

# Using mobile phones to improve young people sexual and reproductive health in low and middle income countries: A systematic review

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## Research

**Keywords:** Mobile Phones, mHealth, young people sexual & reproductive health, Low and Middle Income Countries, Systematic Review, Facilitators, Barriers

**Posted Date:** January 31st, 2020

**DOI:** <https://doi.org/10.21203/rs.2.22374/v1>

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# Abstract

**Background:** Globally, reproductive health programs have used mHealth to provide sexual and reproductive health (SRH) education and services to young people, through diverse communication channels. However, few attempts have been made to systematically review the mHealth programs targeted to improve young people SRH in low-and-middle-income countries (LMICs). This review aims to identify a range of different mHealth solutions which can be used for improving young people SRH in LMICs and highlight facilitators and barriers for adopting mHealth interventions designed to target SRH of young people.

**Methods:** Databases including PubMed, CINAHL Plus, Science Direct, Cochrane and grey literature were searched between January 01, 2005 and March 31, 2018 to identify various types of mHealth interventions that are used to improve SRH services for young people in LMICs. Of 2,181 titles screened after duplication, 207 potentially relevant abstracts were obtained. Out of 207 abstracts, 70 abstracts were shortlisted. Full text of 70 studies were reviewed using a pre-defined data extraction sheet. A total of 11 full text studies were included in the final analysis.

**Results:** The final 11 studies were categorized into three main mHealth applications including; client education and behavior change communication, data collection and reporting and financial transactions and incentives. The most reported use of mHealth was for client education and behavior change communication [n = 10, 91%]. This categorization provided the understanding that the potential of other mHealth applications has yet to be explored. Most studies showed, that mHealth interventions have proven to be effective in improving SRH services and outcomes through addressing barriers of provider prejudice, stigmatization, discrimination, fear of refusal, lack of privacy and confidentiality. Yet, the review also identified barriers to uptake of mHealth interventions for SRH including decreased technological literacy, inferior network coverage, and lower linguistic competency.

**Conclusion:** The review provides detailed information about the implementation of mobile phones at different levels of healthcare system for improving young people SRH outcomes. This systematic review recommends that barriers to uptake mHealth interventions be adequately addressed to increase the potential use of mobile phones for improving access to SRH awareness and services.

## Background

In lower-middle-income countries (LMICs), most young people (adolescents and youth), aged 10–24 years, have very limited, or no access to sexual and reproductive health (SRH) education and services, largely due to lack of awareness, social stigma, policies and procedures inhibiting provision of contraception and abortion services to girls, and judgmental attitudes of healthcare professionals [1, 2]. Thus, young people have special SRH education needs that remain unmet and to address these specific SRH needs, use of innovative and novel approaches are required to ensure access to safe, effective, affordable, and acceptable SRH services [2].

mHealth involves the use of mobile technologies and multimedia tools to accomplish health goals and support healthcare delivery [3]. Many LMICs have attained substantial level of cell phone penetration (over 90%) in the recent years [4, 5]. On account of rapid expansion of cell phone ownership and mobile phone penetration in LMICs, the novel field of mHealth has gained much progress and it is being used rapidly in hundreds of diverse health-related projects [3]. The increased mobile phone penetration has led to increase usage of mobile phone, especially amongst younger population in LMICs [6, 7]. Young people are responsive and enthusiastic to use new innovative technologies such as mHealth to address barriers to receiving SRH information and services [8–10]. The mHealth technology can help overcome most of the barriers including provider prejudice, stigmatization, discrimination, fear of refusal, lack of privacy and confidentiality, embarrassment in seeking SRH education and services on highly sensitive topics, cost prohibitions, and transportation challenges, by providing safe, accurate, cost-effective, timely and tailored SRH services to young people [11]. More importantly, mHealth offers privacy, convenience and easy access in contrast to face-face consultations with healthcare professionals, which eventually addresses the barriers of stigmatization and embarrassment in receiving tailored SRH services [12]. Worldwide, diverse mHealth solutions have been used to connect young population to SRH information and services[13]. Similarly, mHealth technology can be used in LMICs to reach out to youth population and to engage them to provide acceptable, safe, cost-effective and accurate SRH services[11, 14].

In an effort to tap into the potential of mHealth for young people SRH services, there has been an increase in the amount of research in recent years; while published studies from high-income countries (HIC) on mHealth interventions for young people SRH is growing, however, gaps in evidence exists, related to m- = Health for young people SRH in LMICs. In previous studies, attempts have been made to review the mHealth programs for young people SRH using [mHealthEvidence.org](http://mHealthEvidence.org) website and through a global call for collecting information on mHealth interventions [15, 16]. A systematic review by L'Engle and colleagues assessed strategies on using mHealth to improve young people SRH by using the mHealth Evidence Reporting and Assessment (mERA) checklist; although only three out of the 35 articles included in the review were related to LMICs, the small number of articles reflected the lack of literature from LMICs [15]. Another review by Ippoliti & L'Engle summarized 17 projects which involved mHealth interventions to improve young people SRH in LMICs, through the aforementioned global call for information. Both of these reviews included evidence regarding the use of mHealth for improving young people SRH. However, very little is known regarding the potential barriers and facilitators for the uptake of mobile phone interventions for improving young people SRH. This systematic review aims to highlight potential barriers and facilitators for the uptake of mHealth interventions for young people SRH, particularly in LMICs.

Labrique and colleagues identified 12 mHealth applications to respond to various health issues[17]. Few healthcare programs involve one application while others may include two or more mHealth applications for addressing particular health issue. The classification of 12 mHealth applications as per Labrique and colleagues is illustrated in Table 1. Similar framework is being used to categorize the range of mHealth interventions which can be used to improve young people SRH.

