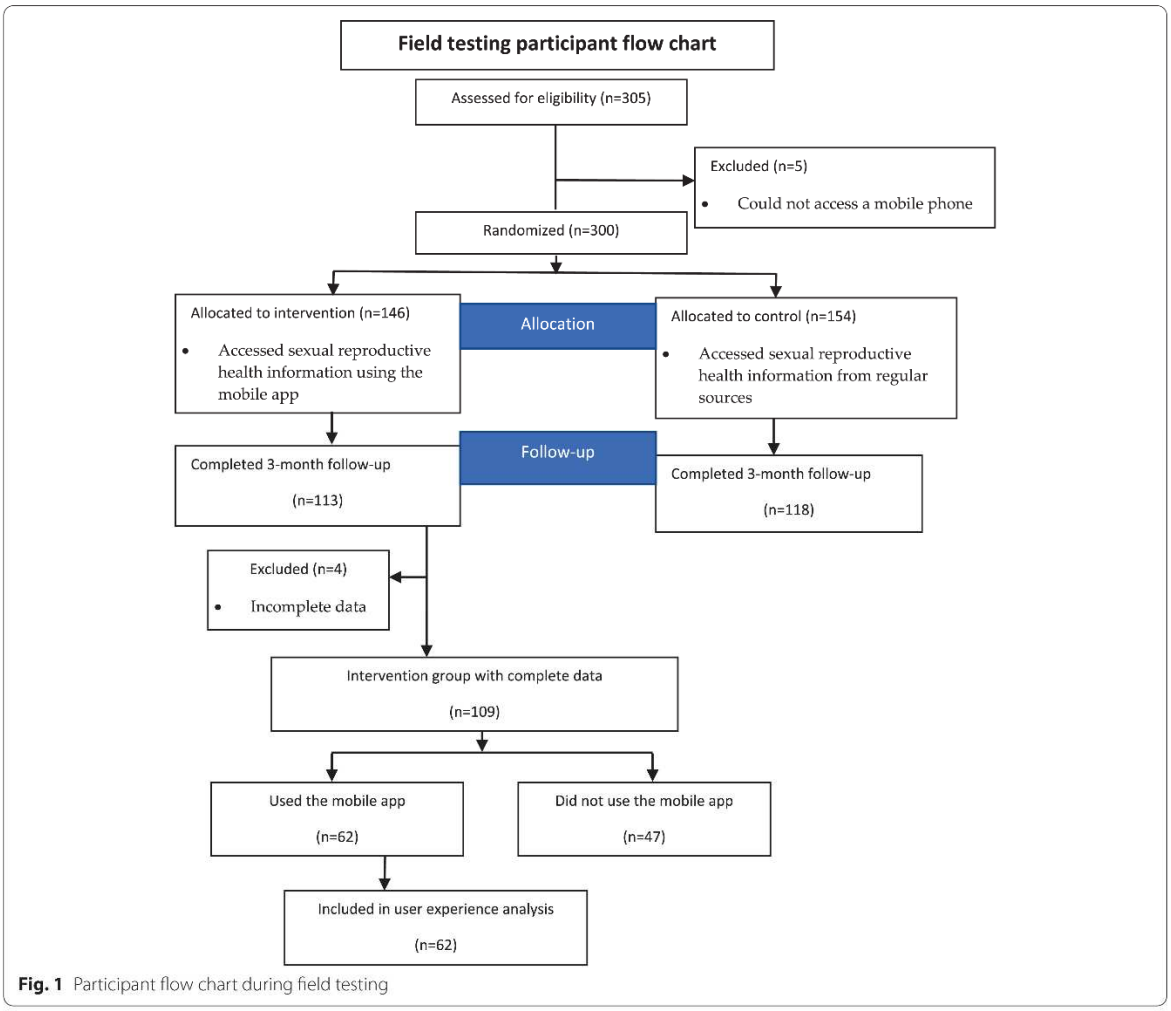

Fig. 1 Participant flow chart during field testing

Mobile app access

During both the alpha and field testing, study staff created an account and a user PIN in the USSD app for each participant. Interaction with the USSD app was demonstrated to each adolescent for 5 to 10 min to increase familiarity and understanding of how the app works. Participants could contact the study team through the community mobilizers if they misplaced their PIN or needed any other help using the app. Each participant was offered the phone number of the community mobilizers to call in case they needed guidance on using the USSD app. The USSD app offered a text-based interactivity on the users' phone. The app also provided contact details of adolescent-friendly healthcare facilities in the Kibra locality so that the adolescent participants could interact with subject experts if they so wished. A video of the USSD app can be availed on request. During the study's formative stage of gathering user needs, the adolescents indicated they preferred the USSD app content presented in English. The English language is one of the two official languages in Kenya and is taught and used in school for communication.

To access the USSD app, the adolescent participants dialed a 7-digit USSD code on a mobile phone. After dialing the code, the adolescent user was prompted to key-in their user PIN. If the PIN was authenticated, then the user could now access the SRH information. Adolescents could access the USSD app from any location as long as they had their user PIN and their registered mobile phone number on the mobile phone device in use.

Alpha testing

Initially, 38 participants were recruited for alpha usability testing in the first week of April 2019. Participants were

then followed-up at the end of April 2019. A recruitment script was used to explain the study procedures and potential benefits to the adolescents. The alpha usability test, a low-fidelity prototyping of the app [25] was guided by a customized mobile application rating scale (MARS) (Additional file 1: Appendix B). In one published work, the MARS demonstrated excellent internal consistency ($\alpha = 0.90$) and interrater reliability intra-class correlation coefficient ($\alpha = 0.79$) [26]. The study team customization only included rephrasing questions to relate to the USSD app and adolescent reproductive health.

The alpha testing evaluated the apps functionality and information content, as well as the usability and user experience of the app. The enrolled participants accessed the app for one month to generate enough data for the alpha usability testing. The MARS was administered at the end of the one month of use.

Field usability testing

After the app had passed the alpha testing a field usability test was carried out. 109 participants in the intervention group were successfully followed-up, only 62 adolescents had used the app at least once over a 3-month period. Adolescent participants included in the final analysis were the 62 who had used to app. The adolescent participants were enrolled in October 2019 and followed up in December 2019 and January 2020. The field usability testing evaluated the success of the app in providing correct, relevant, and on-demand information, and its usability and user experience. At enrollment, a recruitment script was used to explain the study procedures and potential benefits to the adolescents.

Potential participants were enthusiastic that the mobile phone app would provide accurate, up-to-date information on sexual reproductive health. Each eligible adolescent provided a cellphone number for either their own phone or that of a parent, guardian, or sibling. A customized MARS (Additional file 1: Appendix B) was used at the end of the 3-month period to evaluate the app. Adolescent participants in the alpha testing were eligible for the field testing. To minimize bias, participants were randomly assigned to either using the app or the control group.

Statistical analysis

Data was analyzed using R software version 3.6.2 [27]. Descriptive statistics were applied to the participant characteristics, mobile application rating scale and user experience evaluation. For application rating scale scores, standard deviation was used to measure the spread. A Chi square test of independence was carried out on the user experience evaluation outcomes. The Chi square test, a non-parametric test is able to provide information on how each group of participants performs. The test shows significance of any observed differences and the categories account for any differences found [28]. The Chi square test of independence was deemed to be the most appropriate for our study. The p-value calculation in the study used cumulative distribution functions and inverse cumulative distribution functions [29]. A p-value of < 0.05 was deemed to be statistically significant. A Cronbach alpha test [30] was used to provide a measure of the internal consistency of the MARS during the alpha and field testing.

Results

The USSD Mobile Phone App

The final paper-based version of the adolescent reproductive health content (Additional file 1: Appendix A) was programmed into the web-based interface provided by Echomobile® for the USSD platform.

To open the app, users dialed a 7-digit code on a mobile phone, which then prompted them to input a pre-assigned PIN linked to their cellphone number. When the users were authenticated, they selected their gender and age on subsequent screens before selecting a sexual reproductive health topic of interest. The users then interacted with screen-by-screen content guided by their input. A selection of the mobile app interactive screens is shown on Fig. 2.

Adolescent users could select sexual reproductive health topics of interest and access information. Figure 3 shows how a user accessed content on sexual relationships.

Alpha Testing

For the alpha testing, participants were required to dial a 7-digit USSD code on either a feature phone or smartphone., The users were then taken through authentication and selection of gender and age. Table 1 shows the demographic characteristics of the adolescents who were successfully followed up and had used the app at least once during the 1-month period of alpha usability testing. The median age of participants was 15 years for the under 18 and 18 years for the 18 and above group. All attended secondary school. Of the 38 adolescents enrolled, 12 were successfully followed up, only 9 had used the app at least once during the 1-month period. Only survey questions applicable to the USSD app were analyzed. Questions on app customization, sharing, app description on Playstore, buttons and icons were excluded.

Participants feedback on engagement, functionality, aesthetics, and quality of information provided by the mobile app is shown in Table 2. The MARS was scored 1 to 5 with 1 being the lowest score and 5 the highest. The highest scores were attained on engagement of the

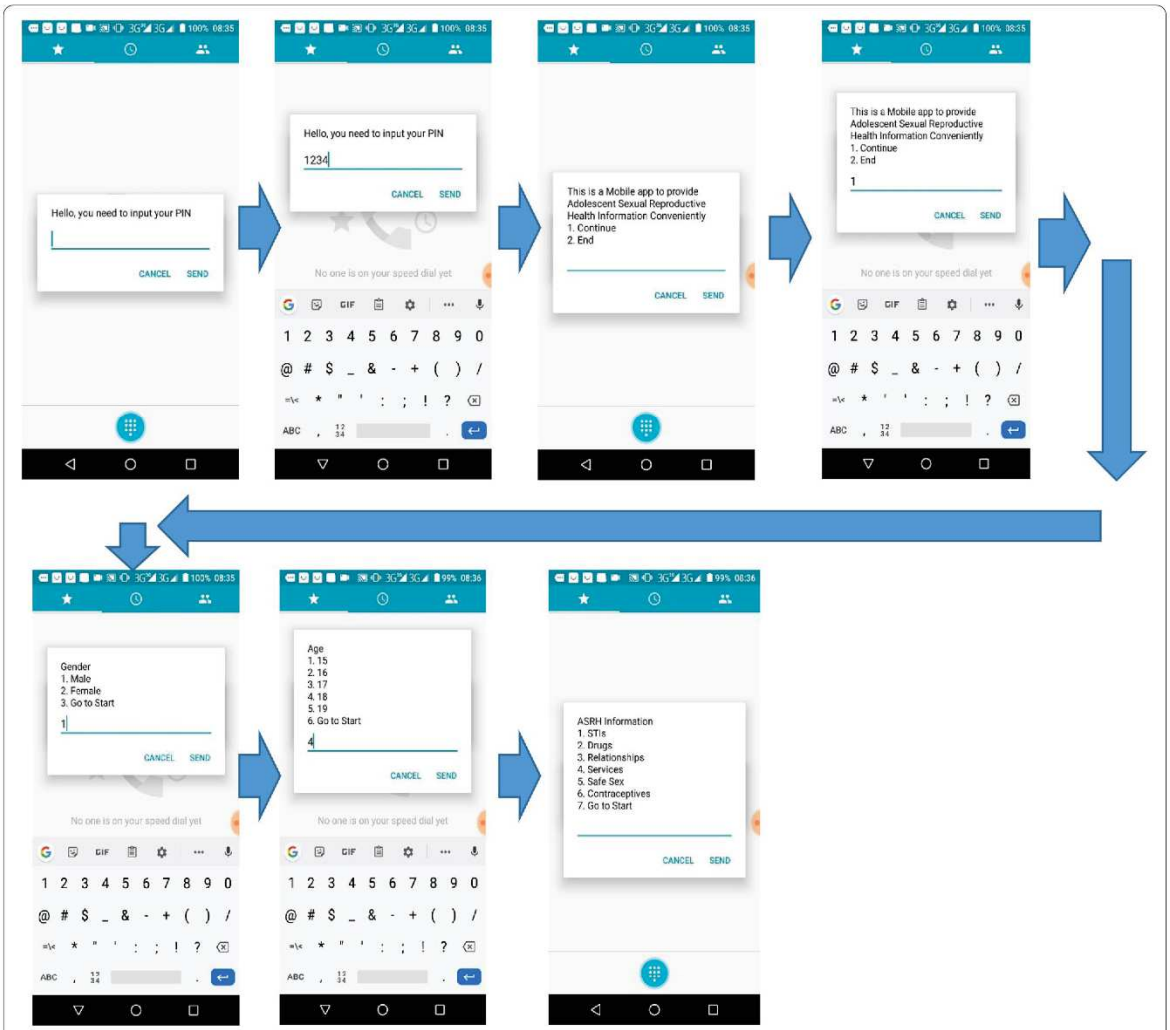

Fig. 2 Connecting to the USSD app

app with a mean score of 4.4, and functionality with a mean score of 4.3. The MARS consisted of 15 items and the value for Cronbach's Alpha for the survey was $\alpha = 0.83$.

Under the aesthetics, information on layout, the "arrangement and size of buttons/icons" and graphics "the quality/resolution of graphics used for buttons/icons/menus/content" were excluded from the final analysis. The research team noted that these features were not applicable to the USSD app, the app contains no buttons, icons or graphics. Since no issues were identified during the alpha testing of the app, nothing was changed before the field testing.

Field Usability Testing

Once the alpha usability test had been completed and performance of the app validated, field usability testing was carried out. Participants had to dial a 7-digit USSD code on either a feature phone or smartphone, before being taken through authentication and selection of gender and age. Once in the app, the users had a list of options to choose from based on their information needs. For the field testing, 146 adolescents were enrolled, 113 were followed-up, and 109 provided complete study data. Among these, 62 had used the app at least once in the 3-month period. The demographic characteristics of participants who used the app during the field usability testing are shown in Table 3. This p-values checked potential

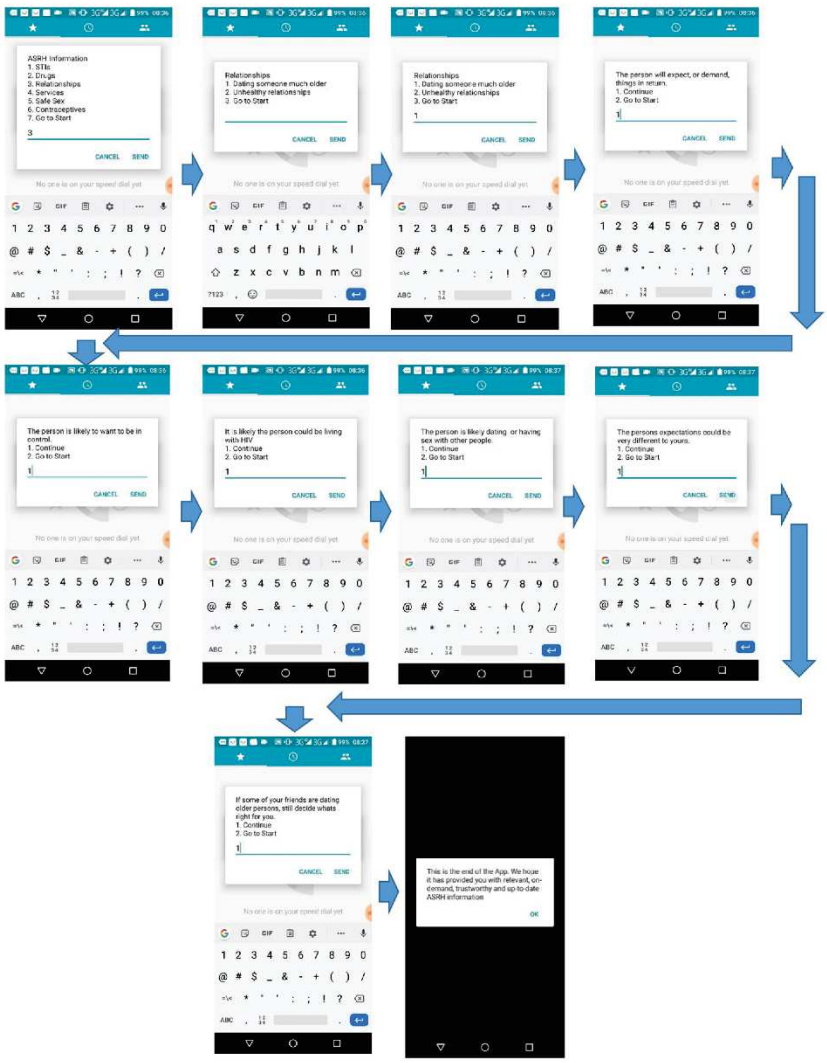

Fig. 3 Accessing specific sexual reproductive health information in the USSD app

statistically significant difference in demographic characteristics between participants under 18 years and above 18 years. The mobile application rating scale scores for the field usability testing are shown in Table 4. Only survey questions applicable to a USSD app were analyzed. Questions on app customization, sharing, app description on Playstore, buttons and icons were excluded.

During the field usability testing, engagement of the app attained a mean score of 4.3 (0.44). The functionality mean score was 4.6 (0.38), with navigation and gestural design ratings within the functionality score attaining a mean score of 4.8 (0.43) and 4.8 (0.35) respectively. The overall mean score for information was 4.4 (0.31), with quantity of information attaining 4.6 (1.11) and quality of information 4.5 (0.71). The value for Cronbach's Alpha for the field testing was $\alpha = 0.54$. It is important to note that, 109 adolescents were successfully followed up after the 3-month period. However, only 62 had used the USSD app at least once. The usability testing interview was only administered to adolescent participants who had used the app at least once during the 3-month period. Table 5 shows participants feedback on the app's characteristics. Only options selected by users are included in this table.