## Methods

The objectives of the review are two-fold:

- To report the range of mHealth solutions which can be used for improving young people SRH
- To report facilitating and impeding factors for the uptake of mHealth interventions for young people SRH

## Eligibility Criteria

## Participants

Studies involving young people (adolescents and youth) aged 10–24 years to which mHealth interventions were delivered for improving their SRH outcomes were included in this review.

## Settings

LMICs were selected according to the World Bank's (WB) 2018 Country Classification lists[18]. According to WB, LMICs are those with a Gross National Income (GNI) per capita between \$996 and \$3,895. Issues concerning the use of mobile phones for young people SRH are common across many LMICs [16]; thus these studies are more comparable than those representing HIC.

## Intervention and Outcomes

Those studies were included that have defined the use of mobile phone to improve young people SRH services and included behavioral, health, and education and awareness related outcomes through mobile-based health interventions. Additionally, studies were included that have identified common barriers and facilitators for implementation of mHealth interventions for young people SRH. For young people SRH outcomes, the review utilized the United Nations Population Fund (UNPF) explanation which states that "Providing access to [comprehensive sexuality education](#); services to prevent, diagnose and treat sexually transmitted infections (STIs); and counseling on [family planning](#)". The UNPF also advocates that young people should be empowered so that they know their rights –including the right to delay marriage and the right to refuse unwanted sexual advances.

## Type of studies

Randomized controlled trials (RCTs), non-randomized studies, pre- and post-test designs, non-experiment observational (cross-sectional, case-series, case studies) and qualitative papers, mixed methods studies

were included in this review. Commentaries, editorials, symposium proceedings, and systematic reviews were excluded in this review as these are non-empirical publications.

## Time period

Studies published between January 2005 and March 2018 were included as the field of mHealth is recent and has emerged over the last decade. English language articles were included only as the authors are proficient in this Language. The inclusion and exclusion criterion is illustrated in Table 2.

## Information sources and search strategy

An electronic systematic literature search was carried out to explore the role of mobile Health technology in improving young people SRH, particularly in LMICs. Although, there are a large number of databases on this pertinent topic; however, we searched four electronic databases including PubMed, CINAHL Plus, Science Direct and Cochrane as they are generally considered large databases in Medicine and are easily accessible and available. These databases were explored using detailed search strategy. Additionally, grey literature (non-published, internal or non-reviewed papers, repositories) was also explored as it is an important source for mHealth evaluations carried out in LMICs. The reference list of included records were also appraised to identify relevant articles. Moreover, the reference lists of identified systematic reviews were also reviewed to see if references include pertinent studies that might be included for review. The databases were searched by two researchers independently (AF and NAA). The search terms were grouped under five major categories of interest; population (youth, adolescents, young people), intervention (mHealth), barriers and facilitators for implementation of mHealth interventions for SRH services, outcome (SRH) and settings (LMICs). Additionally, indexed keywords in the Medical Subject Headings (MeSH) were used in order to ensure uniform search terms. The search strategy was piloted to ensure the sufficient specificity and sensitivity. The search strategy is illustrated in Table 3.

## Study Selection:

Citation management system (Endnote software) was used to manage the records exported from all the electronic databases [19]. In order to ensure the reliability of screening articles among the two reviewers (AF and NAA), a pre-defined screening form was developed and pilot testing was conducted as per the eligibility criteria. Both reviewers (AF and NAA), described outcome measures after reviewing the studies to verify the relevance of the articles. Strong justifications for excluding studies were provided by each reviewer. Any disagreement between the two reviewers were resolved by a third reviewer (AK) in a consensus meeting. The third reviewer was consulted to make the final decision about whether the study meets the eligibility criteria for inclusion.

All studies were first screened by titles, then by abstract, and finally by full text to progressively eliminate studies not meeting the inclusion criteria. Database searches identified a total of 2,235 studies initially. After de-duplication, 2,181 potentially relevant titles were included for title screening. After title screening, 207 records were screened by abstracts. Full texts of remaining 70 studies were reviewed to determine if they fulfill the inclusion criteria. Finally, 11 studies were selected and used for the purpose of this review [20–30]. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram was used to report the study selection process (Fig. 1).

## Quality assessment of included studies

To assess the methodological quality of the included studies, Mixed Methods Appraisal Tool (MMAT) was utilized. The tool was suited for this review as it was specifically developed for quality appraisal in systematic reviews involving qualitative, quantitative and mixed-methods designs. Qualitative and quantitative sections have four criteria each, and studies are scored by dividing the number of criteria met by four to arrive at a value ranging from 25 to 100%. For mixed method studies, we adapted the MMAT by assessing each segment separately and then selecting the lowest quality rating. Articles were not excluded based on MMAT score; the purpose was to examine and gain insight into the rigor of existing research in this field. Two reviewers (AF, NAA) independently assessed the quality of the included studies. In case of disagreement between the two reviewers, a third reviewer (AK) was consulted. Data on quality appraisal is provided in an additional 1 for all the included studies.

## Data Collection Process:

A customized data extraction sheet was filled by the two independent reviewers (AF, NAA) for all the included studies. Data extraction tables of both reviewers were matched to ensure that all key findings are included in the systematic review. Third evaluator (AK) was involved, if discordant information was observed during the data extraction process. The summary of included studies on mHealth interventions to improve young people SRH is provided in the additional file 2.

## Results

The systematic review has been designed and reported according to the PRISMA checklist[31]. The systematic review protocol has been published [32] and registered in the 'International Prospective Register for Systematic Reviews' (PROSPERO) CRD42018087585 [33].

The data from the final 11 studies only fit in to three main mHealth applications defined in the Labrique and colleagues framework which include '*client education and behavior change communication*', '*registries/vital event tracking*', '*data collection and reporting*', and '*financial transaction and incentives*'. All of these applications have been operationalized using various mobile phone functions that include "short message service (SMS), voice communication, and transfer of airtime minutes" [17]. The

conceptual framework was adapted to elaborate the potential of mobile phones for improving young people SRH. The adapted framework is illustrated in Fig. 2.

Figure 2: Conceptual Framework on mHealth Applications for young people sexual and reproductive health

## Type of studies

Out of eleven studies which were included, five were observational studies [21, 23, 25, 29, 30], one was cluster RCT [28], three were mixed-methods study [24, 26, 27] and remaining two were qualitative studies [20, 22]. All these studies included in the review were published within the time period from 2009 to 2017.

## Types of mHealth interventions

The final studies were classified according to the type of mHealth applications. While few studies addressed one mHealth application, many addressed multiple applications. Most of the studies were assigned in more than one category if the intervention was multi-faceted. The final studies were broadly categorized in three main applications which include client education and behavior change communication [20–26, 28–30], data collection and reporting [23, 26, 27], and financial transactions and incentives [23, 26, 28, 29]. The results of the classification exercise are illustrated in Fig. 3.

## Client education and behavior change communication

Ten studies included in this review had client education and behavior change communication as one of the primary mHealth functions to improve young people SRH [20–26, 28–30]. Several studies highlighted that mobile phones are an effective tool to deliver HIV prevention educational program[21], maximize reach and access to family planning (FP) information[20], improve reproductive health knowledge[28], sexual health knowledge and ensure safer sexual behavior[24].

Three studies reported use of mobile phone interventions such as m4RH, text-based system, for improving access to family planning information. A qualitative study conducted at Dar es Salaam, Tanzania Nairobi, and Kenya obtained feedback on the feasibility, design, and content of the m4RH project. The m4RH project is conceptualized as an automated, text-based system that is compatible with every mobile phone to maximize reach and access to family planning (FP) information via mobile phone. This formative research concluded that providing family planning information via text message is a promising method of reaching women and men with health information [20]. Another observational study was conducted to evaluate the feasibility, reach and potential behavioral impact of providing automated family planning information via mobile phones (m4RH) to the general public in Tanzania. The study found out that 2870 unique users accessed m4RH in Tanzania, resulting in 4813 queries about specific contraceptive methods. A variety of changes in family planning use were mentioned after using m4RH,

with reported changes consistent with where the users are in their respective reproductive life cycle[25]. In Kenya, young people's use of m4RH was investigated through a mixed methods study. The study revealed that condom and natural family-planning information was accessed most frequently, although users enquired all family planning methods. Overall, respondents reported increased contraceptive knowledge and use after using m4RH[26].

Two studies examined the usage of mobile phones among adolescents to seek sexual and reproduction health information and services. A qualitative study conducted in six Nigerian states, examined adolescent girls and young women's access and use of mobile phones to seek SRH information and services. The study concluded that there is high mobile phone access but limited use of phones to access SRH information and services[22]. In India, a cross-sectional survey was conducted to study the level and pattern of mobile phone usage among adolescent girls. The study reported that most adolescent girls spent 2–4 hours a day on an average using smartphones and 69% adolescents preferred SMS for awareness about reproductive and sexual health information [30].

Three studies examined the effectiveness of mHealth programs to improve SRH knowledge and ensure safe sexual behaviors among adolescents. A cluster RCT conducted in Ghana evaluated whether text-messaging programs can improve reproductive health among adolescent girls. A total of 38 schools were randomized to unidirectional intervention (n = 12), interactive intervention (n = 12), and control (n = 14). The unidirectional intervention sent participants' text messages with reproductive health information. The interactive intervention engaged adolescents in text-messaging reproductive health quiz games. The study results showed large improvements in knowledge at 3 months that were sustained after 15 months for both 1-way and 2-way programs. However, the 2-way interactive program was significantly more effective at increasing knowledge than the 1-way program [28]. Another observational study conducted in Ghana assessed the degree to which mHealth programs reach target adolescent subpopulations who may be at higher risk of poor SRH outcomes. The mHealth intervention included an interactive mobile phone quiz. The study concluded that mHealth programs are not only an effective tool in increasing SRH knowledge, but that these programs can also engage key target populations who are at higher risk of poor SRH outcomes, including adolescents with low parental education, adolescents with low SRH knowledge, adolescents with early sexual debut, and adolescents with low parental support [29]. A mixed-methods study conducted IN in Uganda evaluated the impact of a health information intervention implemented through mobile phones. The intervention aimed to improve sexual health knowledge and shift individuals towards safer sexual behavior by providing reliable information about sexual health. Unexpectedly, the study found out that there was no increase in SRH knowledge, and no change in attitudes, as a result of mHealth intervention. Infact, there was higher incidence of risky sexual behavior, and more infidelity[24].