Table 1 Demographic characteristics of alpha testing participants who used the app

	Under 18 *n* (%)	18 and above *n* (%)	*p*-value
Participants	7 (77.8)	2 (22.2)	
Age median, (SD) (Range)	15.0, (0.53) (15 – 16)	18.0, (0.00) (18 – 18)	0.029
Gender			
Male	3 (100)	0 (0)	0.777
Female	4 (66.7)	2 (33.3)	
Education			
Primary	0 (0)	0 (0)	0.096
Secondary	7 (77.8)	2 (22.2)	
College	0 (0)	0 (0)	
University	0 (0)	0 (0)	
Occupation			
Student	7 (77.8)	2 (22.2)	0.096
None	0 (0)	0 (0)	

Table 2 Mobile application rating scale scores for the alpha testing

Mobile Application Rating Scale Score	Mean (SD) (Range)
Engagement	
Entertainment	4.1 (0.93) (2)
Interest	4.6 (1.00) (3)
Interactivity	4.2 (1.30) (4)
Target group	4.6 (0.73) (2)
Mean score	**4.4 (0.82) (2.7)**
Functionality score	
Performance	4.1 (1.27) (3)
Ease of use	3.8 (1.09) (4)
Navigation	4.8 (0.44) (1)
Gestural design	4.4 (0.73) (2)
Mean score	**4.3 (0.73) (2.3)**
Aesthetics score	
Visual appeal	3.3 (1.50) (4)
Mean score	**3.3 (1.50) (4)**
Information score	
Goals	4.0 (1.00) (2)
Quality of information	4.7 (0.70) (2)
Quantity of information	3.8 (1.30) (4)
Mean score	**4.1 (0.73) (2.4)**
App quality mean Score	**4.0 (0.74) (2.3)**

The adolescents found the app entertaining, with 43.6% (27) of the users indicating the app was fun to use. Most of the users, 70.9% (44), found the app very interesting. The adolescents deemed the app content to be appropriately directed, with 54.8% (34) users indicating it was perfectly targeted. Only 3.2% (2) of the users felt the content was not well targeted or inappropriate.

On the accuracy of app features, 72.5% (45) of the adolescents felt the features were perfect and did not experience any bugs. The adolescents were able to learn how to use the app swiftly, with 72.6% (45) finding this easy. Regarding the app's interaction, 85.5% (53) of the adolescents found the content consistent and intuitive across all screens.

Over 90% of the adolescents found the content provided in the app relevant to their sexual reproductive health needs. Gender differences were not significant. The content was comprehensive according to 87.1% (54) of the adolescents. Notably, at least one in every two participants, 54.8% (34), indicated they would recommend the app to other adolescents. The app was rated highly, with 72.6% (45) of users describing it as the 'best app' for providing adolescent sexual reproductive health information.

Although 45.2% (28) of users 'strongly agreed' the app could increase awareness of sexual reproductive health information, there were important gender differences within this category. While 66.7% (20) of male participants 'agreed' the app could increase awareness, less than half the female users, 43.7% (14), 'agreed'. The majority of female participants, 56.3% (18), 'strongly agreed' the app could increase awareness. On increasing knowledge, 59.7% (37) of users 'agreed' the app was likely to increase knowledge on sexual reproductive health.

Users also felt that the app could change attitudes toward adolescent sexual reproductive health, with 69.4% (43) agreeing that a change in attitude would improve service provision and uptake. The app was envisioned to potentially increasing the uptake of interventions providing adolescent sexual reproductive health by 81.0% (44) of participants. On whether the app would encourage help-seeking behavior by adolescents on reproductive health issues, 66.1% (41) of participants agreed. A reduction in adolescent sexual reproductive health problems

Table 3 Demographic characteristics of field testing participants who used the app

	Below 18 *n* (%)	18 and above *n* (%)	*p*-value
Participants	33 (53.2)	29 (46.8)	
Age (median, SD) (Range)	17.0, (0.79) (15 – 17)	18.0, (0.44) (18 – 19)	1.102
Gender			
Male	17 (56.7)	13 (43.3)	0.786
Female	16 (50.0)	16 (50.0)	
Education			
Primary	6 (85.7)	1 (14.3)	0.111
Secondary	26 (51.9)	28 (48.1)	
None	1 (100)	0 (0)	
University	0 (0)	0 (0)	
Occupation			
Student	32 (52.5)	29 (47.5)	1.000
None	1 (100)	0 (0)	

through use of the app was predicted by 66.1% (41) of participants.

A number of user experience evaluation components attained substantially different scores from male and female users. On the overall rating of the app, 72.6% (45) rated the app as the 'best app': of these, 84.4% (27) were female users compared to 60.0% (18) male, with a p-value = 0.011. On the USSD app increasing awareness of addressing adolescent sexual reproductive health, 56.3% (18) of the female users 'strongly agreed' compared to 33.3% (10) male users. On the likelihood of the app increasing knowledge on sexual reproductive health, 46.9% (15) of female users 'strongly agreed', but only 30.0% (9) of male users.

Discussion

From a human-centered approach, we designed, developed and prototyped a USSD-based mobile app. Research has shown that adolescents want to be engaged in the design, development and prototyping of mobile apps that are used to monitor and manage their healthcare needs [31]. In this study, feedback from the adolescent participants was applied at every stage of the app development. The participants identified their sexual reproductive health information needs, alpha tested the initial app prototype and participated in field usability testing. Usability testing is a critical step in the development of an effective and engaging mobile app capable of impacting users' health outcomes [32]. As their information and design requests were considered, the participants found that the USSD app effectively provided sexual reproductive health information.

Table 4 Mobile application rating scale scores for the field testing

Mobile Application Rating Scale Score	Mean (SD) (Range)
Engagement	
Entertainment	3.8 (0.93) (4)
Interest	4.7 (0.46) (1)
Interactivity	4.0 (1.17) (4)
Target group	4.5 (0.56) (2)
Mean score	**4.3 (0.44) (1.7)**
Functionality score	
Performance	4.5 (0.97) (3)
Ease of use	4.2 (0.44) (1)
Navigation	4.8 (0.43) (2)
Gestural design	4.8 (0.35) (1)
Mean score	**4.6 (0.38) (1.7)**
Aesthetics score	
Visual appeal	4.3 (0.57) (2)
Mean score	**4.3 (0.57) (2)**
Information score	
Goals	4.1 (0.84) (2)
Quality of information	4.5 (0.71) (3)
Quantity of information	4.6 (1.11) (4)
Mean score	**4.4 (0.60) (2.3)**
App quality mean Score	**4.4 (0.31) (1.5)**

In our study, the users found the mobile app engaging and easy to navigate. The information provided was of high quality, age-group specific and in the right quantity. Feroz et al. [33] found that mobile apps could be highly effective for providing adolescents with reproductive health information in resource-limited settings. This is due to the barriers adolescents have to contend with accessing SRH services at the health facilities. Mobile app users in Feroz's study felt the intervention provided support and connectedness, especially if the app provided targeted communication containing new knowledge, reminders and/or suggestions about health issues [34].

Table 5 User experience evaluation of the mobile application

App characteristics	All *n* (%)	Male *n* (%)	Female *n* (%)	*p*-value
Times used app—median (SD) (Range)	4 (9.9) (1 – 51)	3 (8.1) (1 – 37)	6 (10.9) (1 – 51)	0.534
Is the app fun/entertaining to use?				
Dull	1 (1.6)	1 (3.3)	0 (0)	0.708
Fun enough to entertain user	27 (43.6)	12 (40.0)	15 (46.9)	
Moderately fun and entertaining	15 (24.2)	8 (26.7)	7 (21.8)	
Highly entertaining and fun	19 (30.6)	9 (30.0)	10 (31.3)	
Is the app interesting to use?				
Mostly uninteresting	1 (1.6)	0 (0)	1 (3.1)	0.400
Moderately interesting	17 (27.4)	10 (33.3)	7 (21.9)	
Very interesting	44 (71.0)	20 (66.7)	24 (75.0)	
Is the app content appropriate for you as an adolescent?				
Acceptable but not targeted. May be inappropriate/unclear/confusing	2 (3.2)	1 (3.4)	1 (3.1)	0.974
Well targeted, with negligible issues	26 (41.9)	13 (43.3)	13 (40.6)	
Perfectly targeted, no issues found	34 (54.9)	16 (53.3)	18 (56.3)	
How accurately do the app features and menus work?				
Some functions work, but lagging or contains major technical problems	5 (8.1)	3 (10.0)	2 (6.2)	0.953
App works overall. Some technical problems need fixing	6 (9.7)	3 (10.0)	3 (9.4)	
Mostly functional with minor/negligible problems	6 (9.7)	3 (10.0)	3 (9.4)	
Perfect/timely response; no technical bugs found	45 (72.5)	21 (70.0)	24 (75.0)	
How easy is it to learn how to use the app?				
Easy to learn how to use the app	45 (72.6)	21 (70.0)	24 (75.0)	0.876
Able to use app immediately; intuitive; simple	17 (27.4)	9 (30.0)	8 (25.0)	
Are interactions consistent and intuitive across all screens?				
Mostly consistent/intuitive with negligible problems	9 (14.5)	3 (10.0)	6 (18.7)	0.537
Perfectly consistent and intuitive	53 (85.5)	27 (90.0)	26 (81.3)	
Is app content correct, well written, and relevant to Adolescent Sexual Reproductive Health?				
Barely relevant	2 (3.2)	2 (6.7)	0 (0)	0.237
Moderately relevant	2 (3.2)	0 (0)	2 (6.2)	
Relevant	23 (37.1)	12 (40.0)	11 (34.4)	
Highly relevant, appropriate, coherent, and correct	35 (56.5)	16 (53.3)	19 (59.4)	
Is the content comprehensive and concise?				
Minimal Information	4 (6.5)	2 (6.7)	2 (6.3)	0.237
Insufficient	1 (1.6)	0 (0)	1 (3.1)	
OK but not comprehensive or concise	3 (4.8)	3 (10.0)	0 (0)	
Comprehensive and concise; contains links to more information and resources	54 (87.1)	25 (83.3)	29 (90.6)	
Would you recommend this app to people who might benefit from it?				
There are very few people I would recommend this app to	3 (4.8)	0 (0)	3 (9.4)	0.274
There are several people whom I would recommend it to	6 (9.7)	3 (10.0)	3 (9.4)	
There are many people I would recommend this app to	19 (30.7)	8 (26.7)	11 (34.4)	
I would recommend this app to everyone	34 (54.8)	19 (63.3)	15 (46.8)	
What is your overall rating of the app?				
Average	6 (9.7)	6 (20.0)	0 (0)	**0.011**
Above average	11 (17.7)	6 (20.0)	5 (15.6)	
Best app	45 (72.6)	18 (60.0)	27 (84.4)	
This app is likely to increase awareness of the importance of addressing Adolescent Sexual Reproductive Health?				
Agree	34 (54.8)	20 (66.7)	14 (43.7)	0.119
Strongly agree	28 (45.2)	10 (33.3)	18 (56.3)	

Table 5 (continued)

App characteristics	All *n* (%)	Male *n* (%)	Female *n* (%)	*p*-value
This app is likely to increase knowledge of Adolescent Sexual Reproductive Health?				
Neutral	1 (1.6)	1 (3.3)	0 (0)	0.262
Agree	37 (59.7)	20 (66.7)	17 (53.1)	
Strongly agree	24 (38.7)	9 (30.0)	15 (46.9)	
This app is likely to change attitudes toward improving Adolescent Sexual Reproductive Health?				
Agree	43(69.4)	20 (66.7)	23 (71.9)	0.866
Strongly agree	19 (30.6)	10 (33.3)	9 (28.1)	
This app is likely to increase intentions to address Adolescent Sexual Reproductive Health?				
Agree	44 (81.0)	21 (70.0)	23 (71.9)	1.000
Strongly agree	18 (29.0)	9 (30.0)	9 (28.1)	
Use of this app is likely to encourage further help seeking on Adolescent Sexual Reproductive Health?				
Disagree	1 (1.6)	1 (3.3)	0 (0)	0.418
Agree	41 (66.1)	18 (60.0)	23 (71.9)	
Strongly agree	20 (32.3)	11 (36.7)	9 (28.1)	
Use of this app is likely to reduce problems in Adolescent Sexual Reproductive Health?				
Agree	41 (66.1)	20 (66.7)	21 (65.6)	1.000
Strongly agree	21 (33.9)	10 (33.3)	11 (34.4)	

Information provided by the USSD app in our study was found to be individualized, appropriate and relevant to the participants' sexual reproductive health information needs.

The participants may have found that the USSD app enhanced confidentiality, a feature that influences how an adolescent will access sexual reproductive health information. Healthcare workers may take on a policing role guided by their own or socially-sanctioned standards. Technology-based reproductive health information sources, including the internet, are adolescents preferred options [35, 36]. The USSD app enabled the adolescents to access sexual reproductive health information in a confidential way. No audit trail was left on the mobile phone when the USSD sessions ended. Using the study mobile app, the adolescents could access information when needed/required without fear of being judged. It is important to note that there is no local installation, and no trace is kept in the phone after using the USSD app, any SRH information the adolescent accessed remains confidential improving the user's confidence in the app.

The USSD mobile phone app had content that was accurate and its functionality was free of technical problems. The app was easy to use and the content consistent and intuitive across all interaction screens. As Steinberg et al. [37] demonstrated, mobile phone apps designed to provide adolescents with information should have functionality features that improve user experience and enable users to search content by topic, making it easier to access the required information. The adolescents in our study found the USSD app easy to use and quickly learnt how the app worked, navigating through the content with ease.

Adolescent participants in the study found the USSD app effective for providing sexual reproductive health information. Guilamo-Ramos et al. [38] showed that adolescent users are motivated to use technology-enabled access to reproductive health information due to its accessibility and wide coverage of topics that can be personalized to each user. The USSD app was deemed very appropriate to all the adolescents and could work toll-free on all types of phones. As the app met their sexual reproductive health information needs, the participants were prepared to recommend it to their peers.

The adolescents found the USSD app user-friendly. The USSD technology provides an interactive, user-friendly and simple tool for delivering health information using mobile phones. This technology has been used to build highly promising mobile phone-based clinical decision support systems for healthcare providers [39], USSD was also used to pilot a well-received mobile app enabling users to locate healthcare facilities in their vicinity [40].

As Canavarro et al. [3] determined, girls bear the greatest burden when unable to access accurate and up-to-date reproductive health information. Adolescent pregnancy can lead to dropping out of school, early marriage and/or rejection by family members. This may explain why more female participants in this study deemed the USSD app the 'best app' (p-value = 0.011) than male participants. Female participants also 'strongly agreed' the USSD app could increase awareness and knowledge of adolescent sexual reproductive health issues.

Although there are few apps in Playstore and Appstore on adolescent reproductive health, they only work on Android or iOS smartphones. Many adolescents in resource-limited settings including Kenya and specifically Kibra, our study site location may not easily access smartphones. This was confirmed by our qualitative work [17] during the exploratory stages of gathering the adolescents' SRH information needs. USSD a low cost application that works on both smartphones and feature phones was the option of choice by the adolescent participants.

In alpha testing, research has found that a sample of 10 participants is able to identify over 80% of issues with an application at alpha testing stage [41]. In our study, 9 of the 38 participants were successfully followed-up attaining 90% of the minimum requirements. Adolescent research studies face unique challenges on recruitment, retention and follow-up [42]. In our study, after the alpha testing, we requested the ethics review board to offer the adolescents a gift voucher on successful follow-up. During the field testing, 113 (75%) adolescents were successfully followed-up. Innovate approaches need to be continuously undertaken to improve retention in adolescent studies.

In our study we used the MARS for the usability testing, other studies have used the System Usability Scale (SUS) to measure the usability of mobile apps. The SUS is a 10-question tool used to measure subjective usability [43]. In one setting that evaluated the reliability of a translated SUS assessing mobile apps, the reliability test showed a Cronbach alpha value of 0.85 indicating the SUS is a reliable tool for usability assessment of mobile apps [44]. The MARS measures a significant number of mobile apps quality dimensions and has also been validated in more mhealth apps [45].

Usability testing has also been used to test mhealth apps for other health needs and conditions. In one study, usability testing was used to evaluate an mhealth app that provided information on how to manage chronic conditions to persons living with HIV. From the usability testing, the researchers were able to get useful feedback that made the mhealth app usable and ready for future efficacy testing. [46]. In another study, usability testing evaluated mhealth apps in paediatric obesity. The findings of the study identified the importance of thorough evaluation and collection of evidence in mhealth apps for best practice [47].

Limitations

Although 62 adolescent participants used the app at least one during the 3-month period meeting the minimum sample required, the study findings could have had more confidence if all participants in the intervention group used the app. This study targeted adolescents that could access a mobile phone, adolescents not able to access a mobile phone were screened out. Further research could be carried out to find out how adolescents not able to access a mobile phone could access SRH information.

On participant selection, adolescents were mobilized from youth program venues where 15 to 19 year olds visited. Adolescents who did not visit these places were not enrolled creating a potential selection bias. Relating to the selection bias, what was identified as SRH information needed by the adolescents was based on the sample of adolescents enrolled. A subset of adolescents in Kibra that was not enrolled could have had different SRH information needs. Content provided in the USSD app may have been biased to the needs of enrolled participants. Studies exploring multiple participant mobilization strategies need to be explored to ensure all adolescent get a chance to participate in research studies thus informing interventions.

Although the USSD technology works on feature phones, most feature phone devices have smaller display screens. Adolescents using feature phones may have faced challenges of being able to view the information displayed on their screens. One way we attempted to address this was to keep the statements short and precise. The most effective solution to this limitation is for the adolescents to use a device with a larger display screen.

Conclusions

Adolescents need information on sexual reproductive health, they also want to be meaningfully involved in the design and development process of interventions intended to meet their SRH information needs. Being involved at every stage of the app design and development in this study, participants found both the content and USSD app very appropriate. The USSD app worked on their feature phones and they could access the services toll-free. Their privacy was protected by the absence of an audit trail.

The USSD mobile phone technology is ideal for resource-limited settings, as users in these areas may only be able to access feature phones, have to share a phone and/or be unable to pay for services. The USSD technology works seamlessly on both feature phones and smartphones. No information is saved on the phone when using USSD, thus maintaining confidentiality even on shared phones. The service can be pre-paid by the provider. For future work, with availability of resources, we aim to scale-up prototyping and testing the mobile app with adolescents in different parts of Kenya and the Africa region. Expanding the USSD-based technology providing SRH information to adolescents living in

underprivileged settings could have positive life-long impact on the adolescents' reproductive health.

Received: 12 April 2022 Accepted: 12 July 2022
Published online: 04 August 2022

Abbreviations
HCD: Human-centered design; MARS: Mobile application rating scale; PIN: Personal identification number; SD: Standard deviation; SRH: Sexual reproductive health; STIs: Sexually-transmitted infections; WHO: World Health Organization; USSD: Unstructured Supplementary Service Data.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12874-022-01689-4.

Additional file 1: Appendix A. Paper-based version of the USSD app content. **Appendix B**. A customized mobile application rating scale.

Acknowledgements
Drs. Amy Knopf and Lisa Hightow-Weidman, experts in adolescent health who have worked in the mhealth space, reviewed the USSD prototype prior to usability testing and provided highly constructive feedback. James Serembe, Josphine Ocham, Samwel Oninga and Nolline Oudu worked closely with the adolescent participants at every stage of the study: we thank them for their tireless efforts. We also acknowledge and thank all the adolescent participants.