Two studies assessed the usage of cell phones and effectiveness mHealth campaign for improving HIV/AIDS knowledge and prevention efforts. A cross-sectional study conducted in Uganda assessed cell phone use among 1738 adolescents aged 12 to 18 years, in an effort to understand if cell phones might have the potential for integration into HIV/AIDS prevention efforts. The survey found out that 27%

adolescents have cell phones and about half (51%) of all students and 61% of those who owned a cell phone believe that they would access a text messaging-based HIV prevention educational program if it was available [21]. Another pilot effectiveness study conducted in Northwest Uganda, explored the efficacy of a mHealth campaign using SMS as a platform to disseminate and measure HIV/AIDS knowledge. The Text to Change HIV/AIDS education campaign was designed to increase knowledge about HIV/AIDS, awareness about the regional clinics and testing centers, and HIV testing behaviors in the Arua district of Uganda. The study concluded that the campaign had proportionately limited success in increasing knowledge on a mass scale because correct knowledge was only provided to respondents who answered questions (and people who answered incorrectly tended to answer fewer questions)[23].

## Data collection and reporting

Three studies included in this review had data collection as one of the primary mHealth functions [23, 26, 27]. In Northwest Uganda, a pilot effectiveness study used 'Text to Change' campaign to achieve multiple objectives for public health. One of the main objectives of the campaign was to collect data on effectiveness of SMS-based campaigns in improving health care outcomes, specifically HIV knowledge. Thirteen questions were sent via SMS to collect data on three knowledge areas including (a) HIV/AIDS disease, (b) testing, and (c) HIV Counseling and Testing (HCT) services [23].

In Kenya, a mixed methods study was conducted to investigate young people's use of m4RH, a text message-based contraception information service. The study employed three data collection methods to evaluate the acceptability, information access, and potential impact of providing contraception information via SMS to young people in Kenya. These include recording automatic logging of all m4RH system queries, demographic and behavior change questions sent via SMS to all users who accessed m4RH during the pilot period; and in-depth telephone interviews with a subset of m4RH users [26]. In Democratic Republic of Congo (DRC), a mixed methods study was conducted to understand the needs, expectations, and practices of teenagers in DRC urban areas concerning their sex and emotional life. Data was collected through an interactive radio show program '*please doctor*' in which old adolescents and young people participated by means of their cellphones. The study found that girls' usually inquired information on menstrual cycle calculation, sexual practices, love relationships, and virginity. While boys' asked questions related to masturbation, sexual practices, love relationships, and infections (genital and STI)[27].

## Financial transactions and incentives

Four studies included in this review had used mHealth for financial transaction and incentive purposes [23, 26, 28, 29]. In Northwest Uganda, the Text to Change HIV/AIDS education campaign was designed to increase knowledge about HIV/AIDS, awareness about regional clinics and testing centers, and HIV testing behaviors in the Arua district of Uganda. Between January 29 and February 27 2009, text messages with HIV/AIDS multiple choice and true/false questions were sent to 10,000 identified mobile

phone numbers. Those participants who correctly answered questions received free HIV Counseling and Testing (HCT) services and were entered into weekly drawings to win prizes including mobile phones and airtime[23]. In Kenya, a mixed methods study was conducted to investigate young people's use of m4RH, a text message-based contraception information service. In-depth telephone interviews with a subset of m4RH users to evaluate the acceptability, and potential impact of providing contraception information via SMS. Interviews lasted an average of 30 minutes, and participants received air time as an incentive for participation[26]. In Ghana, a cluster RCT was conducted to evaluate whether text-messaging programs can improve reproductive health among adolescent girls. The interactive intervention group received 1 multiple-choice quiz question via text message each week to which they were invited to respond free of charge. Upon responding, participants immediately received a confirmatory text message informing them whether they answered correctly along with the correct answer and additional information. For every 2 correct responses, participants were sent an airtime credit reward of 1 GHS (US\$0.38) [28]. In Ghana, an observational study was conducted to assess the degree to which mHealth programs reach target adolescent subpopulations who may be at higher risk of poor SRH outcomes. The mHealth intervention included an interactive mobile phone quiz in which participants could win airtime (i.e. mobile phone credit that can be used for making calls or sending texts) for texting correct answers to SRH questions [29].

## **Type of outcomes examined**

### **Access to sexual and reproductive health services**

Seven studies included in this review evaluated the impact of mobile health interventions to improve access to SRH services [20–23, 27, 28, 30]. Most of these studies were largely conducted in African countries and used qualitative and observational study designs to understand the effect of mHealth technology on SRH education and services [20–23, 27, 28]. Most studies examined the use of text messaging program to improve SRH services, while one study, used cell phone-based interactive radio show program to understand needs, expectations, and practices of teenagers concerning their sex and emotional life. Most studies reported positive outcomes such as, improved access to family planning information due to automated text-based system, improved reproductive health knowledge among adolescent girls through text-messaging program, willingness to use SMS for awareness about reproductive and sexual health information, and readiness to access a text messaging-based HIV prevention educational program [20, 21, 27, 28, 30]. However, only two studies reported unfavorable outcomes such as, restricted use of phones to access SRH information and services and limited success to increase SRH knowledge levels on a mass scale via mHealth campaign [22, 23].

### **Sexual and reproductive health outcomes**

Four studies examined the impact of mHealth solutions on SRH outcomes [24–26, 29]. Studies largely used mixed methods and observational study designs to assess the feasibility of mHealth programs to

improve SRH outcomes. The studies reported use of different type of mHealth programs to improve SRH outcomes such as, m4RH, interactive mobile phone quiz and health information mobile intervention [24–26, 29]. Most studies reported positive outcomes such as, improved family planning knowledge and use, and increased involvement of target populations, who are at higher risk of poor SRH outcomes, through interactive mobile phone quiz[25, 26, 29]. Unexpectedly, one study reported limited success in increasing SRH knowledge, and changing attitudes including risky sexual behaviors, and infidelity, as a result of mHealth intervention [24].