Authors' contributions
PM, AN, II, RN and CR contributed to the research protocol development, data review and preparation of this manuscript. The author(s) read and approved the final manuscript.

Funding
This research received no external funding.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author (pmacharia@uoc.edu) on reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Kenyatta National Hospital/University of Nairobi Ethics Review Committee protocol code P707/10/2018 in March 2019. Informed consent was obtained from all subjects involved in the study. The informed consent statement was "What will happen to the results of the research study? The results of the study will be discussed and presented in a report at team meetings and it will be used to help the design of a mobile phone technology-based system to bridge the SRH information gap. The information may be presented at a conference with other studies that relate to adolescent SRH. Neither the report nor the presentation will show your name".

Consent for publication
All the participants provided consent for the research findings to be published. No personally identifiable data in in the published data.

Competing interests
The authors declare no conflict or competing of interests.

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Publisher's Note

6 Results: Field Testing in a Randomized Control Trial

In this results section, the field testing in a RCT outcomes are presented. This work has been published in the journal of medical and internet research (JMIR).

6.1 Overview of Study Findings

From late December 2019, 77% (231/300) of the adolescents were successfully followed up—74.7% (109/300) from the intervention group and 76.6% (118/300) from the control group. As the app was not used at least once, 47 participants, together with another 4 participants with incomplete data in the intervention group, were excluded from the final analysis. Figure 7 shows the enrollment and follow-up stages of the study. The data were analyzed as per the per-protocol analysis.

The distribution of the study participants according to the selected background characteristics indicated a desired comparable result at baseline as shown in Table 1. The mean ages of the participants in the control group (17.29, SD 1.23 years) and the intervention group (17.27, SD 1.12 years) were statistically comparable (*P*=.94). There were no significant differences in participant demographics. However, there was a statistically significant difference in the distribution of sex (*P*=.025) by the study enrollment group.

Table 7: Demographic characteristics of the field testing participants

Variables	Total (n=180), n (%)	Intervention (n=62), n (%)	Control (n=118), n (%)	*p*-value
Sex				
Male	67 (37.2)	30 (48.4)	37 (31.4)	0.03
Female	113 (62.8)	32(51.6)	81 (68.6)	
Phone ownership				
Adolescent	81 (45)	30 (48.4)	51 (43.2)	0.64
Parent or guardian	90 (50)	30 (48.4)	60 (50.8)	
Other relative	9 (5)	2 (3.2)	7 (5.9)	
Highest level of education				
Primary	23 (12.8)	8 (12.9)	15 (12.7)	0.97
Secondary and above	157 (87.2)	54 (87.1)	103 (87.3)	

Participants' responses were analyzed by attitude toward contraceptives, gender role stereotypes, abstinence, and perceived vulnerability to negative SRH outcomes. Knowledge scores were also analyzed as aggregated data. A paired sample *t* test analysis of the relationship between the knowledge score and the use of the mobile app was performed using R software.

Table 8 presents an analysis of the effect of the intervention on specific indicator scores. The difference in the mean scores between those enrolled in the intervention group compared with those in the control group showed statistical significance in the total knowledge scores. The overall mean change in total scores in the intervention group was 0.5 (*P*=.015) compared with the control group 0.246 (*P*=.236). The *P* value between the two groups on the total knowledge scores was .029, which was statistically significant, indicating that the mobile app had an impact on the adolescents' SRH knowledge scores. In the intervention group, the intervention had a statistically significant effect on contraceptive scores (0.355; *P*=.017). The intervention also showed a trend toward statistical significance in abstinence knowledge scores (0.129, *P*=.088).

Table 8: Effects of intervention on overall and specific knowledge scores

Outcome (knowledge score)	**Intervention**					**Control**					**Between group, *p*-value**
	Baseline, mean [SD] (95% CI)	End line, mean [SD] (95% CI)	Difference in scores, mean [SD](95% CI)	Effect sizes	Within group, *p*-value	Baseline, mean [SD](95% CI)	End line, mean [SD](95% CI)	Difference in score, mean [SD](95% CI)	Effect sizes	Within group, *p*-value	
Contraceptives	3.613 [1.107] (3-4)	3.968 [0.887] (4-5)	0.355 [1.147] (0.064 to 0.646)	0.309	0.02	3.602 [1.039] (3-4)	3.678 [1.183] (3-5)	0.076 [1.235] (–0.148 to 0.301)	0.062	0.5	0.06
Vulnerability	2.000 [0.768] (1.25-3)	2.032 [0.768] (2-3)	0.0323 [0.829] (–0.178 to 0.243)	0.038	0.76	1.856 [0.860] (1-2.75)	1.941 [0.798] (1-2.75)	0.085 [0.939] (–0.086 to 0.256)	0.090	0.33	0.32
Gender stereotype	3.097 [0.987] (3-4)	3.081 [1.060] (3-4)	–0.016 [0.757] (–0.208 to 0.176)	0.021	0.87	2.890 [1.160] (2-4)	2.881 [1.126] (2-4)	–0.008 [1.121] (–0.213 to 0.196)	0.008	0.94	0.88
Abstinence	1.565 [0.532] (1-2)	1.694 [0.465] (1-2)	0.129 [0.586] (–0.020 to 0.278)	0.220	0.09	1.576 [0.576] (1-2)	1.669 [0.539] (1-2)	0.129 [0.569] (–0.011 to 0.197)	0.163	0.08	0.01
Total knowledge score	10.270 [2.050] (9-12)	10.770 [2.012] (10-12)	0.5 [1.576] (0.099 to 0.900)	0.317	0.02	9.924 [2.227] (8.25-12)	10.170 [2.412] (9-12)	0.246 [2.242] (–0.163 to 0.654)	0.109	0.24	0.03

The use and perceptions questionnaires were used to measure the perceived usefulness of the app. We also aimed to evaluate how the knowledge adolescents received from the app influenced their SRH decision-making. Tables 3 and 4 show the descriptive statistics of our evaluation. The tables show the responses from each adolescent who had used the mobile app at least once in 3 months. The questions addressed topics of interest, the perceived usefulness of information, and the mobile app features the users appreciated. The information in Table 9 is stratified by age—adolescents aged < 18 years and those ≥18 years. Table 10 is stratified by gender.

Table 9: Use and perception of the mobile app stratified by age groups

Variable		All, n (%)	Age <18 years, n (%)	Age ≥18 years, n (%)	*p*-value
What information did you require when you last used the mobile app?					
	STIs[a]	20 (26.7)	8 (40)	12 (60)	0.37
	Drugs	18 (24)	12 (66.7)	6 (33.3)	0.16
	Relationship	17 (22.7)	9 (52.9)	8 (47.1)	0.81
	Sex	12 (16)	4 (33.3)	8 (66.7)	0.25
	Contraceptives	6 (8)	3 (50)	3 (50)	>0.99
	Pregnancy	2 (2.7)	0 (0)	2 (100)	0.16
What knowledge about SRH[b] issues have you gained?					
	Abstinence	53 (42.4)	28 (52.8)	25 (47.2)	0.68
	STIs	30 (24)	14 (46.7)	16 (53.3)	0.72
	Condom use	22 (17.6)	12 (54.5)	10 (45.5)	0.67
	Contraceptives	12 (9.6)	6 (50)	6 (50)	>0.99
	Drugs	8 (6.4)	5 (62.5)	3 (37.5)	0.48
What decision-making was informed by the information you accessed on the mobile app?					
	Abstinence	51 (38.1)	28 (54.9)	23 (45.1)	0.48
	Condom use	36 (26.9)	18 (50)	18 (50)	>0.99
	STIs	29 (21.6)	11 (37.9)	18 (62.1)	0.19
	Contraceptives	9 (6.7)	6 (66.7)	3 (33.3)	0.32
	Drugs	9 (6.7)	6 (66.7)	3 (33.3)	0.32
Were the questions you on SRH had answered adequately?					
	Yes	56 (90.3)	30 (53.6)	26 (46.4)	>0.99
	No	6 (9.7)	3 (50)	3 (50)	
Did the information you receive inform better decision-making on SRH matters?					
	Yes	62 (100)	33 (53.2)	29 (46.8)	0.62
	No	0 (0)	0 (0)	0 (0)	
What are the most important features of the mobile phone app?					
	Ease of use	54 (28.3)	28 (51.9)	26 (48.1)	0.79
	Confidentiality	51 (26.7)	26 (51)	25 (49)	0.89
	Quality of information	45 (23.6)	24 (53.3)	21 (46.7)	0.65
	Immediate feedback	41 (21.5)	20 (48.8)	21 (51.2)	0.88

[a]STI: sexually transmitted infection.

[b]SRH: sexual reproductive health.

Information about STIs was of great interest to the participants, with 26.7% (20/75) of the responses by users seeking information on this subject the last time they used the app. Adolescent girl participants had a higher interest in STIs, with 55% (11/20) accessing this information. Most participants (56/62, 90.8%) found the information provided in the app to have adequately answered their questions or met their SRH information needs. All the 62 adolescents who used the app felt that the information they received could improve their decision-making on issues relating to SRH. This outcome was similar when data were stratified by age and gender.

The participants reported gaining knowledge from the app on several SRH issues in their responses, including abstinence (53/125, 42.4%), STIs (30/125, 24%), and condom use (22/125, 17.6%). Although only 9.7% (12/125) of the participant's responses showed increased knowledge of contraceptives, 75% (9/12) of these were female, showing a trend toward significance (*P*=.08).

On improved decision-making, 38.1% (51/134) of the adolescent participant's responses show they were able to abstain from sex. Of these responses, 54.9% (28/51) were aged between 15 and 17 years and 52.9% (27/51) were male. The knowledge obtained may have also prompted 26.9% (36/134) of the responses to show use a condom by the adolescent participants during a sexual encounter. Although sex is illegal for ages under 18 years in Kenya, 50% of those who reported deciding to use a condom were aged ≤17 years. Of the participants who used a condom, 52.8% (19/36) were male. Adolescent participants were also able to identify STIs, with 21.6% (29/134) responses reporting that app information guided their decision to seek treatment after identifying an STI; 51.7% (15/29) of these responses were from female participants.

Ease of use was the most important feature of the app for 28.3% (54/191) of the participants' responses, followed by confidentiality at 26.7% (51/191) and high-quality information at 23.6% (45/191), with 60% (27/45) of the latter being from responses by female participants.

6.2 Discussion

This study was an RCT that explored the use of a USSD-based mobile phone intervention to deliver on-demand adolescent SRH information in an RCT. We studied the effectiveness and impact of a USSD-based mobile phone app on increasing adolescents' knowledge of contraceptives, gender-based stereotypes, STIs, abstinence, and perceived vulnerability. We also evaluated the USSD-based ability of the mobile phone app to help adolescents make informed decisions regarding their SRH. Our results show improved awareness of SRH information and improved knowledge about contraceptives and abstinence. Increased awareness has enabled more adolescents to abstain from sex, improve condom use, and identify STIs. Confidentiality when accessing SRH information was of particular importance to the participants.

Adolescents' needs for information on contraceptives is unmet in most resource-limited settings; adolescents are unable to secure information on available contraceptive options or discover where they can access this information [157]. In our study, adolescents using the app improved their knowledge of contraceptives, with a trend towards statistical significant (*P*=.057). Our findings are promising, and mobile phone apps could help increase awareness on and knowledge of contraceptives among adolescents. The provision of information on contraceptives to adolescents is complex because of cultural, religious, and political setbacks. Innovative approaches are needed to meet adolescents' information needs. The study outcomes also show the need to make information about contraceptives accessible to adolescents in a culturally and age-appropriate manner [158], [159].

Table 10: Use and perception of the mobile app stratified by gender

Variable		All, n (%)	Male, n (%)	Female, n (%)	*p*-value
What information did you require when you last used the mobile app?					
	STIs[a]	20 (27)	9 (45)	11 (55)	0.65
	Drugs	18 (24.3)	10 (55.6)	8 (44.4)	0.64
	Relationships	16 (21.6)	8 (47.1)	9 (52.9)	0.81
	Sex	12 (16.2)	5 (41.7)	7 (58.3)	0.56
	Contraceptives	6 (8.1)	1 (16.7)	5 (83.3)	0.10
	Pregnancy	2 (2.7)	1 (50)	1 (50)	>0.99
What knowledge about sexual reproductive health matters have you gained?					
	Abstinence	53 (42.7)	26 (49.1)	27 (50.9)	0.89
	STIs	30 (24.2)	13 (43.3)	17 (56.7)	0.47
	Condom use	22 (17.7)	13 (50.1)	9 (40.9)	0.39
	Contraceptives	12 (9.7)	3 (25)	9 (75)	0.08
	Drugs	7 (5.6)	2 (25)	6 (75)	0.16
What better decision-making was informed by the information you accessed on the mobile app?					
	Abstinence	51 (38.1)	27 (52.9)	24 (48.1)	0.67
	Condom use	36 (26.9)	19 (52.8)	17 (47.2)	0.74
	STIs	29 (21.6)	14 (48.3)	15 (51.7)	0.85
	Contraceptives	9 (6.7)	4 (44.4)	5 (55.6)	0.74
	Drugs	9 (6.7)	3 (33.3)	6 (66.7)	0.32
Were the questions you had on SRH answered adequately?					
	Yes	56 (90.3)	26 (46.4)	30 (53.6)	0.61
	No	6 (9.7)	4 (33.3)	2 (66.7)	
Did the information you receive inform better decision-making on SRH[b] matters?					
	Yes	62 (100)	30 (48.4)	32 (51.6)	0.8
	No	0 (0)	0	0	
What are the most important features of the mobile phone app?					
	Easy to use	54 (28.3)	26 (48.1)	28 (51.9)	0.79
	Confidentiality	51 (26.7)	24 (47.1)	27 (52.9)	0.67
	Quality of information	45 (23.6)	18 (40)	27 (60)	0.18
	Immediate feedback	41 (21.5)	19 (46.3)	22 (53.7)	0.64

[a]STIs: sexually transmitted infections.

[b]SRH: sexual reproductive health.

When accessing SRH information and services, adolescents want their confidentiality to be respected and upheld. Fear of being *judged* and the possibility of negative attitudes from health care providers can prevent adolescents from accessing these important services [160]. During

follow-up visits, of the 62 adolescent participants who had used the mobile app, 51 (82.3%) indicated that confidentiality was one of the most important features of the app. Adolescent users can access any SRH information in a user-friendly manner. Research has shown that adolescents value confidentiality when accessing SRH information and are more willing to seek SRH care and interventions when their confidentiality is assured [161].

mHealth apps have shown great potential for engaging with and increasing SRH information access for adolescents from different age groups and social demographics [141], [162]. In one study, text messages improved SRH outcomes by reducing pregnancy rates [163]. The aforementioned studies show the great potential of mHealth apps in improving and increasing adolescents' knowledge of SRH. Our study findings show that adolescents require high-quality SRH information provided in an easy-to-use, confidential manner with immediate feedback. The USSD technology enables an interactive user-driven mobile app to provide information based on a user's inputs. This USSD technology is low cost, works on both feature phones and smartphones, and can be provided free of charge.

6.3 Limitations

During the study, 47 adolescents were unable to use the mobile app, mainly because of a lack of access to mobile phones. This may explain why there appeared to have been a minimal change in adolescent users' knowledge scores. Access to mobile phones in most resource-limited settings is associated with the household economic status. In addition, access to a phone was self-reported. Several adolescents hoped to be provided with a phone by their parents, caregivers, or older siblings. Adolescent participants in the intervention group who were unable to use the app reported that either their parents travelled or the mobile phone they hoped to use stopped functioning. Some studies have opted to provide adolescent participants with mobile phones to ensure that participants in the intervention group accessed the mobile apps. This approach has increased the cost of the study, and other researchers have viewed providing mobile phones as an inducement. In resource-limited settings such as Kenya, access to the internet is limited and web-based apps may not be an option in this setting. However, internet cybercafes are available in many places. Providing internet payment vouchers to adolescents to access the internet and a customized web-based study app could be explored. The results of our study may not be generalizable across Kibra due to the unique challenges of adolescents accessing mobile phones.

6.4 Conclusions

Adolescents require accurate and up-to-date SRH information to guide their decision-making and improve health outcomes. As they already use mobile phones in their day-to-day lives, mobile phone apps provide an ideal platform. Considerable promise has been shown by studies using mobile apps to improve adolescents' access to SRH information. Scaled-up research on mHealth apps providing SRH information is required to better evaluate their impact on SRH outcomes.

6.5 Publication

JMIR MHEALTH AND UHEALTH Macharia et al

Original Paper

An Unstructured Supplementary Service Data–Based mHealth App Providing On-Demand Sexual Reproductive Health Information for Adolescents in Kibra, Kenya: Randomized Controlled Trial

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Abstract

Background: Adolescents transitioning from childhood to adulthood need to be equipped with sexual reproductive health (SRH) knowledge, skills, attitudes, and values that empower them. Accessible, reliable, appropriate, and friendly information can be provided through mobile phone–based health interventions.

Objective: This study aims to investigate the effectiveness and impact of an Unstructured Supplementary Service Data (USSD)–based app in increasing adolescents' knowledge about contraceptives, gender-based stereotypes, sexually transmitted infections (STIs), abstinence, and perceived vulnerability, and helping adolescents make informed decisions about their SRH.

Methods: A randomized controlled trial (RCT) methodology was applied to investigate the potential of a USSD-based app for providing on-demand SRH information. To be eligible, adolescents aged 15 to 19 years residing in Kibra, Kenya, had to have access to a phone and be available for the 3-month follow-up visit. Participants were randomly assigned to the intervention (n=146) and control (n=154) groups using sequentially numbered, opaque, sealed envelopes. The primary outcome was improved SRH knowledge. The secondary outcome was improved decision-making on SRH. The outcomes were measured using validated tools on adolescent SRH and user perceptions during the follow-up visit. A paired sample *t* test was used to compare the changes in knowledge scores in both groups. The control group did not receive any SRH information.

Results: During the RCT, 54.9% (62/109) of adolescents used the USSD-based app at least once. The mean age by randomization group was 17.3 (SD 1.23) years for the control group and 17.3 (SD 1.12) years for the intervention group. There was a statistically significant difference in the total knowledge scores in the intervention group (mean 10.770, SD 2.012) compared with the control group (mean 10.170, SD 2.412) conditions (t_{179}=2.197; P=.03). There was a significant difference in abstinence (P=.01) and contraceptive use (P=.06). Of the individuals who used the app, all participants felt the information received could improve decision-making regarding SRH. Information on STIs was of particular interest, with 27% (20/62) of the adolescents seeking information in this area, of whom 55% (11/20) were female. In relation to improved decision-making, 21.6% (29/134) of responses showed the adolescents were able to identify STIs and were likely to seek treatment; 51.7% (15/29) of these were female. Ease of use was the most important feature of the app for 28.3% (54/191) of the responses.

Conclusions: Adolescents require accurate and up-to-date SRH information to guide their decision-making and improve health outcomes. As adolescents already use mobile phones in their day-to-day lives, apps provide an ideal platform for this information. A USSD-based app could be an appropriate tool for increasing SRH knowledge among adolescents in low-resource settings.

Adolescents in the study valued the information provided because it helped them identify SRH topics on which they needed more information.

Trial Registration: Pan African Clinical Trial Registry PACTR202204774993198; https://pactr.samrc.ac.za/TrialDisplay.aspx?TrialID=22623

(JMIR Mhealth Uhealth 2022;10(4):e31233) doi: 10.2196/31233

KEYWORDS

adolescents; sexual reproductive health; mobile phones; randomized controlled trial

Introduction

Background

The World Health Organization (WHO) has stated that universal access to quality sexual reproductive health (SRH) services is essential for sustainable development and global realization of health and human rights [1]. The United Nations has also made a commitment to ensure "universal access to sexual health and reproductive health-care services, including family planning, information and education" [2]. As SRH rights are fundamental to humanity's well-being, the provision of evidence-based SRH interventions will secure lifelong positive impacts on health benefits and outcomes [3].

Adolescents transitioning from childhood to adulthood must be equipped with SRH knowledge, skills, attitudes, and values that empower them to develop successful sexual relationships. Several approaches, including comprehensive sexuality education and curriculum-based approaches, have been used to teach adolescents different aspects of sexuality [4]. Health interventions can be expanded to settings that adolescents engage in, beyond family and health care facilities [5]. Adolescents can be provided with high-impact, easily accessible, and reliable health information that is crucial for improving their reproductive health [6]. Content should be adolescent-friendly, appropriate to their SRH needs, swiftly provided, and not overwhelming [7].

In low- and middle-income countries, the exponential growth of mobile-based technologies has provided opportunities for the adoption of mobile health (mHealth) apps. The WHO identifies many mobile phone technologies that can be used to improve health outcomes in low- and middle-income countries, including SMS text messaging [8]. As research has shown, modes of information delivery and content must vary according to audience, appealing to different users in different ways [9]. In resource-limited settings, for instance, technology-based interventions have proven to be an effective way of providing health information [10].

Using evidence-based content to deliver adolescent SRH information on mobile phones has the potential to impact behaviors and improve health outcomes [11]. Several mobile phone–based interventions providing adolescent SRH services and their impact have been well-documented [12]. Research has shown that mHealth interventions have the potential to engage adolescents across sociodemographic settings and increase their knowledge and awareness [13]. Such interventions appeal to adolescents and, therefore, can mitigate the barriers to access associated with the delivery of adolescent SRH information at health care facilities [14].

Mobile phone–based health interventions are an increasingly feasible way to connect adolescents with SRH information and services in low-resource settings. Research has shown that interventions have been able to provide adolescents with knowledge that can lead to behavior change and improved health outcomes [15]. Mobile phone–based interventions can be tailored to each adolescent's context and provide individualized and effective services [16]. To improve such interventions, it is important to document and review system interaction data to inform design and delivery improvements, thereby making mHealth apps more effective [17]. There are often concerns about privacy when using mobile phone apps, which must be considered during the app development process [15]. Unstructured Supplementary Service Data (USSD)-based mobile phone technology has been found to be a user-friendly, convenient, and confidential method for adolescent users to access SRH information [18,19].

Objective

This study investigates the potential of a USSD-based app for providing on-demand SRH information to adolescents in the resource-limited setting of Kibra, Nairobi County, Kenya. The aim of this study is to determine the effectiveness and impact of a USSD-based mobile phone app in (1) increasing adolescents' knowledge about contraceptives, gender-based stereotypes, sexually transmitted infections (STIs), abstinence, and perceived vulnerability and (2) helping adolescents make informed decisions about their SRH.

Methods

Ethics Approval

The study protocol was reviewed and approved by the Kenyatta National Hospital University of Nairobi Ethics Review Committee in March 2019 (reference number P707/10/2018).

Intervention Design

The intervention design was based on the health belief model, a behavior change framework intended to increase knowledge that can inform actions to reduce health risks [20]. Through a randomized controlled trial (RCT), a USSD-based app was evaluated on its ability to influence adolescents' knowledge, attitudes, and practices related to SRH health awareness. Content provided in the app was based on validated adolescent sexual health information (Multimedia Appendix 1) created through Avert's Young Voices, a project that developed materials and content on adolescent sexual health through a co-creation

process with adolescents from South Africa, Lesotho, Zambia, Zimbabwe, and Malawi [21].

Sample Size

The study enrolled 300 adolescents: 146 (48.7%) randomized to the intervention group and 154 (51.3%) to the control group. It is estimated that around 8% of adolescents aged 15 to 19 years in Kenya access SRH information [22]. A minimum sample size of 226 adolescents was required to attain a 95% CI. Thus, the sample size of 300 adolescents had 74 more participants than the minimum sample size. The additional participants ensured that the sample strength would be maintained, even with loss at follow-up.

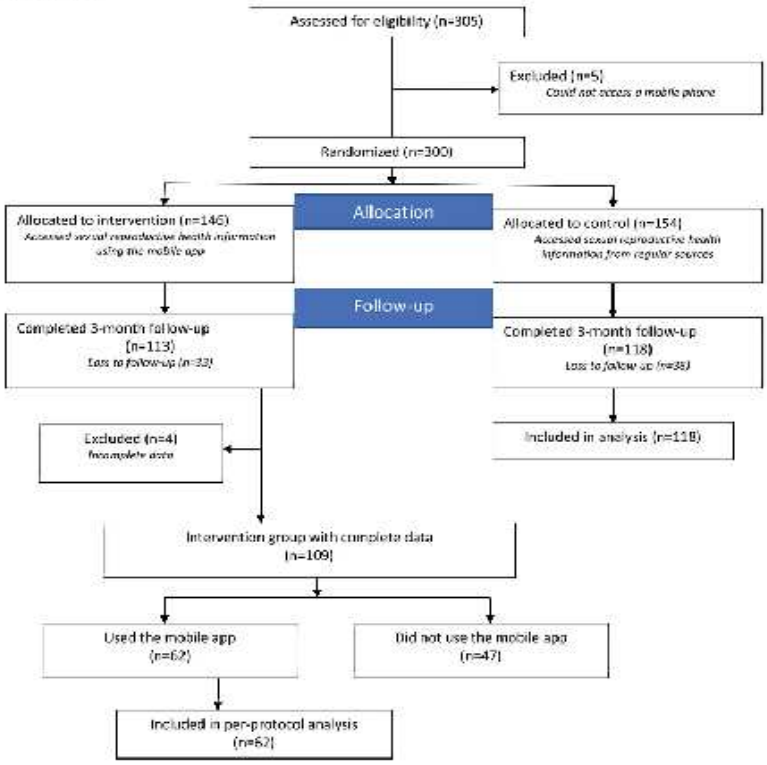
The study used sequentially numbered, opaque sealed envelopes—an affordable and effective method for randomizing participants [23]. Having passed screening for eligibility, the adolescents picked a sealed envelope from a box. Each envelope contained a randomization group and an assigned participant ID number. A randomization list was generated using a web-based tool [24].

Recruitment

The study population consisted of adolescents aged 15 to 19 years residing in the Kibra suburb of Nairobi City County, Kenya. Kibra consists of 12 villages, with both formal and informal settlements. The informal settlements house approximately 2.5 million residents. Participants were mobilized from 12 villages; community mobilizers approached potential participants at social halls, sports events, and other social activities that attracted adolescents aged 15 to 19 years. The study procedures were explained individually or to small groups of 3 to 5 adolescents using a study recruitment script (Multimedia Appendix 2). Adolescents interested in the study were referred to the study venue.

Efforts were made to distribute enrollment across all villages, as there are intervillage ethnic differences. Enrollment numbers were monitored by village and randomization groups during enrollment to ensure equitable distribution, providing an improved representation of adolescent SRH needs and awareness across the area. Ethnicity data were not collected because of the stigma associated with issues or discussions on ethnicity in the study site setting. We distributed enrollment across all the villages, ensuring a true representation of Kibra. In 2 cases, the enrollment team moved the study site to a social hall near a particular village to make it easier for local adolescents to participate. Figure 1 shows the enrollment and follow-up processes.

Figure 1. Study participant flowchart.



Inclusion and Exclusion Criteria

To participate in the study, adolescents should be aged between 15 and 19 years, live in Kibra, and be able to access a mobile phone. Participants aged 15 to 17 years signed an assent form after assenting to the study procedures; those aged ≥18 years were required to sign a consent form.

Adolescents aged <18 years should be accompanied by a parent or guardian, should get the permission from the parent or guardian, and should provide their assent. As the study presented minimal risk, the study team requested a waiver of parental permission for adolescents aged <18 years who were unaccompanied. In this setting, there are cultural challenges related to discussions with parents regarding adolescent SRH. Parents or guardians in Kibra, as in many settings, may not be involved in or fully aware of their adolescents' SRH information needs. If the study opted to secure parental permission for adolescents participating in the study, this may have required disclosure of the participants' SRH information needs, potentially leading to an elevated risk of harm or prevention of participation.

Intervention Implementation and Data Collection

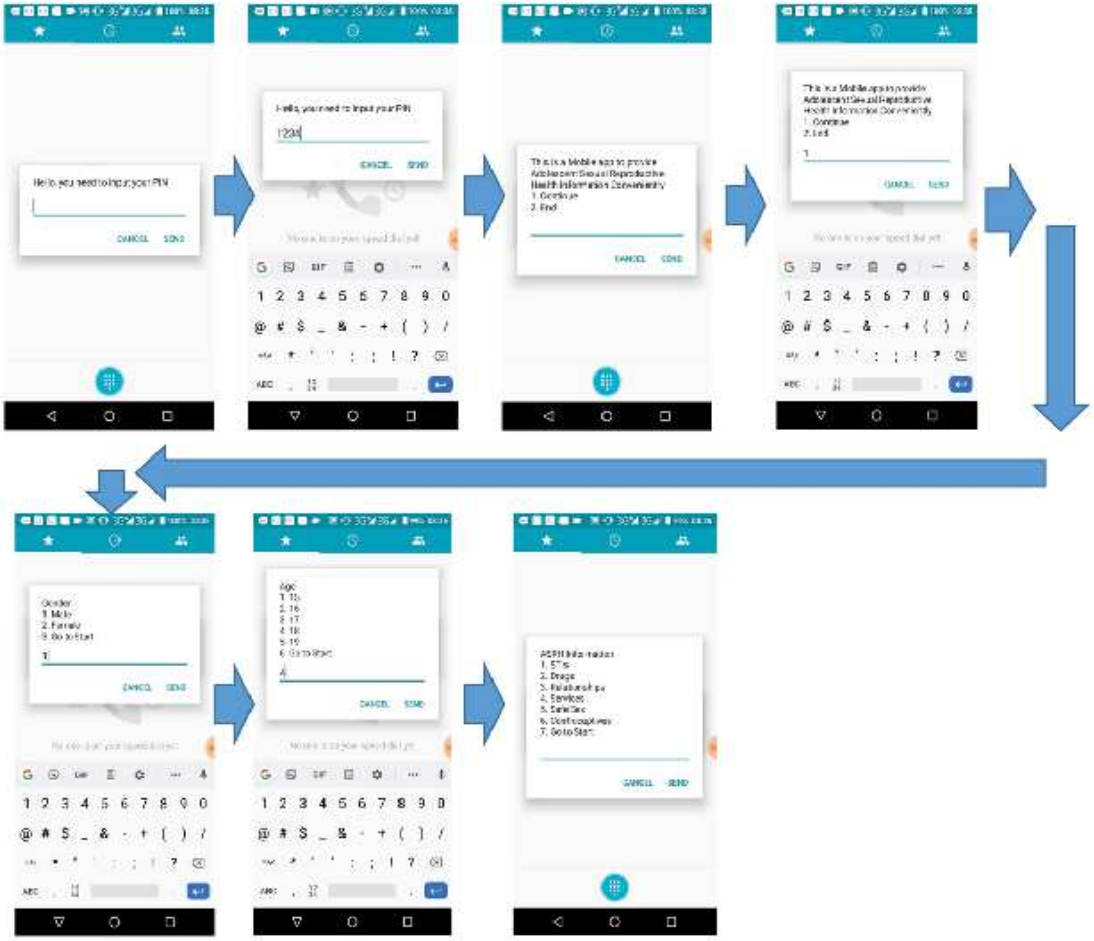
At the study venue, all potential participants were provided with further details of the study, eligibility criteria, and study procedures. On the basis of their age, an approved informed consent or assent form was provided in either English or Swahili. Potential participants were given time to ask questions, and after these were addressed, the study staff verified whether the potential participants were still interested. After the study procedures were explained in detail, participants signed a consent or assent form. Study staff then signed and dated the consent or assent forms, and participants were provided with a copy, if desired. For adolescents in the control group, no SRH information was provided. It was assumed that these adolescents would get information from their regular sources, including their parents, peers, or seminars held by nongovernmental organizations in Kibra.

The *Evaluation of Knowledge of SRH Information* (Multimedia Appendix 3) and *Use and Perception of the Mobile Phone App* (Multimedia Appendix 4) questionnaires were administered to adolescents by study staff. Open Data Kit was used to administer the 2 questionnaires. This mobile app enables a survey to be administered through a smartphone, question by question, in an easy-to-use, user-friendly interface. The *Evaluation of Knowledge of SRH Information* questionnaire was administered at enrollment and follow-up visits. The *Use and Perception of the Mobile Phone App* questionnaire was only administered to adolescents in the intervention group who had used the app at least once.

For the follow-up visit, community mobilizers called each participant, requesting them to visit the study site. Follow-up interviews were scheduled based on adolescents' availability. A USSD app offering validated SRH information accessible on both feature phones and smartphones was availed to the adolescents in the intervention group. To visualize the USSD app, Figure 2 shows the layout of the app and its interactive screens. A user-centered design approach was used in the design and development of the USSD app [18].

5. Results: Usability Analysis

Figure 2. Connecting to the Unstructured Supplementary Service Data (USSD) app. STI: sexually transmitted infection.



Sexual Reproductive Health Knowledge Score

To evaluate intervention outcomes, the *Evaluation of Knowledge of SRH Information* questionnaire (Multimedia Appendix 3) based on Monitoring and Evaluation to Assess and Use Results evaluation indicators on adolescent SRH was administered during the 3-month follow-up visit [25]. The knowledge scores calculated from these questionnaires were used to evaluate awareness.

The questions required yes or no responses. Each correct response earned one point and the wrong answer scored zero. Questions were posed to adolescents in both the intervention and control groups at enrollment and follow-up visits. The knowledge score data were analyzed as an aggregate score and by each subsection of the *Evaluation of Knowledge of SRH Information* questionnaire (Multimedia Appendix 3). Only the questions in section 2 of the questionnaire were used to evaluate knowledge scores. All estimates were adjusted for age, sex, access to phones, and level of education.

Use and Perceptions of the Mobile Phone App

The *Use and Perception of the Mobile Phone App* questionnaire (Multimedia Appendix 4) was administered to participants who had used the app at least once during the 3-month period. This questionnaire is based on WHO-validated instruments intended to be used by investigators studying SRH among adolescents [26] and assesses potentially improved decision-making. Knowledge of contraceptive use, STIs, and abstinence was also assessed. This study paid particular attention to detailed descriptions of recent encounters to determine the intervention's impact on improved awareness of SRH information.

Statistical Analysis

Overview

A paired sample *t* test was conducted to compare the knowledge score data. The *t* test attempted to show if there were differences in knowledge scores between the intervention and control groups at the 3-month follow-up visit. We also attempted to assess changes in attitude toward contraceptives, gender role

stereotypes, abstinence, and perceived vulnerability. The data were analyzed using R software (R Core Team).

For the *Use and Perception of the Mobile Phone App* questionnaire data, descriptive statistics were used to assess adolescents' knowledge, awareness, and potentially improved decision-making in relation to SRH. A chi-square test was used to assess any differences by age group, with a P value <.05 regarded as significant. Data analysis was performed using the R software (version 3.6.2).

Univariate Analyses

Exploratory data analysis techniques were performed to reveal the distribution structure of the outcome variables and identify outliers or unusually entered values. Statistical analyses were performed using descriptive statistics for continuous (mean and SD) and categorical (frequency and proportion) variables. These tests were performed on each participant's demographics and the *Use and Perception of the Mobile Phone App* data.

Bivariate Analysis

The distribution of the background characteristics of the study groups was compared. To establish baseline equivalence between the intervention and control groups, 2 analytical tests were used. The distribution of categorical variables (proportions) was compared using Pearson chi-square test, whereas the distribution of continuous variables (mean and SD) was compared using an independent t test. Bivariate analysis was also performed on participant demographics, and the use and perception of mobile phone app data. A P value <.05 was regarded as significant.

Analysis of the Effect of the Intervention

Longitudinal continuous outcome scores were analyzed across time points (baseline and end line) to understand the effect of variations in outcome scores. The 2-tailed paired sample t test would compare the means of the intervention and control groups. The continuous outcomes were normally distributed. The threshold for statistical significance for all analyses was set at P<.05. This analysis was performed on the knowledge score data.

Results

Overview

In October 2019, 305 adolescents from 12 villages in Kibra were mobilized and screened for eligibility. Owing to lack of access to a mobile phone, 5 adolescents were excluded from the study. Study participants were then randomized to the intervention (154/300, 51.3%) and control (146/300, 48.7%) groups. From late December 2019, 77% (231/300) of the adolescents were successfully followed up—74.7% (109/300) from the intervention group and 76.6% (118/300) from the control group. As the app was not used at least once, 47 participants, together with another 4 participants with incomplete data in the intervention group, were excluded from the final analysis. Figure 1 shows the enrollment and follow-up stages of the study. The data were analyzed as per the per-protocol analysis.

Background Characteristics of the Study Participants

The distribution of the study participants according to the selected background characteristics indicated a desired comparable result at baseline as shown in Table 1. The mean ages of the participants in the control group (17.29, SD 1.23 years) and the intervention group (17.27, SD 1.12 years) were statistically comparable (P=.94). There were no significant differences in participant demographics. However, there was a statistically significant difference in the distribution of sex (P=.03) by the study enrollment group.

Table 1. Characteristics of the study participants (N=300).