## **Factors facilitating and impeding uptake of mHealth interventions for young people sexual and reproductive health**

Out of 11 final studies, three studies reported benefits of using mHealth services for improving SRH. In Kenya, young people's use of m4RH was investigated through a mixed methods study. Study participants perceived m4RH as confidential, convenient, and a valuable source of contraception information outside of the clinic setting[26]. Another study conducted separately reported the benefits of SMS and voice call, perceived by the study participants. The major factors facilitating the use of mHealth solutions include confidentiality, secrecy, quick and easy correspondence, easy retrieval of information, etc[22]. A qualitative study conducted at Dar es Salaam, Tanzania Nairobi, and Kenya obtained feedback on the feasibility, design, and content of the m4RH project. The participants appreciated the m4RH service and preferred to use it in the future as it ensures privacy and address stigma related issues[20].

Only two studies reported barriers to uptake of mHealth interventions for SRH. A study conducted in Ghana reported barriers pertinent to mHealth such as decreased technological literacy, inferior network coverage, and lower linguistic competency[29]. Another study conducted in six Nigerian states, examined adolescent girls and young women's access and use of mobile phones, to seek SRH information and services. The study reported several barriers to mHealth services utilization including cost of service, request for socio-demographic information that could break anonymity, poor marketing and publicity, socio-cultural beliefs and expectations of young girls, individual personality and beliefs, as well as infrastructural/network quality [22].

## **Discussion**

The review synthesizes evidence on the types of mHealth interventions used at different levels of the health care system for improving young people SRH in urban and rural communities of LMICs. Most of the studies took place in East Africa and West Africa, while few were undertaken in Central Africa and South Asia. The mHealth solutions identified in this systematic review mainly aimed to improve contraception related SRH education, services and outcomes, for young people. A Cochrane review published in the similar research domain report that, a series of voice messages and daily educational text messages can improve continued use of contraceptive pill among young adults[34].

Labrique and colleagues framework was adapted for categorizing the mHealth interventions according to their purpose. Based on our analysis, the most reported use of mHealth was for client education and behavior change communication [20–26, 28–30], followed by data collection and reporting [23, 26, 27], and financial transactions and incentives [23, 26, 28, 29]. The categorization of the studies in to various mHealth applications provided the understanding that the strongest evidence exists on client education and behavior change communication mHealth application. These findings are in concordance with the other reviews, which suggests, that mobile phone approaches; including texting in particular, have been explored much by various studies as it provides feasible and potential efficacious medium for increasing levels of reproductive and sexual health education[35]. Little evidence exists on other type of mHealth applications such as, sensors and point-of-care diagnostics, registries/ vital events tracking, electronic decision support, and supply chain management. Thus, a more comprehensive understanding of the role of mobile phones for improving young people SRH is required, to strengthen the evidence base in overlooked areas.

As with most reviews in the emerging field of mHealth, this review is limited by the difficulty of analyzing complex intervention studies and the variety of different interventions across included studies. More studies are needed to refine the current work with a larger body of evidence and to establish how best to integrate it with the published existing framework. The heterogeneity of the interventions and outcomes measures restricted the interpretation through meta–analyses. The studies did not utilize a common taxonomy for explaining the type of mHealth application. In addition, several studies combined multiple mHealth interventions [23, 26, 28, 29], making it difficult to determine to what extent each intervention contributed towards the expected outcome.

Overall, most studies included in this review were of moderate quality, indicating the significance of increasing the methodological rigor of future research.

The review has provided an understanding of how mHealth interventions targeted to youth population help overcome barriers of provider prejudice, stigmatization, discrimination, fear of refusal, lack of privacy and confidentiality, cost prohibitions, and transportation challenges [20, 22, 26]. Simultaneously, the review has highlighted the barriers to uptake mHealth solutions for SRH including poor technological literacy, inferior network coverage, and lower linguistic competency, high cost of service, and socio-cultural beliefs and expectations which does not favor the use of mHealth[22, 29]. Similar to other reviews, this paper recommends that more understanding is needed about the challenges of data privacy, technological literacy, linguistic competency and phone access to address the barriers impeding the uptake of mHealth for improving young people SRH information and services [16]. The results of this review will be disseminated through local and international conference presentations and peer-reviewed publications.

## **Public Health Implications**

The review provides insights for the research community and public health professionals in making decisions regarding the use of innovative, engaging and effective mobile phone interventions to improve young people SRH outcomes, yet the room remains for additional evidence and innovation in overlooked areas. Finally, as the field of mHealth is maturing, additional research would be beneficial to discover the cost-effectiveness of mHealth interventions for improving SRH services and outcomes for young people.

## List Of Abbreviations

STI: Sexually transmitted infections; GNI: Gross National Income; SRH: Sexual and Reproductive Health; LMICs: Lower-Middle-Income Countries; HIC: High Income Countries; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analyses; RCTs: Randomized Controlled Trials; WB: World Bank; UNPF: United Nations Population Fund.

## Declarations

### Ethics approval and consent to participate

Not applicable

### Consent for publication

Not applicable

### Availability of data and materials

Not applicable

### Competing interests

The authors declare that they have no competing interests.

## Funding

Not applicable

## Authors' contributions

AF conceived and designed the study. AF drafted the manuscript and is the guarantor of the systematic review. AF, NAA, AK developed the search strings and performed searching the studies, selection of the studies, data extraction, and synthesis. AF, NAA, AK, AH, SS extensively reviewed the manuscript and

incorporated intellectual inputs. All authors read, provided feedback, and approved the final version of the manuscript.