Variables	Total (n=180), n (%)	Intervention (n=62), n (%)	Control (n=118), n (%)	P value
Sex				.03
Male	67 (37.2)	30 (48.4)	37 (31.4)	
Female	113 (62.8)	32(51.6)	81 (68.6)	
Phone ownership				.64
Adolescent	81 (45)	30 (48.4)	51 (43.2)	
Parent or guardian	90 (50)	30 (48.4)	60 (50.8)	
Other	9 (5)	2 (3.2)	7 (5.9)	
Highest level of education				.97
Primary	23 (12.8)	8 (12.9)	15 (12.7)	
Secondary and above	157 (87.2)	54 (87.1)	103 (87.3)	

SRH Knowledge Score

Participants' responses were analyzed by attitude toward contraceptives, gender role stereotypes, abstinence, and perceived vulnerability to negative SRH outcomes. Knowledge scores were also analyzed as aggregated data. A paired sample t test analysis of the relationship between the knowledge score and the use of the mobile app was performed using R software.

Table 2 presents an analysis of the effect of the intervention on specific indicator scores. The difference in the mean scores between those enrolled in the intervention group compared with those in the control group showed statistical significance in the

total knowledge scores. The overall mean change in total scores in the intervention group was 0.5 (P=.02) compared with the control group 0.246 (P=.24). The P value between the 2 groups on the total knowledge scores was .03, which was statistically significant, indicating that the mobile app had an impact on the adolescents' SRH knowledge scores. In the intervention group, the intervention had a statistically significant effect on contraceptive scores (0.355; P=.02). The intervention also showed a trend toward statistical significance in abstinence knowledge scores (0.129, P=.09).

Table 2. Effects of intervention on overall and specific knowledge scores.

Outcome (knowledge score)	Intervention					Control					Between group, P value
	Baseline, mean (SD); 95% CI	End line, mean (SD); 95% CI	Difference in scores, mean (SD); 95% CI	Effect sizes	Within group, P value	Baseline, mean (SD); 95% CI	End line, mean (SD); 95% CI	Difference in score, mean (SD); 95% CI	Effect sizes	Within group, P value	
Contraceptives	3.613 (1.107); 3 to 4	3.968 (0.887); 4 to 5	0.355 (1.147); 0.064 to 0.646	0.309	.02	3.602 (1.039); 3 to 4	3.678 (1.183); 3 to 5	0.076 (1.235); −0.148 to 0.301	0.062	.5	.06
Vulnerability	2.000 (0.768); 1.25 to 3	2.032 (0.768); 2 to 3	0.0323 (0.829); −0.178 to 0.243	0.038	.76	1.856 (0.860); 1 to 2.75	1.941 (0.798); 1 to 2.75	0.085 (0.939); −0.086 to 0.256	0.090	.33	.32
Gender stereotype	3.097 (0.987); 3 to 4	3.081 (1.060); 3 to 4	−0.016 (0.757); −0.208 to 0.176	0.021	.87	2.890 (1.160); 2 to 4	2.881 (1.126); 2 to 4	−0.008 (1.121); −0.213 to 0.196	0.008	.94	.88
Abstinence	1.565 (0.532); 1 to 2	1.694 (0.465); 1 to 2	0.129 (0.586); −0.020 to 0.278	0.220	.09	1.576 (0.576); 1 to 2	1.669 (0.539); 1 to 2	0.129 (0.569); −0.011 to 0.197	0.163	.08	.01
Total knowledge score	10.270 (2.050); 9 to 12	10.770 (2.012); 10 to 12	0.5 (1.576); 0.099 to 0.900	0.317	.02	9.924 (2.227); 8.25 to 12	10.170 (2.412); 9 to 12	0.246 (2.242); −0.163 to 0.654	0.109	.24	.03

Use and Perceptions of the Mobile Phone App

The use and perceptions questionnaires were used to measure the perceived usefulness of the app. We also aimed to evaluate how the knowledge adolescents received from the app influenced their SRH decision-making. Tables 3 and 4 show the descriptive statistics of our evaluation. The tables show the responses from each adolescent who had used the mobile app at least once in 3 months. The questions addressed topics of interest, the perceived usefulness of information, and the mobile app features the users appreciated. The information in Table 3 is stratified by age—adolescents aged <18 years and those ≥18 years. Table 4 is stratified by gender.

Information about STIs was of great interest to the participants, with 26.7% (20/75) of the responses by users seeking information on this subject the last time they used the app. Adolescent girl participants had a higher interest in STIs, with 55% (11/20) accessing this information. Most participants (56/62, 90.8%) found the information provided in the app to have adequately answered their questions or met their SRH information needs. All the 62 adolescents who used the app felt that the information they received could improve their decision-making on issues relating to SRH. This outcome was similar when data were stratified by age and gender.

The participants reported gaining knowledge from the app on several SRH issues in their responses, including abstinence (53/125, 42.4%), STIs (30/125, 24%), and condom use (22/125, 17.6%). Although only 9.7% (12/125) of the participant's responses showed increased knowledge of contraceptives, 75% (9/12) of these were female, showing a trend toward significance (P=.08).

On improved decision-making, 38.1% (51/134) of the adolescent participant's responses show they were able to abstain from sex. Of these responses, 54.9% (28/51) were aged between 15 and 17 years and 52.9% (27/51) were male. The knowledge obtained may have also prompted 26.9% (36/134) of the responses to show use a condom by the adolescent participants during a sexual encounter. Although sex is illegal for ages under 18 years in Kenya, 50% of those who reported deciding to use a condom were aged ≤17 years. Of the participants who used a condom, 52.8% (19/36) were male. Adolescent participants were also able to identify STIs, with 21.6% (29/134) responses reporting that app information guided their decision to seek treatment after identifying an STI; 51.7% (15/29) of these responses were from female participants.

Ease of use was the most important feature of the app for 28.3% (54/191) of the participants' responses, followed by confidentiality at 26.7% (51/191) and high-quality information

at 23.6% (45/191), with 60% (27/45) of the latter being from responses by female participants.

Table 3. Use and perception of the mobile app stratified by age groups (62 participants).

Variable	All, n (%)	Age <18 years, n (%)	Age ≥18 years, n (%)	*P* value
What information did you require when you last used the mobile app?				
STIs[a]	20 (26.7)	8 (40)	12 (60)	.37
Drugs	18 (24)	12 (66.7)	6 (33.3)	.16
Relationship	17 (22.7)	9 (52.9)	8 (47.1)	.81
Sex	12 (16)	4 (33.3)	8 (66.7)	.25
Contraceptives	6 (8)	3 (50)	3 (50)	>.99
Pregnancy	2 (2.7)	0 (0)	2 (100)	.16
What knowledge about SRH[b] issues have you gained?				
Abstinence	53 (42.4)	28 (52.8)	25 (47.2)	.68
STIs	30 (24)	14 (46.7)	16 (53.3)	.72
Condom use	22 (17.6)	12 (54.5)	10 (45.5)	.67
Contraceptives	12 (9.6)	6 (50)	6 (50)	>.99
Drugs	8 (6.4)	5 (62.5)	3 (37.5)	.48
What decision-making was informed by the information you accessed on the mobile app?				
Abstinence	51 (38.1)	28 (54.9)	23 (45.1)	.48
Condom use	36 (26.9)	18 (50)	18 (50)	>.99
STIs	29 (21.6)	11 (37.9)	18 (62.1)	.19
Contraceptives	9 (6.7)	6 (66.7)	3 (33.3)	.32
Drugs	9 (6.7)	6 (66.7)	3 (33.3)	.32
Were the questions you had on SRH answered adequately?				
Yes	56 (90.3)	30 (53.6)	26 (46.4)	>.99
No	6 (9.7)	3 (50)	3 (50)	
Did the information you receive inform better decision-making on SRH matters?				
Yes	62 (100)	33 (53.2)	29 (46.8)	.62
No	0 (0)	0 (0)	0 (0)	
What are the most important features of the mobile phone app?				
Ease of use	54 (28.3)	28 (51.9)	26 (48.1)	.79
Confidentiality	51 (26.7)	26 (51)	25 (49)	.89
Quality of information	45 (23.6)	24 (53.3)	21 (46.7)	.65
Immediate feedback	41 (21.5)	20 (48.8)	21 (51.2)	.88

[a]STI: sexually transmitted infection.

[b]SRH: sexual reproductive health.

Table 4. Use and perception of the mobile app stratified by gender (62 participants).

Variable	All, n (%)	Male, n (%)	Female, n (%)	*P* value
What information did you require when you last used the mobile app?				
STIs[a]	20 (27)	9 (45)	11 (55)	.65
Drugs	18 (24.3)	10 (55.6)	8 (44.4)	.64
Relationships	16 (21.6)	8 (47.1)	9 (52.9)	.81
Sex	12 (16.2)	5 (41.7)	7 (58.3)	.56
Contraceptives	6 (8.1)	1 (16.7)	5 (83.3)	.10
Pregnancy	2 (2.7)	1 (50)	1 (50)	>.99
What knowledge about sexual reproductive health matters have you gained?				
Abstinence	53 (42.7)	26 (49.1)	27 (50.9)	.89
STIs	30 (24.2)	13 (43.3)	17 (56.7)	.47
Condom use	22 (17.7)	13 (50.1)	9 (40.9)	.39
Contraceptives	12 (9.7)	3 (25)	9 (75)	.08
Drugs	7 (5.6)	2 (25)	6 (75)	.16
What better decision-making was informed by the information you accessed on the mobile app?				
Abstinence	51 (38.1)	27 (52.9)	24 (48.1)	.67
Condom use	36 (26.9)	19 (52.8)	17 (47.2)	.74
STIs	29 (21.6)	14 (48.3)	15 (51.7)	.85
Contraceptives	9 (6.7)	4 (44.4)	5 (55.6)	.74
Drugs	9 (6.7)	3 (33.3)	6 (66.7)	.32
Were the questions you had on SRH[b] answered adequately?				
Yes	56 (90.3)	26 (46.4)	30 (53.6)	.61
No	6 (9.7)	4 (33.3)	2 (66.7)	
Did the information you receive inform better decision-making on SRH matters?				
Yes	62 (100)	30 (48.4)	32 (51.6)	.80
No	0 (0)	0	0	
What are the most important features of the mobile phone app?				
Easy to use	54 (28.3)	26 (48.1)	28 (51.9)	.79
Confidentiality	51 (26.7)	24 (47.1)	27 (52.9)	.67
Quality of information	45 (23.6)	18 (40)	27 (60)	.18
Immediate feedback	41 (21.5)	19 (46.3)	22 (53.7)	.64

[a]STI: sexually transmitted infection.
[b]SRH: sexual reproductive health.

Discussion

Principal Findings

This study explored the use of a USSD-based mobile phone intervention to deliver on-demand adolescent SRH information in an RCT. We studied the effectiveness and impact of a USSD-based mobile phone app on increasing adolescents' knowledge of contraceptives, gender-based stereotypes, STIs, abstinence, and perceived vulnerability. We also evaluated the USSD-based ability of the mobile phone app to help adolescents make informed decisions regarding their SRH. Our results show improved awareness of SRH information and improved knowledge about contraceptives and abstinence. Increased awareness has enabled more adolescents to abstain from sex, improve condom use, and identify STIs. Confidentiality when accessing SRH information was of particular importance to the participants.

Adolescents' needs for information on contraceptives is unmet in most resource-limited settings; adolescents are unable to secure information on available contraceptive options or discover where they can access this information [27]. In our study, adolescents using the app improved their knowledge of contraceptives, with a trend toward statistical significant (*P*=.06). Our findings are promising, and mobile phone apps

could help increase awareness on and knowledge of contraceptives among adolescents. The provision of information on contraceptives to adolescents is complex because of cultural, religious, and political setbacks. Innovative approaches are needed to meet adolescents' information needs. The study outcomes also show the need to make information about contraceptives accessible to adolescents in a culturally and age-appropriate manner [28,29].

When accessing SRH information and services, adolescents want their confidentiality to be respected and upheld. Fear of being *judged* and the possibility of negative attitudes from health care providers can prevent adolescents from accessing these important services [30]. During follow-up visits, of the 62 adolescent participants who had used the mobile app, 51 (82.3%) indicated that confidentiality was one of the most important features of the app. Adolescent users can access any SRH information in a user-friendly manner. Research has shown that adolescents value confidentiality when accessing SRH information and are more willing to seek SRH care and interventions when their confidentiality is assured [31].

mHealth apps have shown great potential for engaging with and increasing SRH information access for adolescents from different age groups and social demographics [32,33]. In one study, text messages improved SRH outcomes by reducing pregnancy rates [34]. The aforementioned studies demonstrate the great potential of mHealth apps in improving and increasing adolescents' knowledge of SRH. Our study findings show that adolescents require high-quality SRH information provided in an easy-to-use, confidential manner with immediate feedback. The USSD technology enables an interactive user-driven mobile app to provide information based on a user's inputs. This USSD technology is low cost, works on both feature phones and smartphones, and can be provided free of charge.

Limitations

During the study, 47 adolescents were unable to use the mobile app, mainly because of a lack of access to mobile phones. This may explain why there appeared to have been a minimal change in adolescent users' knowledge scores. Access to mobile phones in most resource-limited settings is associated with the household economic status. In addition, access to a phone was self-reported. Several adolescents hoped to be provided with a phone by their parents, caregivers, or older siblings. Adolescent participants in the intervention group who were unable to use the app reported that either their parents traveled or the mobile phone they hoped to use stopped functioning. Some studies have opted to provide adolescent participants with mobile phones to ensure that participants in the intervention group accessed the mobile apps. This approach has increased the cost of the study, and other researchers have viewed providing mobile phones as an inducement. In resource-limited settings such as Kenya, access to the internet is limited and web-based apps may not be an option in this setting. However, internet cybercafes are available in many places. Providing internet payment vouchers to adolescents to access the internet and a customized web-based study app could be explored. The results of our study may not be generalizable across Kibra.

Conclusions

Adolescents require accurate and up-to-date SRH information to guide their decision-making and improve health outcomes. As they already use mobile phones in their day-to-day lives, mobile phone apps provide an ideal platform. Considerable promise has been demonstrated by studies using mobile apps to improve adolescents' access to SRH information. Scaled-up research on mHealth apps providing SRH information is required to better evaluate their impact on SRH outcomes.

Acknowledgments

The authors would like to thank James Serembe, Josephine Ocham, Samwel Oninga, and Nolline Oudu for working closely with the adolescents during enrollment and follow-up. In addition, they would like to thank all adolescent participants.

Authors' Contributions

PM, APN, II, JK, RN, and CC contributed to research protocol development, data review, and preparation of this manuscript. BS contributed to data review and paired sample t-test analysis.

Conflicts of Interest

None declared.

Editorial notice: This randomized study was only retrospectively registered. The editor granted an exception of ICMJE rules for prospective registration of randomized trials because the risk of bias appears low and the study was considered formative. However, readers are advised to carefully assess the validity of any potential explicit or implicit claims related to primary outcomes or effectiveness, as retrospective registration does not prevent authors from changing their outcome measures retrospectively.

Multimedia Appendix 1

Unstructured Supplementary Service Data app content.
[PDF File (Adobe PDF File), 65 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Adolescent recruitment script page of the approved consent form in English.

[PDF File (Adobe PDF File), 47 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Evaluation of knowledge of sexual reproductive health (SRH) information.
[PDF File (Adobe PDF File), 43 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Use and perceptions of the mobile phone app.
[PDF File (Adobe PDF File), 42 KB-Multimedia Appendix 4]

Multimedia Appendix 5

CONSORT-EHEALTH (V 1.6.1) checklist.
[PDF File (Adobe PDF File), 936 KB-Multimedia Appendix 5]

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Abbreviations

mHealth: mobile health
RCT: randomized controlled trial
SRH: sexual reproductive health
STI: sexually transmitted infection

USSD: Unstructured Supplementary Service Data
WHO: World Health Organization

Edited by L Buis, A Mavragani; submitted 14.06.21; peer-reviewed by D Levine, J Cyriac; comments to author 05.08.21; revised version received 07.09.21; accepted 20.02.22; published 15.04.22

Please cite as:
Macharia P, Pérez-Navarro A, Sambai B, Inwani I, Kinuthia J, Nduati R, Carrion C
An Unstructured Supplementary Service Data–Based mHealth App Providing On-Demand Sexual Reproductive Health Information for Adolescents in Kibra, Kenya: Randomized Controlled Trial
JMIR Mhealth Uhealth 2022;10(4):e31233
URL: https://mhealth.jmir.org/2022/4/e31233
doi: 10.2196/31233
PMID:

7. Conclusions and Future Work

7.1 Conclusions

Healthcare providers and parents are important sources of SRH information. Adolescents view healthcare providers as knowledgeable and expect them to offer user-friendly services. These services need constant review and improvement to meet adolescents' expectations. Parents need to continue to provide factual SRH information, as adolescents expect their parents to be able to offer reliable and trustworthy information to guide their decision making.

Interventions to increase awareness among adolescents about dangers relating to unprotected sex and drug use should be provided. User-friendly, on-demand information provided in an anonymous way could improve awareness and empower adolescents to make informed decisions, thereby improving their reproductive health outcomes. According to our participants, mobile phone apps have the potential to provide SRH information to adolescents.

Most of our participants favored the use of USSD. This technology works on any mobile phone, no installation is needed and no audit trail is left on the device, thereby enhancing confidentiality. The USSD service can be provided as a pre-paid service, which enables adolescents to access information without cost.

Adolescents need information on sexual reproductive health, and want to be involved in the design and development process of interventions intended to meet their needs. A HCD approach to the design and development of mhealth apps leads to technology acceptance by the users. The developed technology can be easily scaled-up as it meets the user's needs and is user friendly. Being involved at every stage of the app design and development in this study, participants found both the content and USSD app very appropriate. The USSD app worked on the feature phones they could access and the services were toll-free. Their privacy was protected by the absence of an audit trail.

The USSD mobile phone technology is ideal for resource-limited settings, as users in these areas may only be able to access feature phones, have to share a phone and/or be unable to pay for services. The USSD technology works seamlessly on both feature phones and smartphones. No information is saved on the phone when using USSD, thus maintaining confidentiality even on shared phones, and the service can be pre-paid by the provider.

Adolescents require accurate and up-to-date SRH information to guide their decision making and improve health outcomes. As they already use mobile phones in their day-to-day lives, mobile phone apps provide an ideal platform. A considerable amount of promise has been demonstrated by studies using mobile apps to improve adolescents' access to SRH information. Scaled-up research into mHealth apps providing SRH information is required to better evaluate their impact on SRH outcomes.

7.2 Future work

Measuring behavior change and SRH outcomes needs longer follow-up periods to evaluate impact. It would be important to further test mobile phone-based SRH apps in settings were STIs, pregnancies or other biomarkers could be included to effectively show how such an app improves SRH. In resource-limited settings like Kenya, access to the internet is limited, web-based apps may not be an option in this setting. However, internet cyber cafes are available in a number of places. Maybe, providing internet payment vouchers to adolescents to access the internet and a customized web-based study app could be explored.

The HCD approach to mhealth app development has been proved in this study to positively impact the design and development of the final product. Meaningful involvement of adolescents to design and develop an mhealth app improves acceptance and uptake.

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Appendices

Appendix 1A English: Adolescent (15 – 17-year-old) Recruitment Script

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies to Provide On-Demand Adolescent Sexual Reproductive Health Information in A Resource Limited Setting: Kibra, Nairobi County

Adolescent (15 – 17-year-old) Recruitment Script

My name is _____; I am a PhD student in Network and Information Technologies at the Open University of Catalonia. This discussion will principally focus on identifying the adolescent SRH needs from a sample of adolescents in your locality. By so doing, the study will document your SRH needs, identified gaps and preferred mobile phone technology-based modes of access. We value your opinions. Please remember that your participation is voluntary and you are free to not respond to any question or to end the interview at any time.

You will be required to be accompanied by your parent or guardian to the study site location for consenting and assenting procedures before you can take part in the study.

The interview will last approximately 30 – 40 minutes. Should you choose to participate, you will receive a gift worth Kshs. 100 for your time and effort if you agree to be part of the interview.

Your permission is also sought to record the interview to be transcribed and analyzed afterwards. The recording will be locked away in a safe place and the final reports will not be traceable back to individual participants.

Would you be interested in participating in a discussion with other adolescents to provide your experiences and perspectives on adolescents SRH needs, identified gaps and preferred mobile phone technology-based modes of access? **Yes**/**No**

Are you 15 – 17 years old? **Yes**/**No**

Are you accompanied by a Parent /Guardian**? Yes**/**No**

Have you lived in this community for the last 3 months? **Yes**/**No**

If **YES TO ALL ABOVE**: Proceed to consent process.

If **NO TO ANY**: Thank you for your time.

Appendix 1B English: Adolescent (18 – 19-year-old) Recruitment Script

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies to Provide On-Demand Adolescent Sexual Reproductive Health Information in A Resource Limited Setting: Kibra, Nairobi County

Adolescent (18 – 19-year-old) Recruitment Script

My name is _____; I am a PhD student in Network and Information Technologies at the Open University of Catalonia. This discussion will principally focus on identifying the adolescent SRH needs from a sample of adolescents in your locality. By so doing, the study will document your SRH needs, identified gaps and preferred mobile phone technology-based modes of access. We value your opinions. Please remember that your participation is voluntary and you are free to not respond to any question or to end the interview at any time.

The interview will last approximately 30 – 40 minutes. Should you choose to participate, you will receive a gift worth Kshs. 100 for your time and effort if you agree to be part of the interview.

Your permission is also sought to record the interview to be transcribed and analyzed afterwards. The recording will be locked away in a safe place and the final reports will not be traceable back to individual participants.

Would you be interested in participating in a discussion with other adolescents to provide your experiences and perspectives on adolescents SRH needs, identified gaps and preferred mobile phone technology-based modes of access? **Yes**/**No**

Are you 18 – 19 years old? **Yes**/**No**

Have you lived in this community for the last 3 months? **Yes**/**No**

If **YES TO ALL ABOVE**: Proceed to consent process.

If **NO TO ANY**: Thank you for your time.

Appendix 1C English: Adolescent (15 – 17-year-old) Recruitment Script

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies to Provide On-Demand Adolescent Sexual Reproductive Health Information in A Resource Limited Setting: Kibra, Nairobi County

Adolescent (15 – 17-year-old) Recruitment Script

My name is _____; I am a PhD student in Network and Information Technologies at the Open University of Catalonia. This discussion will principally focus on identifying the adolescent SRH needs from a sample of adolescents in your locality. By so doing, the study seeks to pilot a preferred mobile phone technology-based mode of accessing SRH information. The ultimate goal of this study is to improve the health and well-being of adolescents like ***you.*** Please remember that your participation is voluntary and you are free to not respond to any question or to end the interview at any time.

You will be required to be accompanied by your parent or guardian to the study site location for consenting and assenting procedures before you can take part in the study.

The interview will last approximately 30 – 40 minutes. Should you choose to participate, you will receive a gift worth Kshs. 100 for your time and effort if you agree to be part of the interview.

Would you be interested in participating in a discussion with other adolescents to provide your experiences and perspectives on adolescents SRH needs, identified gaps and preferred mobile phone technology-based modes of access? **Yes**/**No**

Are you 15 – 17 years old? **Yes**/**No**

Are you accompanied by a Parent /Guardian**? Yes**/**No**

Have you lived in this community for the last 3 months? **Yes**/**No**

If **YES TO ALL ABOVE**: Proceed to consent process.

If **NO TO ANY**: Thank you for your time.

Appendix 1D English: Adolescent (18 – 19-year-old) Recruitment Script

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies to Provide On-Demand Adolescent Sexual Reproductive Health Information in A Resource Limited Setting: Kibra, Nairobi County

Adolescent (18 – 19-year-old) Recruitment Script

My name is _____; I am a PhD student in Network and Information Technologies at the Open University of Catalonia. This discussion will principally focus on identifying the adolescent SRH needs from a sample of adolescents in your locality. By so doing, the study seeks to pilot a preferred mobile phone technology-based mode of accessing SRH information. The ultimate goal of this study is to improve the health and well-being of adolescents like ***you.*** Please remember that your participation is voluntary and you are free to not respond to any question or to end the interview at any time.

The interview will last approximately 30 – 40 minutes. Should you choose to participate, you will receive a gift worth Kshs. 100 for your time and effort if you agree to be part of the interview.

Would you be interested in participating in a discussion with other adolescents to provide your experiences and perspectives on adolescents SRH needs, identified gaps and preferred mobile phone technology-based modes of access? **Yes**/**No**

Are you 18 – 19 years old? **Yes**/**No**

Have you lived in this community for the last 3 months? **Yes**/**No**

If **YES TO ALL ABOVE**: Proceed to consent process.

If **NO TO ANY**: Thank you for your time.

Appendix 2 English: Adolescent Focus Group Discussion Guide

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies to Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent Focus Group Discussion Guide

1. How do you currently access sexual reproductive health information including relationships, sex and contraception?
2. How knowledgeable do you feel about sexual reproductive health?
3. Whom or what do you rely on for information? Whom or what are the most important sources to you? How important to you is each source?
4. Can you list the places and people you know of which young people like yourself are able to visit and talk to, to find out about sexual reproductive health information including relationships, sex and contraception?
5. Do you feel that the information you have received has been adequate? What issues do you feel you lack knowledge of?
6. What are your general feelings about the services you have accessed?
7. What do you think are the most important features of a sexual reproductive health service for young people?
8. What role has the technology played in informing you about sexual reproductive health information including relationships, sex and contraception?
9. What role could mobile phone technologies play to improve adolescents' access to sexual reproductive health information?
10. Would you access sexual reproductive health information on a mobile phone technology? Why?
11. Do you think adolescents would be able to access mobile phone to use? Why?
12. What mobile phone technologies (SMS, USSD, WhatsApp, Facebook or Customized Android app) would you prefer to use to access SRH information?
13. If a customized Android app, what features would you like the app to have?

Appendix 3 English: Mobile Application Rating Scale (MARS)

Mobile Application Rating Scale (MARS)

App Classification

The Classification section is used to collect descriptive and technical information about the app. Please review the app description in iTunes / Google Play to access this information.

App Name: _____

Rating this version:_____ **Rating all versions:** _____

Developer: _____

N ratings this version:_____ **N ratings all versions:** _____

Version:_____ **Last update:** _____

Cost - basic version:_____ **Cost - upgrade version:** _____

Platform: iPhone iPad Android Feature Phone

Brief description: _____

Focus: what the app targets (select all that apply)

Increase Happiness/Well-being
Mindfulness/Meditation/Relaxation
Reduce negative emotions
Depression
Anxiety/Stress
Anger
Behaviour Change
Alcohol /Substance Use
Goal Setting
Entertainment
Relationships
Physical health
Other _____

Theoretical background/Strategies (all that apply)

Assessment
Feedback
Information/Education
Monitoring/Tracking
Goal setting
Advice /Tips /Strategies /Skills training
CBT - Behavioural (positive events)
CBT – Cognitive (thought challenging)
ACT - Acceptance commitment therapy
Mindfulness/Meditation
Relaxation
Gratitude
Strengths based
Other _____

Affiliations:

Unknown Commercial Government NGO University

Age group (all that apply)

Adolescents (13-17)
Young Adults (18-25)
Adults
General

Technical aspects of app (all that apply)

Allows sharing (Facebook, Twitter, etc.)
Has an app community
Allows password-protection
Requires login
Sends reminders
Needs web access to function

App Quality Ratings

The Rating scale assesses app quality on four dimensions. All items are rated on a 5-point scale from “1 Inadequate” to “5 Excellent”. Circle the number that most accurately represents the quality of the app component you are rating. Please use the descriptors provided for each response category.

SECTION A

Engagement – fun, interesting, customisable, interactive (e.g. sends alerts, messages, reminders, feedback, enables sharing), well-targeted to audience

1. ***Entertainment: Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g. through gamification)?***

    1 Dull, not fun or entertaining at all
    2 Mostly boring
    3 OK, fun enough to entertain user for a brief time (< 5 minutes)
    4 Moderately fun and entertaining, would entertain user for some time (5-10 minutes total)
    5 Highly entertaining and fun, would stimulate repeat use

2. ***Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?***

    1 Not interesting at all
    2 Mostly uninteresting
    3 OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
    4 Moderately interesting; would engage user for some time (5-10 minutes total)
    5 Very interesting, would engage user in repeat use

3. ***Customization: Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?***

    1 Does not allow any customization or requires setting to be input every time
    2 Allows insufficient customization limiting functions
    3 Allows basic customization to function adequately
    4 Allows numerous options for customization
    5 Allows complete tailoring to the individual's characteristics/preferences, retains all settings

4. ***Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customizable and not overwhelming in order to be perfect.***

    1 No interactive features and/or no response to user interaction
    2 Insufficient interactivity, or feedback, or user input options, limiting functions
    3 Basic interactive features to function adequately
    4 Offers a variety of interactive features/feedback/user input options
    5 Very high level of responsiveness through interactive features/feedback/user input options

5. ***Target group: Is the app content (visual information, language, design) appropriate for your target audience?***

1 Completely inappropriate/unclear/confusing
2 Mostly inappropriate/unclear/confusing
3 Acceptable but not targeted. May be inappropriate/unclear/confusing
4 Well-targeted, with negligible issues
5 Perfectly targeted, no issues found

A. Engagement mean score = _____

SECTION B
Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of app

6. ***Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?***

1 App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
2 Some functions work, but lagging or contains major technical problems
3 App works overall. Some technical problems need fixing/Slow at times
4 Mostly functional with minor/negligible problems
5 Perfect/timely response; no technical bugs found/contains a 'loading time left' indicator

7. ***Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?***

1 No/limited instructions; menu labels/icons are confusing; complicated
2 Useable after a lot of time/effort
3 Useable after some time/effort
4 Easy to learn how to use the app (or has clear instructions)
5 Able to use app immediately; intuitive; simple

8. ***Navigation: Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?***

1 Different sections within the app seem logically disconnected and random/confusing/navigation is difficult
2 Usable after a lot of time/effort
3 Usable after some time/effort
4 Easy to use or missing a negligible link
5 Perfectly logical, easy, clear and intuitive screen flow throughout, or offers shortcuts

9. Gestural design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?

1 Completely inconsistent/confusing
2 Often inconsistent/confusing
3 OK with some inconsistencies/confusing elements
4 Mostly consistent/intuitive with negligible problems
5 Perfectly consistent and intuitive

B. Functionality mean score = _____

SECTION C

Aesthetics – graphic design, overall visual appeal, colour scheme, and stylistic consistency

10. Layout: Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?

1 Very bad design, cluttered, some options impossible to select/locate/see/read device display not optimized
2 Bad design, random, unclear, some options difficult to select/locate/see/read
3 Satisfactory, few problems with selecting/locating/seeing/reading items or with minor screen- size problems
4 Mostly clear, able to select/locate/see/read items
5 Professional, simple, clear, orderly, logically organized, device display optimized. Every design component has a purpose

11. Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?

1 Graphics appear amateur, very poor visual design - disproportionate, completely stylistically inconsistent
2 Low quality/low resolution graphics; low quality visual design – disproportionate, stylistically inconsistent
3 Moderate quality graphics and visual design (generally consistent in style)
4 High quality/resolution graphics and visual design – mostly proportionate, stylistically consistent
5 Very high quality/resolution graphics and visual design - proportionate, stylistically consistent throughout

12. Visual appeal: How good does the app look?

1 No visual appeal, unpleasant to look at, poorly designed, clashing/mismatched colours
2 Little visual appeal – poorly designed, bad use of colour, visually boring
3 Some visual appeal – average, neither pleasant, nor unpleasant

4 High level of visual appeal – seamless graphics – consistent and professionally designed

5 As above + very attractive, memorable, stands out; use of colour enhances app features/menus

C. Aesthetics mean score = _____

SECTION D

Information – Contains high quality information (e.g. text, feedback, measures, references) from a credible source. Select N/A if the app component is irrelevant.

13. Accuracy of app description (in app store): Does app contain what is described?

1 Misleading. App does not contain the described components/functions. Or has no description

2 Inaccurate. App contains very few of the described components/functions

3 OK. App contains some of the described components/functions

4 Accurate. App contains most of the described components/functions

5 Highly accurate description of the app components/functions

14. Goals: Does app have specific, measurable and achievable goals (specified in app store description or within the app itself)?

N/A Description does not list goals, or app goals are irrelevant to research goal (e.g. using a game for educational purposes)

1 App has no chance of achieving its stated goals

2 Description lists some goals, but app has very little chance of achieving them

3 OK. App has clear goals, which may be achievable.

4 App has clearly specified goals, which are measurable and achievable

5 App has specific and measurable goals, which are highly likely to be achieved

15. Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?

N/A There is no information within the app

1 Irrelevant/inappropriate/incoherent/incorrect

2 Poor. Barely relevant/appropriate/coherent/may be incorrect

3 Moderately relevant/appropriate/coherent/and appears correct

4 Relevant/appropriate/coherent/correct

5 Highly relevant, appropriate, coherent, and correct

16. Quantity of information: Is the extent coverage within the scope of the app; and comprehensive but concise?

N/A There is no information within the app

1 Minimal or overwhelming

2 Insufficient or possibly overwhelming

3 OK but not comprehensive or concise

4 Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources

5 Comprehensive and concise; contains links to more information and resources

17. Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc.

– clear, logical, correct?

N/A There is no visual information within the app (e.g. it only contains audio, or text)

1 Completely unclear/confusing/wrong or necessary but missing

2 Mostly unclear/confusing/wrong

3 OK but often unclear/confusing/wrong

4 Mostly clear/logical/correct with negligible issues

5 Perfectly clear/logical/correct

18. Credibility: Does the app come from a legitimate source (specified in app store description or within the app itself)?

1 Source identified but legitimacy/trustworthiness of source is questionable (e.g. commercial business with vested interest)

2 Appears to come from a legitimate source, but it cannot be verified (e.g. has no webpage)

3 Developed by small NGO/institution (hospital/centre, etc.) /specialised commercial business, funding body

4 Developed by government, university or as above but larger in scale

5 Developed using nationally competitive government or research funding (e.g. Australian Research Council, NHMRC)

19. Evidence base: Has the app been trialed/tested; must be verified by evidence (in published scientific literature)?

N/A The app has not been trialed/tested

1 The evidence suggests the app does not work

2 App has been trialed (e.g., acceptability, usability, satisfaction ratings) and has partially positive outcomes in studies that are not randomized controlled trials (RCTs), or there is little or no contradictory evidence.

3 App has been trialed (e.g., acceptability, usability, satisfaction ratings) and has positive outcomes in studies that are not RCTs, and there is no contradictory evidence.

4 App has been trialed and outcome tested in 1-2 RCTs indicating positive results

5 App has been trialed and outcome tested in ≥ 3 high quality RCTs indicating positive results

D. Information mean score =_____*

* Exclude questions rated as “N/A” from the mean score calculation.

SECTION E: App subjective quality

1. ***Would you recommend this app to people who might benefit from it?***

Not at all	I would not recommend this app to anyone
	There are very few people I would recommend this app to
Maybe	There are several people whom I would recommend it to
	There are many people I would recommend this app to
Definitely	I would recommend this app to everyone

2. **How many times do you think you would use this app in the next 12 months if it was relevant to you?**

1 **None**
2 1-2
3 3-10
4 10-50
5 >50

3. ***Would you pay for this app?***

1 No
3 Maybe
5 Yes

4. ***What is your overall rating of the app?***

1 One of the worst apps I've used
2 Below Average App
3 Average App
4 Above Average App
5 One of the best apps I've used

Scoring
App quality scores for
SECTION

A: Engagement Mean Score = _____

B: Functionality Mean Score = _____

C: Aesthetics Mean Score = _____

D: Information Mean Score = _____

App quality mean Score ***=*** _____

App subjective quality Score = _____

App-specific
These added items can be adjusted and used to assess the perceived impact of the app on the user's knowledge, attitudes, intentions to change as well as the likelihood of actual change in the target health behavior.

SECTION F

1. **Awareness: This app is likely to increase awareness of the importance of addressing [insert target health behavior]**

Strongly disagree 1 2 3 4 5 Strongly Agree

2. ***Knowledge: This app is likely to increase knowledge/understanding of [insert target health behavior]***

Strongly disagree 1 2 3 4 5 Strongly Agree

3. ***Attitudes: This app is likely to change attitudes toward improving [insert target health behavior]***

Strongly disagree 1 2 3 4 5 Strongly Agree

4. ***Intention to change: This app is likely to increase intentions/motivation to address [insert target health behaviour]***

Strongly disagree 1 2 3 4 5 Strongly Agree

5. ***Help seeking: Use of this app is likely to encourage further help seeking for [insert target health behaviour] (if It is required)***

Strongly disagree 1 2 3 4 5 Strongly Agree

6. ***Behaviour change: Use of this app is likely increase/decrease [insert target health behaviour]***

Strongly disagree 1 2 3 4 5 Strongly Agree

Appendix 4 English: Use and Perceptions of the Mobile Phone Application

Have you ever used the mobile application for information on contraception, pregnancy, abortion or sexually transmitted infections?	Yes 1 No 2	END if No
How many times have used the mobile application for information for these services in the last three (3) months?	Number of times	END if 0 times
When you last used the mobile application, what was your reason? (All that Apply)	Contraception STIs Sex Pregnancy Other……	
Did you feel comfortable enough using the mobile application?	Yes 1 No 2	
Yes, Why?		
No, Why?		
Were the questions you had answered adequately?	Yes 1 No 2	
Yes, Why?		
No, Why?		
Did you feel that the information you received informed better decision making on sexual reproductive health matters?	Yes 1 No 2	
Yes, Why?		
No, Why?		
If yes, what better decision making on sexual reproductive health matters was informed by the information you accessed on the mobile application? (All that Apply)	Condom use with partners Choice of Contraception Identifying an STI Abstenance Other Specify…….	