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## Tables

1. Client education and behavior change communication (BCC)
2. Sensors and point-of-care diagnostics
3. Registries/ vital events tracking
4. Data collection and reporting
5. Electronic health records
6. Electronic decision support (information, protocols, algorithms, checklists)
7. Provider to provider communication (user groups and consultation)
8. Provider work planning and scheduling
9. Provider training and education
10. Human Resource management
11. Supply chain management
12. Financial transactions and incentives

Table 1: Twelve common mHealth applications

Table 2: Eligibility Criteria

Attribute	Inclusion Criteria	Exclusion Criteria
Population	<p>Various terms are used to categorize young people: “adolescents” refers to 10–19 years; “youth” refers to 15–24 years; and “young people” refers to 10–24 years.</p> <p>Studies involving young people (adolescents and youth) aged 10–24 years to which m-Health interventions were delivered for improving their SRH outcomes</p>	Studies involving groups women, men s and girls under the age of 10 years and over the age of 24 years
Intervention	Studies will be included that has involved mHealth intervention to improve ASRH services	Studies involving other ICT interventions, ART compliance reminders, EmONC coverage, managerial and financial level interventions, physical mobile clinics and teleconsultations
Comparison	The comparison is the usual standard of care, or in the case of a randomized control trial, the comparison is the control condition.	Not applicable
Outcome	<p>Improvement in adolescent sexual and reproductive health services</p> <p>Behavioral outcomes</p> <p>Improved education and awareness</p> <p>ASR Health outcomes</p>	Studies with other outcomes such as demonstrating skilled birth attendants, emergency care, quality of life, immunization coverage, cost-effectiveness of intervention, child development and others
Setting	Studies conducted in LMICs	Studies conducted elsewhere
Study Designs	Randomized and non-randomized controlled trials, pre- and post-test designs, non-experiment observational (cross-sectional, case-series, case studies) and qualitative papers	Commentaries, editorials, symposium proceedings, systematic reviews
Language	Studies available in English Language as authors are proficient in this language	Studies which were not available in English translation
Time period	Studies published between January, 2005 to March, 2018 as the field of	Studies published before January, 2005 and after March, 2018

Table 3: Search Strategy

Population	('adolescen*' [Mesh] OR 'school*age*' OR student* OR teen* OR youth* OR 'young adult*' OR 'young people' OR 'younger people' OR 'young women' OR 'young men' 'teenager' OR 'middle schooler' OR 'high schooler' OR 'secondary school'OR 'Young adult' [Mesh]) AND
Intervention	(Mobile phone OR mhealth[All Fields]) OR telemedicine[MeSH Terms]) OR cellphone[MeSH Terms]) OR reminder system[MeSH Terms]) OR wireless technology[MeSH Terms])OR text messaging[MeSH Terms]) OR medical informatics[MeSH Terms]) OR pda[MeSH Terms]) OR smartphone[MeSH Terms]) OR tablet computer[MeSH Terms]) AND
Outcome	(Health outcomes OR behavioral outcomes OR Education and awareness OR 'sexual health' OR 'reproductive health' OR 'sexual behavior' OR 'sex education' OR condom* OR HIV OR HIV/AIDS OR PLHIV OR "acquired immunodeficiency syndrome" OR HPV OR 'family planning' OR abortion* OR abstinen* OR contracept* OR pregnan* OR sexual health rights OR 'sexually transmitted infection' OR 'sexually transmitted infections' OR STI OR STIs OR 'sexually transmitted disease' OR 'sexually transmitted diseases' OR 'STD' OR 'STDs' OR 'sexual debut' OR puberty OR 'safe sex') AND
Setting	('Developing country' OR 'South Asian countries' OR 'African countries' OR 'low and middle income Arab Countries' OR 'developing nation' OR 'least developed country' OR 'least developed nation' OR 'less developed nation' OR 'third world country' OR 'third world nation' OR 'under developed country' OR 'remote region' OR 'low and middle income country' OR 'under developed nation' OR 'low and middle income nation' OR Angola OR Indonesia OR Philippines OR Armenia OR Jordan OR São Tomé and Príncipe OR Bangladesh OR Kenya OR Solomon Islands OR Bhutan OR Kiribati OR Sri Lanka OR Bolivia Kosovo OR Sudan OR Cabo Verde OR Kyrgyz Republic OR Swaziland OR Cambodia OR Lao PDR OR Syrian Arab Republic OR Cameroon OR Lesotho OR Tajikistan OR Congo, Rep. OR Mauritania OR Timor-Leste OR Côte d'Ivoire OR Micronesia, Fed. Sts. Tunisia OR Djibouti OR Moldova OR Ukraine OR Egypt, Arab Rep. OR Mongolia OR Uzbekistan OR El Salvador OR Morocco OR Vanuatu OR Georgia OR Myanmar OR Vietnam OR Ghana OR Nicaragua OR West Bank and Gaza OR Guatemala OR Nigeria OR Yemen, Rep. OR Honduras OR Pakistan OR Zambia OR India OR Papua New Guinea)
Filters	Publication date from 2005/01/01 to date; Humans; English