Do you now feel knowledgeable about sexual reproductive health matters?	Yes 1 No 2	
Yes, Why?		
No, Why?		
If yes, what knowledge about sexual reproductive health matters have you gained? (All that Apply)	Condom use with partners Choice of Contraception Identifying an STI Abstenance Other Specify…….	
What do you think are the most important features of the mobile phone application on adolescent sexual reproductive health? (All that Apply)	Easy to use Quality information Confidential Immediate feedback Other specify ……..	
Was there enough confidentiality?	Yes 1 No 2	
Yes, Why?		
No, Why?		

Appendix 5 English: Adolescent Participant Profile

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent Focus Group Discussion Guide and user experience questionnaire

Participant Profile

Participant ID: ……

Date: ……..

DO NOT put your name on this form

Please use a tick, circle or insert information that applies to you,

1. Age: …….
2. Gender: (a) Male (b) Female
3. Educational Background
   (a) None (b) Primary (c) Secondary (d) College (e) University
4. Occupation

(a) None (b) House wife (c) Self-employed (d) Employed (e) Student

Appendix 6A English: Parent/Guardian Informed Consent Form

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Parent/Guardian Informed Consent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

Introduction

Hello, my name is ----------. **Your child** has been invited to take part in a research study. Before you decide whether to **allow your child to participate**, you need to understand why the research is being done and what it would involve. Please take the time to read or to listen as I read the following information. You may talk to others about the study if you wish. Please ask me if there is anything that is not clear, or if you would like more information. When all of your questions have been answered and you feel that you understand this study, you will be asked if you **will allow your child to participate** in the study, and if you decide to **allow your child to participate** in this research study, we will then ask you to give your **written consent**. Your **child's participation** is completely voluntary and **you** can withdraw participation at any time with no penalty.

Purpose of the Study and Study Requirements

What is the study about? This study is being carried out by **Paul Macharia of the open University of Catalonia**, The study seeks to identify the adolescent SRH needs, map SRH services from a sample of youth programs at the Ministry of Health facilities and identify SRH information gaps and preferred mobile phone technology-based modes of access. The ultimate goal of this study is to improve the health and well-being of adolescents like ***your child.***

Why have you been invited to take part? You have been invited to take part because **your child** is an adolescent with SRH needs.

What will happen if I take part?

1. Your child will be enrolled in a Focus group discussion (FGD) to identify adolescent SRH needs, identify SRH information gaps and preferred mobile phone technology-based modes of access with other adolescents like your child.

Risks

What are the risks of participating in the study? Your child may feel uneasy participating in a discussion on Sexual Reproductive Health.

Benefits

What are the benefits of participating in the study?
There is no direct benefit to you, however your child will have an opportunity to be sensitized on ASRH information and available services in this community. Their participation will inform the design of a mobile phone technology-based system to bridge the SRH information gap which could enhance access to adolescent SRH information.

Confidentiality

Will participation in the study be kept confidential? We will take all steps necessary to ensure **your** privacy and confidentiality. Given that your child will be visiting study site venue, **your child's** attendance may be known to other people who are also participating in this study. However we will request all participants to keep information that they observe about others during the visits confidential and not to share it with anyone.

Your child will be assigned a unique number and **their** name will not appear on any information like survey responses on the computer or services accessed. Safeguards for protecting confidentially of all data will be strictly enforced. All data will be kept in a secure location and will be destroyed at the end of the study. Each participant will respect the participation of others at the study site venue.

Voluntariness

What are my rights as a research participant/subject? Your child's participation in this study is completely voluntary. If you decide not participate, this will not affect their access to the Youth activities. Even after you decide **they could take part**, **you** may end **their** participation at any time without penalty or loss of existing benefits to which **they are** entitled.

Involuntary Early Termination of Participation:

Participants may be withdrawn from the study if the study sponsors, government or regulatory authorities, ethical/institutional review boards stop the study before its planned end date.

Additional Information

What will I receive for participating? Your child will not be paid for participation in the study, but we will give them a gift worth Kshs. 100 and you will get transport reimbursement of Ksh. 200 during today's visit.

Will it cost me anything to participate? No, it will not cost you anything to participate.

What will happen to the results of the research study? The results of the study will be discussed and presented in a report at team meetings and it will be used to help the design of a mobile phone technology-based system to bridge the SRH information gap. The information may be presented at a conference with other studies that relate to adolescent SRH. Neither the report nor the presentation will show **your child's** name.

Who has reviewed the study for ethical issues? This study has been reviewed and approved by the **Kenyatta Hospital/University of Nairobi Ethics Research Committee**.

What if I need more information? If you have a concern about any aspect of the study, you can ask me now or you can speak to any of the study staff who will do their best to answer your questions. If you have any other questions about the study, you may also **call Paul Macharia on +254-0722- 866753** or **email** at paulmachariah@gmail.com

What if there is a problem? Any complaint about the way you **or your child** has been treated during the study or any possible harm you might suffer will be addressed. **Please contact Prof. Chindia secretary to the Kenyatta National Hospital/University of Nairobi Ethics and research committee on +254-020-2726300.**

At this time, I want to make sure you understand the study and see whether you have any additional questions. After we discuss any questions you may have, we can discuss whether you are interested in participating in the study today.

Are you willing to allow your child participate in the study?

No □ **(if no, stop here)**
Yes □ **(if yes, continue below)**

Parent/Guardian of Participant: If you have read this consent form (or had it read and explained to you), all of your questions have been answered and you agree to **allow your child** take part in this study, please sign this form or make your mark to indicate your willingness to allow **her** participate.

Study staff who conducted informed consent discussion: I confirm that I have personally explained the nature and extent of the planned research, study procedures, potential risks and benefits, and confidentiality of personal information.

Participant's name (print)	**Participant's signature/thumbprint and date**
Participant's legal guardian name (print)	**Legal guardian signature/thumbprint and date**
Study staff conducting consent discussion (print)	**Study staff signature and date**
Witness's name (print) (if appropriate)	**Witness's signature (if appropriate)**

Appendix 6B English: Adolescent (15 – 17 year olds) Assent Form

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent (15 – 17 year olds) Assent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

Introduction

Hello, my name is ----------. **You** have been invited to take part in a research study. Before you decide whether to **participate**, you need to understand why the research is being done and what it would involve. Please take the time to read or to listen as I read the following information. You may talk to others about the study if you wish. Please ask me if there is anything that is not clear, or if you would like more information. When all of your questions have been answered and you feel that you understand this study, you will be asked if you **will participate** in the study, and if you decide to **Participate** in this research study, we will then ask you to give your **written assent**. Your **participation** is completely voluntary and **you** can withdraw participation at any time with no penalty.

Purpose of the Study and Study Requirements

What is the study about? This study is being carried out by **Paul Macharia of the open University of Catalonia**, the study seeks to identify the adolescent SRH needs, map SRH services from a sample of youth programs at the Ministry of Health facilities and identify SRH information gaps and preferred mobile phone technology-based modes of access. The ultimate goal of this study is to improve the health and well-being of adolescents like ***you.***

Why have you been invited to take part? You have been invited to take part because **you** are an adolescent in this study site location.

What will happen if I take part?

1. You will be enrolled in a Focus group discussion (FGD) to identify adolescent SRH needs, identify SRH information gaps and preferred mobile phone technology-based modes of access with other adolescents like you.

Risks

What are the risks of participating in the study? You may feel uneasy participating in a discussion on Sexual Reproductive Health.

Benefits

What are the benefits of participating in the study?
You have an opportunity to be sensitized on ASRH information and available services in this community. Your participation will also inform the design of a mobile phone technology-based system to bridge the SRH information gap which could enhance access to adolescent SRH information.

Confidentiality

Will participation in the study be kept confidential? We will take all steps necessary to ensure **your** privacy and confidentiality. Given that your will be visiting study site venue, **your** attendance may be known to other people who are also participating in this study. However, we will request all participants to keep information that they observe about others during the visits confidential and not to share it with anyone.

You will be assigned a unique number and **your** name will not appear on any information like survey responses on the computer or services accessed. Safeguards for protecting confidentially of all data will be strictly enforced. All data will be kept in a secure location and will be destroyed at the end of the study. Each participant will respect the participation of others at the study site venue.

Voluntariness

What are my rights as a research participant/subject? Your participation in this study is completely voluntary. If you decide not participate, this will not affect your access to the Youth Centre services. Even after you decide **to take part**, **you** may end **your** participation at any time without penalty or loss of existing benefits to which **you are** entitled.

Involuntary Early Termination of Participation:

Participants may be withdrawn from the study if the study sponsors, government or regulatory authorities, ethical/institutional review boards stop the study before its planned end date.

Additional Information

What will I receive for participating? You will not be paid for participation in the study, but we will give you a small gift worth Ksh. 100 during today's visit.

Will it cost me anything to participate? No, it will not cost you anything to participate.

What will happen to the results of the research study? The results of the study will be discussed and presented in a report at team meetings and it will be used to help the design of a mobile phone technology-based system to bridge the SRH information gap. The information may be presented at a conference with other studies that relate to adolescent SRH. Neither the report nor the presentation will show **your** name.
Who has reviewed the study for ethical issues? This study has been reviewed and approved by the **Kenyatta Hospital/University of Nairobi Ethics Research Committee**.

What if I need more information? If you have a concern about any aspect of the study, you can ask me now or you can speak to any of the study staff who will do their best to answer your questions. If you have any other questions about the study, you may also **call Paul Macharia on +254-0722- 866753** or **email** at paulmachariah@gmail.com

What if there is a problem? Any complaint about the way **you** have been treated during the study or any possible harm you might suffer will be addressed. **Please contact Prof. Chindia secretary to the Kenyatta National Hospital/University of Nairobi Ethics and research committee on +254-020-2726300.**

At this time, I want to make sure you understand the study and see whether you have any additional questions. After we discuss any questions you may have, we can discuss whether you are interested in participating in the study today.

Are you willing to participate in the study?

No □ **(if no, stop here)**
Yes □ **(if yes, continue below)**

Parent/Guardian of Participant: If you have read this consent form (or had it read and explained to you), all of your questions have been answered and you agree to **allow your child** take part in this study, please sign this form or make your mark to indicate your willingness to allow **her** participate.

Study staff who conducted informed consent discussion: I confirm that I have personally explained the nature and extent of the planned research, study procedures, potential risks and benefits, and confidentiality of personal information.

Participant's name (print)	**Participant's signature/thumbprint and date**
Participant's legal guardian name (print)	**Legal guardian signature/thumbprint and date**
Study staff conducting consent discussion (print)	**Study staff signature and date**
Witness's name (print) (if appropriate)	**Witness's signature (if appropriate)**

Appendix 6C English: Adolescent (18 – 19 year olds) Consent Form

Open University of Catalonia
Baseline Survey
Adolescent Focus Group Discussion
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent (18 – 19 year olds) Consent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

Introduction

Hello, my name is ----------. **You** have been invited to take part in a research study. Before you decide whether to **participate**, you need to understand why the research is being done and what it would involve. Please take the time to read or to listen as I read the following information. You may talk to others about the study if you wish. Please ask me if there is anything that is not clear, or if you would like more information. When all of your questions have been answered and you feel that you understand this study, you will be asked if you **will participate** in the study, and if you decide to **Participate** in this research study, we will then ask you to give your **written assent**. Your **participation** is completely voluntary and **you** can withdraw participation at any time with no penalty.

Purpose of the Study and Study Requirements

What is the study about? This study is being carried out by **Paul Macharia of the open University of Catalonia**, the study seeks to identify the adolescent SRH needs, map SRH services from a sample of youth programs at the Ministry of Health facilities and identify SRH information gaps and preferred mobile phone technology-based modes of access. The ultimate goal of this study is to improve the health and well-being of adolescents like ***you.***

Why have you been invited to take part? You have been invited to take part because **you** are an adolescent in this study site location.

What will happen if I take part?

1. You will be enrolled in a Focus group discussion (FGD) to identify adolescent SRH needs, identify SRH information gaps and preferred mobile phone technology-based modes of access with other adolescents like you.

Risks

What are the risks of participating in the study? You may feel uneasy participating in a discussion on Sexual Reproductive Health.

Benefits

What are the benefits of participating in the study?
You have an opportunity to be sensitized on ASRH information and available services in this community. Your participation will also inform the design of a mobile phone technology-based system to bridge the SRH information gap which could enhance access to adolescent SRH information.

Confidentiality

Will participation in the study be kept confidential? We will take all steps necessary to ensure **your** privacy and confidentiality. Given that your will be visiting study site venue, **your** attendance may be known to other people who are also participating in this study. However, we will request all participants to keep information that they observe about others during the visits confidential and not to share it with anyone.

You will be assigned a unique number and **your** name will not appear on any information like survey responses on the computer or services accessed. Safeguards for protecting confidentially of all data will be strictly enforced. All data will be kept in a secure location and will be destroyed at the end of the study. Each participant will respect the participation of others at the study site venue.

Voluntariness

What are my rights as a research participant/subject? Your participation in this study is completely voluntary. If you decide not participate, this will not affect your access to the Youth Centre services. Even after you decide **to take part**, **you** may end **your** participation at any time without penalty or loss of existing benefits to which **you are** entitled.

Involuntary Early Termination of Participation:

Participants may be withdrawn from the study if the study sponsors, government or regulatory authorities, ethical/institutional review boards stop the study before its planned end date.

Additional Information

What will I receive for participating? You will not be paid for participation in the study, but we will give you a small gift worth Ksh. 100 during today's visit.

Will it cost me anything to participate? No, it will not cost you anything to participate.

What will happen to the results of the research study? The results of the study will be discussed and presented in a report at team meetings and it will be used to help the design of a mobile phone technology-based system to bridge the SRH information gap. The information may be presented at a conference with other studies that relate to adolescent SRH. Neither the report nor the presentation will show **your** name.
Who has reviewed the study for ethical issues? This study has been reviewed and approved by the **Kenyatta Hospital/University of Nairobi Ethics Research Committee**.

What if I need more information? If you have a concern about any aspect of the study, you can ask me now or you can speak to any of the study staff who will do their best to answer your questions. If you have any other questions about the study, you may also **call Paul Macharia on +254-0722- 866753** or **email** at paulmachariah@gmail.com

What if there is a problem? Any complaint about the way **you** have been treated during the study or any possible harm you might suffer will be addressed. **Please contact Prof. Chindia secretary to the Kenyatta National Hospital/University of Nairobi Ethics and research committee on +254-020-2726300.**

At this time, I want to make sure you understand the study and see whether you have any additional questions. After we discuss any questions you may have, we can discuss whether you are interested in participating in the study today.

Are you willing to participate in the study?

No ☐ **(if no, stop here)**
Yes ☐ **(if yes, continue below)**

Study staff who conducted informed consent discussion: I confirm that I have personally explained the nature and extent of the planned research, study procedures, potential risks and benefits, and confidentiality of personal information.

Participant's name (print)	**Participant's signature/thumbprint and date**
Participant's legal guardian name (print)	**Legal guardian signature/thumbprint and date**
Study staff conducting consent discussion (print)	**Study staff signature and date**
Witness's name (print) (if appropriate)	**Witness's signature (if appropriate)**

Appendix 6D English: Parent/Guardian Informed Consent Form

Open University of Catalonia
Baseline Survey
Mobile Application Pilot
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Parent/Guardian Informed Consent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

Introduction

Hello, my name is ----------. **Your child** has been invited to take part in a research study. Before you decide whether to **allow your child to participate**, you need to understand why the research is being done and what it would involve. Please take the time to read or to listen as I read the following information. You may talk to others about the study if you wish. Please ask me if there is anything that is not clear, or if you would like more information. When all of your questions have been answered and you feel that you understand this study, you will be asked if you **will allow your child to participate** in the study, and if you decide to **allow your child to participate** in this research study, we will then ask you to give your **written consent**. Your **child's participation** is completely voluntary and **you** can withdraw participation at any time with no penalty.

Purpose of the Study and Study Requirements

What is the study about? This study is being carried out by **Paul Macharia of the open University of Catalonia**, the study seeks to pilot of a preferred mobile phone technology-based mode of accessing SRH information. The ultimate goal of this study is to improve the health and well-being of adolescents like ***your child.***

Why have you been invited to take part? You have been invited to take part because **your child** is an adolescent with SRH needs.

What will happen if I take part?

1. Your child will be enrolled in a 3-month pilot of a preferred mobile phone technology-based mode of accessing SRH information.

Risks

What are the risks of participating in the study? Your child may feel uneasy accessing Sexual Reproductive Health information in a mobile phone device.

Benefits

What are the benefits of participating in the study?
There is no direct benefit to you, your child will have an opportunity to be sensitized on ASRH information and available services in this community however their participation will inform the design of a mobile phone technology-based system to bridge the SRH information gap which could enhance access to adolescent SRH information.

Confidentiality

Will participation in the study be kept confidential? We will take all steps necessary to ensure **your** privacy and confidentiality. Given that your child will be visiting study site venue for registration, **your child's** attendance may be known to other people who are also participating in this study. However, we will request all participants to keep information that they observe about others during the visits confidential and not to share it with anyone.

Your child will be assigned a unique number and **their** name will not appear on any information like survey responses on the computer or services accessed. Safeguards for protecting confidentially of all data will be strictly enforced. All data will be kept in a secure location and will be destroyed at the end of the study. Each participant will respect the participation of others at the study site venue.

Voluntariness

What are my rights as a research participant/subject? Your child's participation in this study is completely voluntary. If you decide not participate, this will not affect their access to the Youth activities. Even after you decide **they could take part**, **you** may end **their** participation at any time without penalty or loss of existing benefits to which **they are** entitled.

Involuntary Early Termination of Participation:

Participants may be withdrawn from the study if the study sponsors, government or regulatory authorities, ethical/institutional review boards stop the study before its planned end date.

Additional Information

What will I receive for participating? Your child will not be paid for participation in the study, but we will receive Kshs. 1 of talk-time on the study registered cell phone number for their every access of the mobile phone technology-based SRH system. We will give you transport reimbursement of Ksh. 200 during today's visit.

Will it cost me anything to participate? No, it will not cost you anything to participate.

What will happen to the results of the research study? The results of the study will be discussed and presented in a report at team meetings and it will be used to help the design of a mobile phone technology-based system to bridge the SRH information gap. The information may be presented at a conference with other studies that relate to adolescent SRH. Neither the report nor the presentation will show **your child's** name.

Who has reviewed the study for ethical issues? This study has been reviewed and approved by the **Kenyatta Hospital/University of Nairobi Ethics Research Committee**.
What if I need more information? If you have a concern about any aspect of the study, you can ask me now or you can speak to any of the study staff who will do their best to answer your questions. If you have any other questions about the study, you may also **call Paul Macharia on +254-0722- 866753** or **email** at paulmachariah@gmail.com

What if there is a problem? Any complaint about the way you **or your child** has been treated during the study or any possible harm you might suffer will be addressed. **Please contact Prof. Chindia secretary to the Kenyatta National Hospital/University of Nairobi Ethics and research committee on +254-020-2726300.**

At this time, I want to make sure you understand the study and see whether you have any additional questions. After we discuss any questions you may have, we can discuss whether you are interested in participating in the study today.

Are you willing to allow your child participate in the study?

No □ **(if no, stop here)**
Yes □ **(if yes, continue below)**

Parent/Guardian of Participant: If you have read this consent form (or had it read and explained to you), all of your questions have been answered and you agree to **allow your child** take part in this study, please sign this form or make your mark to indicate your willingness to allow **her** participate.

Study staff who conducted informed consent discussion: I confirm that I have personally explained the nature and extent of the planned research, study procedures, potential risks and benefits, and confidentiality of personal information.

Participant's name (print)	**Participant's signature/thumbprint and date**
Participant's legal guardian name (print)	**Legal guardian signature/thumbprint and date**
Study staff conducting consent discussion (print)	**Study staff signature and date**
Witness's name (print) (if appropriate)	**Witness's signature (if appropriate)**

Appendix 6E English: Adolescent (15 – 17 year olds) Assent Form

Open University of Catalonia
Baseline Survey
Mobile Application Pilot
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent (15 – 17 year olds) Assent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

Introduction

Hello, my name is ----------. **You** have been invited to take part in a research study. Before you decide whether to **participate**, you need to understand why the research is being done and what it would involve. Please take the time to read or to listen as I read the following information. You may talk to others about the study if you wish. Please ask me if there is anything that is not clear, or if you would like more information. When all of your questions have been answered and you feel that you understand this study, you will be asked if you **will participate** in the study, and if you decide to **Participate** in this research study, we will then ask you to give your **written assent**. Your **participation** is completely voluntary and **you** can withdraw participation at any time with no penalty.

Purpose of the Study and Study Requirements

What is the study about? This study is being carried out by **Paul Macharia of the open University of Catalonia**, the study seeks to pilot a preferred mobile phone technology-based mode of accessing SRH information. The ultimate goal of this study is to improve the health and well-being of adolescents like ***you.***

Why have you been invited to take part? You have been invited to take part because **you** are an adolescent in this study site location.

What will happen if I take part?

1. **You** will be enrolled in a 1-month pilot of a preferred mobile phone technology-based mode of accessing SRH information.

Risks

What are the risks of participating in the study? You may feel uneasy accessing Sexual Reproductive Health information in a mobile phone device.

Benefits

What are the benefits of participating in the study?
You will have an opportunity to be sensitized on ASRH information and available services in this community, your participation will inform the design of a mobile phone technology-based system to bridge the SRH information gap which could enhance access to adolescent SRH information.

Confidentiality

Will participation in the study be kept confidential? We will take all steps necessary to ensure **your** privacy and confidentiality. Given that **you** will be visiting study site venue for registration, **your** attendance may be known to other people who are also participating in this study. However, we will request all participants to keep information that they observe about others during the visits confidential and not to share it with anyone.

You will be assigned a unique number and **your** name will not appear on any information like survey responses on the computer or services accessed. Safeguards for protecting confidentially of all data will be strictly enforced. All data will be kept in a secure location and will be destroyed at the end of the study. Each participant will respect the participation of others at the study site venue.

Voluntariness

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Are you willing <u>to participate</u> in the study?

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Yes ☐ **(if yes, continue below)**

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Appendix 6F English: Adolescent (18 – 19 year olds) Informed Consent Form

Open University of Catalonia
Baseline Survey
Mobile Application Pilot
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent (18 – 19 year olds) Informed Consent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

Introduction

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Purpose of the Study and Study Requirements

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Why have you been invited to take part? You have been invited to take part because **you** are an adolescent in this study site location.

What will happen if I take part?

1. **You** will be enrolled in a 1-month pilot of a preferred mobile phone technology-based mode of accessing SRH information.

Risks

What are the risks of participating in the study? You may feel uneasy accessing Sexual Reproductive Health information in a mobile phone device.

Benefits

What are the benefits of participating in the study?
You will have an opportunity to be sensitized on ASRH information and available services in this community, your participation will inform the design of a mobile phone technology-based system to bridge the SRH information gap which could enhance access to adolescent SRH information.

Confidentiality

Will participation in the study be kept confidential? We will take all steps necessary to ensure **your** privacy and confidentiality. Given that **you** will be visiting study site venue for registration, **your** attendance may be known to other people who are also participating in this study. However, we will request all participants to keep information that they observe about others during the visits confidential and not to share it with anyone.

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Will it cost me anything to participate? No, it will not cost you anything to participate.

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No ☐ **(if no, stop here)**
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Appendix 6G English: Adolescent (15 – 17 year olds) Assent Form

Open University of Catalonia
Baseline Survey
Mobile Application Pilot
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Adolescent (15 – 17 year olds) Assent Form

Name	Institution	Qualification	Contact
Paul Macharia	Open University of Catalonia	Bsc, Msc	+254722866753

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Why have you been invited to take part? You have been invited to take part because **you** are an adolescent in this study site location.

What will happen if I take part?

2. **You** will be enrolled in a 3-month pilot of a preferred mobile phone technology-based mode of accessing SRH information.

Risks

What are the risks of participating in the study? You may feel uneasy accessing Sexual Reproductive Health information in a mobile phone device.

Benefits

What are the benefits of participating in the study?
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Appendix 6H English: Adolescent (18 – 19 year olds) Informed Consent Form

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Baseline Survey
Mobile Application Pilot
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

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Appendix 7 English: Evaluation of the Knowledge of SRH Information

Open University of Catalonia
Baseline Survey
Adolescent Knowledge Evaluation
Leveraging Mobile Phone-Based Technologies To Provide On-Demand Adolescent Sexual Reproductive Health Information In A Resource Limited Setting: Kibra, Nairobi County

Evaluation of the knowledge of SRH information

Questionnaire

Section 1: Sexual and reproductive health knowledge

a) How would you explain the female menstrual cycle?
   a. About once a month, females who have gone through puberty will experience menstrual bleeding.
   b. This happens because the lining of the uterus has prepared itself for a possible pregnancy by becoming thicker and richer in blood vessels.
   c. If pregnancy does not occur, this thickened lining is shed, accompanied by bleeding.
   d. Bleeding usually lasts for 3-8 days.
   e. No idea
   f. Other Specify ……..
b) What are ways to avoid pregnancy?
   a. Condoms
   b. Contraceptive pills
   c. Intrauterine devices and implants
   d. Natural family planning
   e. No idea
   f. Other Specify…….
c) How do you think sexually transmitted infections (STIs) can be avoided?
   a. Abstinence
   b. Condom use
   c. Avoid Substance Use
   d. Sharing sex toys
   e. No idea
   f. Other Specify ……..
d) What are Symptoms of STIs?
   a. Genital/anal ulcer/sore
   b. Discharge from rectum
   c. Pain during defaecation

d. Burning pain while urination
e. Urethral discharge
f. Swelling in the groin
g. Genital warts(penile or anal bumbs)
h. Other Specify…….

Section 2: Adolescents who have "positive" attitudes toward sexual and reproductive health issues

1. Attitudes toward contraceptives
    a) Condoms reduce sexual pleasure? Yes__ No __
    b) Carrying condoms difficult? Yes__ No __
    c) Using condoms is a sign of mutual re-spect? Yes__ No __
    d) Condoms are easy to obtain and use? Yes__ No __
    e) Unmarried adolescents don‘t need to use condoms in all sexual encounters? Yes__ No __
2. Gender-role stereotypes:
    a) Women who carry condoms are —easy“ or pros-titutes? Yes__ No __
    b) Having sex with many women is a sign of man-hood? Yes__ No __
    c) “Real men” don‘t use condoms? Yes__ No __
    d) The female (sexual partner) is responsible for protection? Yes__ No __
3. Attitudes toward abstinence:
    a) It is OK for adolescents to wait for marriage to have sex? Yes__ No __
    b) My friends would laugh at me for refusing to have sex? Yes__ No __
4. Perceived vulnerability:
    a) Pregnancy won‘t happen to me? Yes__ No __
    b) STIs won‘t happen to me? Yes__ No __
    c) Young people are healthy and don‘t need to worry about STIs? Yes__ No __
    d) Women can get pregnant the first time they have sex? Yes__ No __

Appendix 8: Unstructured Supplementary Service Data App Content

No.	Question	Response
1	Gender	1. Male 2. Female
2	Age	1. 15 (go to 3b) 2. 16 (go to 3b) 3. 17 (go to 3b) 4. 18 (go to 3a) 5. 19 (go to 3a)
3	**ASRH Information**	
3a	List of options (Age 18 and above)	1. STIs Information (go to 4) 2. Contraceptives (go to 5) 3. Safe Sex (go to 13) 4. Abstain from Drugs (go to 3c) 5. Sexual Relationships (go to 6) 6. Adolescent friendly services (go to 18)
3b	List of options (Age 15–17)	1. STIs Information (go to 4) 2. Abstain from Sex (go to 13) 3. Abstain from Drugs (go to 3c) 4. Sexual relationship (go to 6) 5. Adolescent friendly services (go to 18)
3c	Abstain from Drugs	1. Drug use screening 2. Drugs and sex
4	STIs Information	3. STI Symptoms (go to 7) 4. Talking about HIV (go to 10)
5	Contraceptives	1. Options (go to 11) 2. Sex with no condom (go to 12)
6	Sexual relationships	1. Dating someone much older (go to 14) 2. Signs of unhealthy relationships (go to 15)
STIs Information		
7	***Symptomatic STI Screening*** https://web.uri.edu/antimicrobial-stewardship/files/Sexually-Transmitted-Infections.pdf	1. Female (go to 8) 2. Male (go to 9)
8	***Symptomatic STI Screening*** Females	
8a	Vaginal itching	1. Yes 2. No
8b	Vaginal discharge	1. Yes 2. No
8c	Painful urination	1. Yes 2. No
8d	Increased urinary urgency	1. Yes 2. No

8e	Pelvic pain	1. Yes 2. No
8f	Pain with sexual intercourse	1. Yes 2. No
8g	Vaginal bleeding	1. Yes 2. No
8h	Genital blisters	1. Yes 2. No
8i	Genital ulcer	1. Yes 2. No
8j	You need further assessment (If "Yes" in any of 8a – 8i go to 18)	
9	***Symptomatic STI Screening*** Males	
9a	Penile discharge	1. Yes 2. No
9b	Painful urination	1. Yes 2. No
9c	Increased urgency	1. Yes 2. No
9d	Pelvic pain	1. Yes 2. No
9e	Swollen/tender testicles	1. Yes 2. No
9f	Pain with sexual intercourse	1. Yes 2. No
9g	Genital blisters	1. Yes 2. No
9h	Genital ulcer	1. Yes 2. No
9i	You need further assessment (If "Yes" in any of 9a – 9h go to 18)	1. Continue
10. Talking about HIV with a partner https://www.avert.org/hubs/young-voices-africa/talking-about-hiv		
10a	You don't have to apologize because you are living with HIV.	1. Continue
10b	Have some information on hand to share with them.	1. Continue
10c	Think of the best time to tell them, not when in a rush or stressed.	1. Continue
10d	Find a place you are less likely to be interrupted.	1. Continue
10e	Whatever your partner's first reaction, it could change over time.	1. Continue
10f	It is important your partner gets tested. Practice safer sex in the future.	1. Continue
10g	Fear and stigma could stir up very strong emotions.	1. Continue
10h	Your status may make some people afraid or judgmental.	1. Continue 2. Main

Contraceptives https://www.avert.org/hubs/young-voices-africa/options-for-contraception		
11	**Options for contraception**	
11a	Many contraceptives only prevent pregnancies.	1. Continue
11b	How long lasting you want it to be; able to remember to take it.	1. Continue
11c	A good idea to talk about the options with partner.	1. Continue
11d	**Condoms** prevent both pregnancy and STIs.	1. Continue
11e	The **contraceptive pill** taken by women, prevents pregnancy but no protection from STIs.	1. Continue
11f	An **implant** for women prevents pregnancy. Lasts up to four years, no protection from STIs.	1. Continue
11g	**Injections** for women, prevent pregnancy. No protection from STIs.	1. Continue 2. Main
12	**Sex with no condom** https://www.avert.org/hubs/young-voices-africa/sex-without-a-condom	1. Continue
12a	Condom use, is one of the only protections from STIs and pregnancy.	1. Continue
12b	Talking about it beforehand, both clear on what you want.	1. Continue
12c	Partner pressurizing for sex without a condom is a sign they aren't taking care of themselves and you.	1. Continue
12d	Remember that you should never use a condom more than once.	1. Continue
12e	Neither should you double up, this creates friction, condoms could break.	1. Continue
12f	Condoms usually come pre-lubricated, but extra lubrication reduces STI risk.	1. Continue
12g	If using latex condoms, make sure you use a water-based lube.	1. Continue 2. Main
13. Safe/Abstain from sex https://www.avert.org/sex-stis/consent		
13a	You can say no at any time.	1. Continue
13b	Being in a relationship does not give your partner the right to do anything they want to you.	1. Continue
13c	You can change your mind about sex at any time.	1. Continue
13d	The legal age to have sex in Kenya is 18.	1. Continue
13e	Sexual contact without consent is wrong whatever the age of people involved.	1. Continue
13f	Difficult to say no in the heat of the moment – let partner know beforehand about your wishes.	1. Continue 2. Main
Sexual Relationships		
14	**Dating someone much older than you.** https://www.avert.org/hubs/young-voices-africa/dating-older-people	1. Continue

14a	The person will expect, or demand, things in return.	1. Continue
14b	The person is likely to want to be in control.	1. Continue
14c	The person could be living with HIV.	1. Continue
14d	The person is likely dating/having sex with other people.	1. Continue
14e	The person's expectations could be very different to yours.	1. Continue
14f	If some of your friends are dating older persons, still decide what's right for you.	1. Continue 2. Main
15	**Signs of unhealthy relationships** https://www.avert.org/hubs/young-voices-africa/unhealthy-relationships	
15a	Partner attempts to exercise control and power over you.	1. Continue
15b	Pressures you to send intimate photo messages that you don't want to.	1. Continue
15c	You don't feel able or willing to communicate with your partner.	1. Continue
15d	Your partner is being repeatedly dishonest.	1. Continue
15e	They call you names, constantly question and criticize your choices and decisions.	1. Continue
15f	You don't feel you have any control over whether to use contraceptives.	1. Continue
15g	You don't feel able to go out and see your friends without the partner being angry or sad or jealous.	1. Continue
15h	You are made to feel guilty for the choices that you make.	1. Continue 2. Main
Abstain from Drugs		
16	Adolescent Screening tool for drug use disorders https://crafft.org/	
Part A		
16a	During the PAST 12 MONTHS, did you: Drink any alcohol?	1. Yes 2. No
16b	During the PAST 12 MONTHS, did you: Smoke any marijuana or hashish?	1. Yes 2. No
16c	During the PAST 12 MONTHS, did you: Use anything else to get high?	1. Yes 2. No
If "Yes" in any of 16a – 16c go to Part B		
Part B		
16d	Have you ever ridden in a CAR driven by someone using alcohol or drugs?	1. Yes 2. No

16e	Do you ever use alcohol or drugs to RELAX, feel better about yourself, or fit in?	1. Yes 2. No
16f	Do you ever use alcohol or drugs while you are by yourself, or ALONE?	1. Yes 2. No
16g	Do you ever FORGET things you did while using alcohol or drugs?	1. Yes 2. No
16h	Do your FAMILY or FRIENDS ever tell you that you should cut down on your drinking or drug use?	1. Yes 2. No
16i	Have you ever gotten into TROUBLE while using alcohol or drugs?	1. Yes 2. No
16j	You need additional assessment. (If "Yes" for two or more question 16a -16i) (Go to 18e)	1. Continue
17	Risks of mixing drugs and sex	1. Continue
17a	Forget to use a condom	1. Continue
17b	Not be able to consent for sex	1. Continue
17c	Unaware of someone spiking your drink	1. Continue
17d	Engage in more risky sexual activities	1. Continue 2. Main
Information on youth friendly services		
18	The following are adolescent-friendly services in your neighborhood	1. Facility A (go to 18a) 2. Facility B (go to 18b) 3. Facility C (go to 18c) 4. Facility D (go to 18d)
18a	Contact details of facility A	
18b	Contact details of facility B	
18c	Contact details of facility C	
18d	Contact details of facility D	
18e	Contact details of facility E (Drug use screening and referral)	

Appendix 9: Ethical Approval Letter

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

KENYATTA NATIONAL HOSPITAL APPROVED 21 MAR 2019 KNH/UoN-ERC P. O. BOX 20723 - 00202 NAIROBI

Ref: KNH-ERC/A/99

21st March, 2019

Paul Mwangi Macharia
(PhD Candidate)
Reg. No.927935
Dept. of Information Technology, Multimedia and Telecommunications
Open University of Catalonia,

Dear Paul

RESEARCH PROPOSAL: LEVERAGING MOBILE PHONE-BASED TECHNOLOGIES TO PROVIDE ON-DEMAND ADOLESCENT SEXUAL REPRODUCTIVE HEALTH INFORMATION IN A RESOURCE LIMITED SETTING: KIBRA, NAIROBI COUNTY (P707/10/2018)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is 21st March 2019 – 20th March 2020.

This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website **http://www.erc.uonbi.ac.ke**

Yours sincerely,

PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
Supervisors: Dr. Antonio Perez-Navarro, Dr. Carme Carrion, Dr. Irene Inwani