## Figures

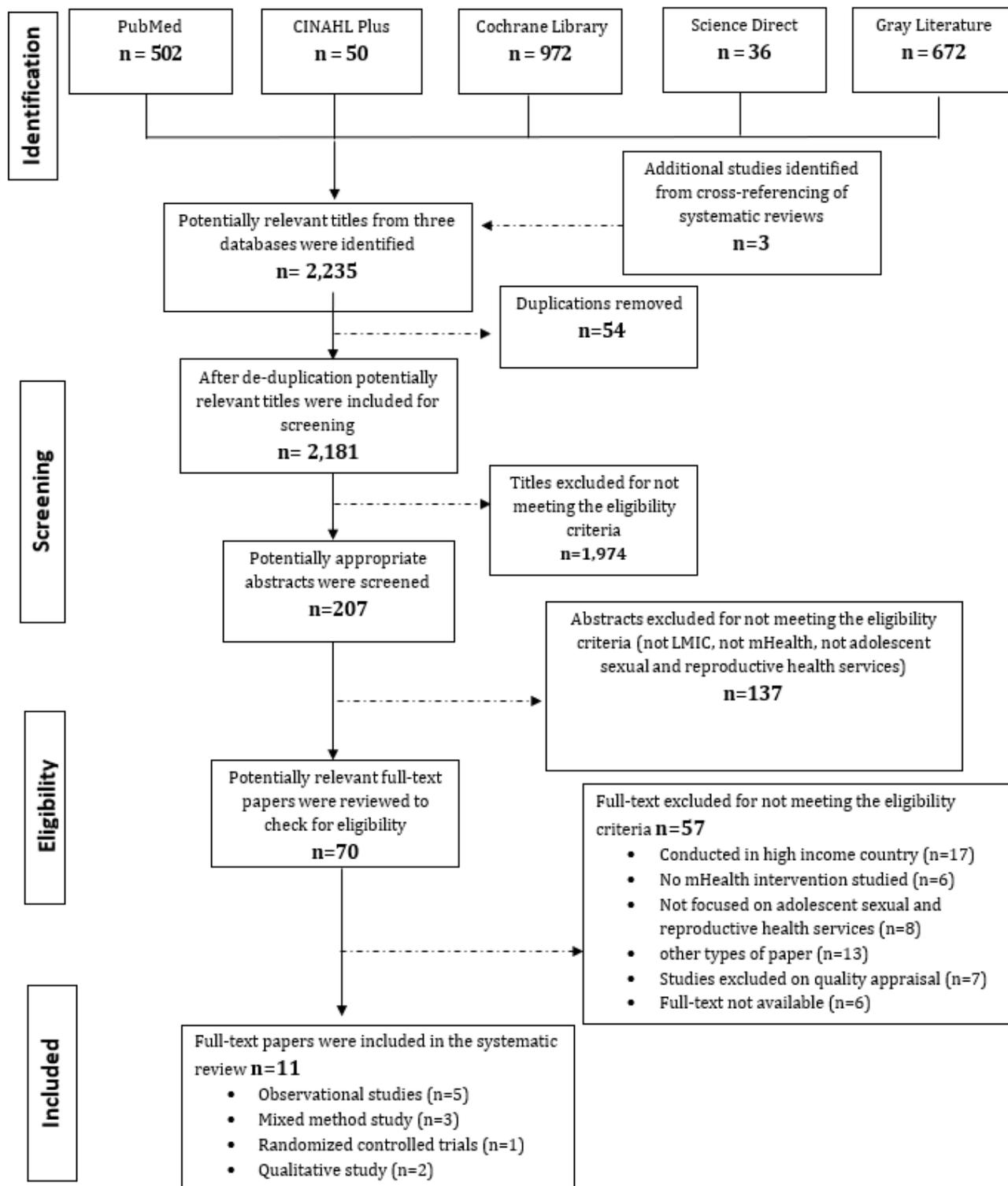
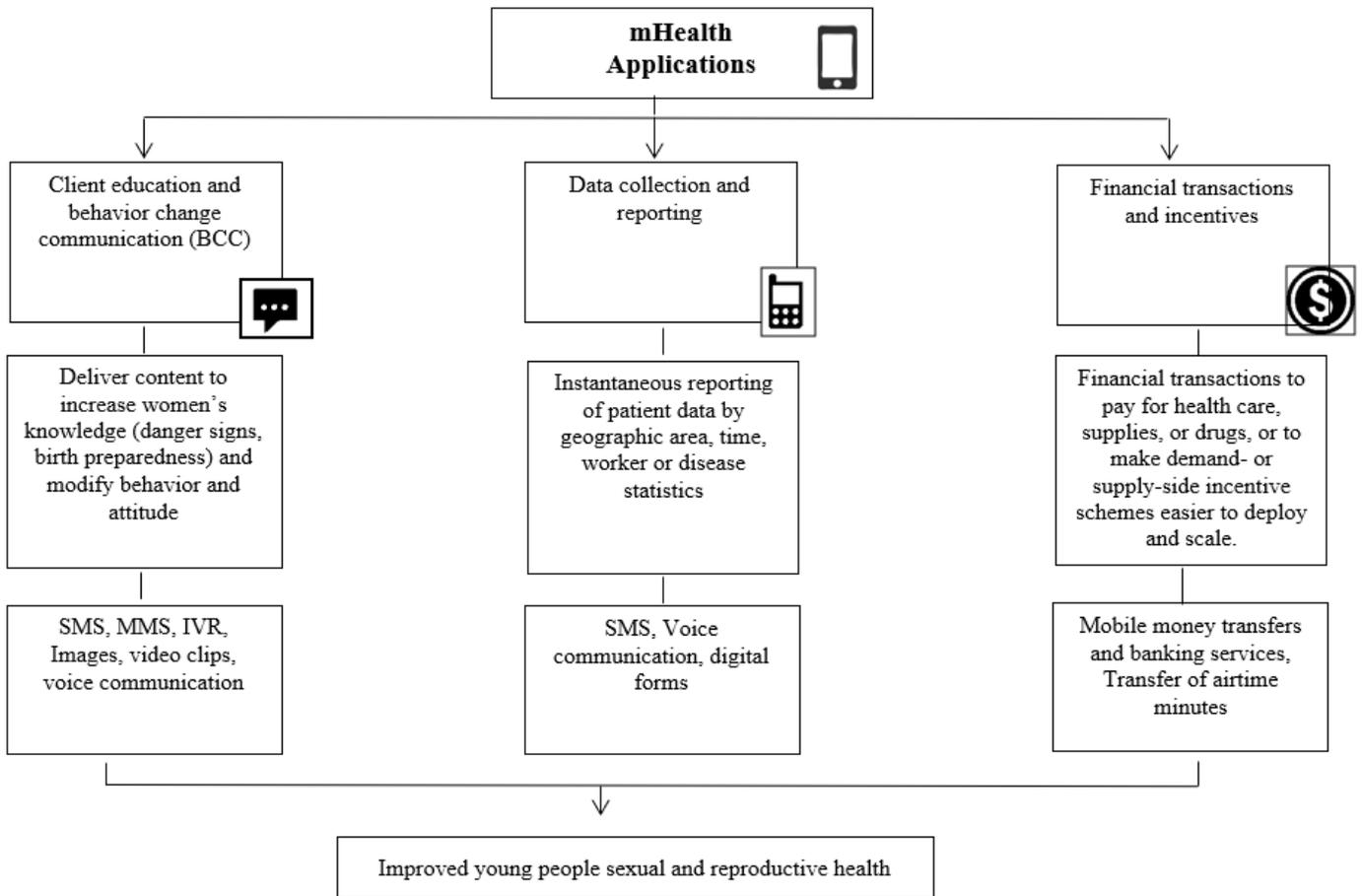


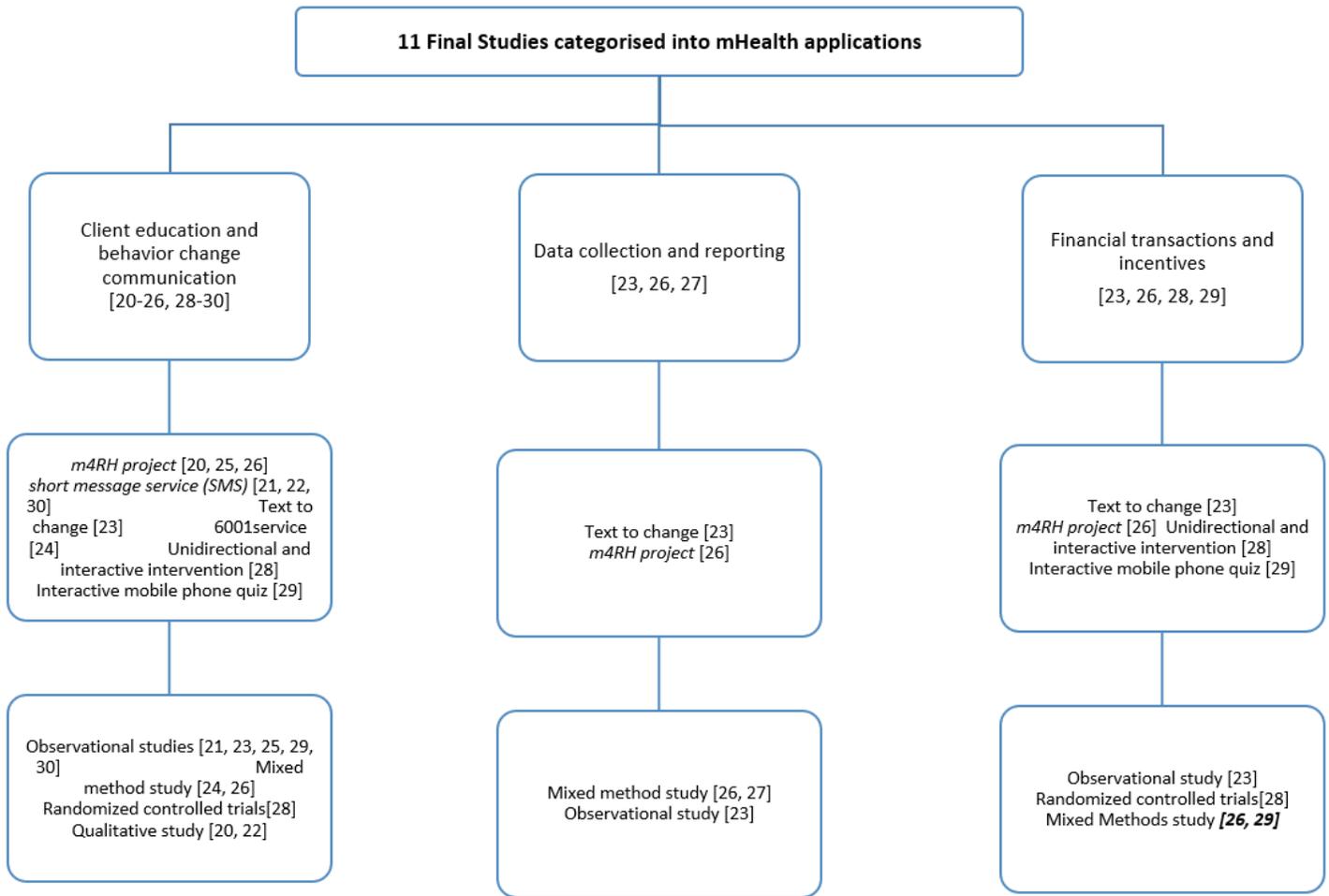
Figure 1

PRISMA Flow Diagram



**Figure 2**

Conceptual Framework on mHealth Applications for young people sexual and reproductive health



**Figure 3**

Classification of the Included Studies based on the Type of mHealth Interventions used

## Supplementary Files

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