Digitizing Adolescent Health: A Comprehensive Literature Review of Digital Educational Tools for Sexual and Reproductive Health in Africa

by

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Abstract

Background: Digital educational tools present a promising avenue to enhance sexual and reproductive health (SRH) education among adolescents in sub-Saharan Africa. This region faces significant challenges in providing accurate and comprehensive SRH information due to socio-cultural norms, stigma, and limited resources. A systematic literature review was conducted to describe the geographic and demographic distribution and the types and format of digital educational tools available for delivering sexual and reproductive health education to adolescents in the sub-Saharan Africa region.

Methods: The review followed PRISMA guidelines, searching databases like Ovid-MEDLINE, Google Scholar, PubMed, and ERIC. Studies addressing digital tools used to assess or deliver SRH education, their implementation, and effectiveness among African adolescents were included. 22 studies met the criteria, revealing diverse digital tools like social media, mobile apps, and gamified learning experiences.

Results: These tools successfully engaged adolescents by providing accessible and relevant SRH information. They improved knowledge, influenced attitudes, and encouraged healthy behaviors. However, challenges were noted, including the digital divide, cultural sensitivity of material, and the need to assess long-term impact on behavior modification.

Conclusion: Digital educational tools offer great potential to improve SRH education for adolescents in sub-Saharan Africa. They can enhance health outcomes and accessibility by

delivering easy-to-understand, interesting, and tailored information. Future research should address identified challenges, bridge the digital divide, ensure cultural relevance, and assess long-term impact on behavior and health outcomes. Policymakers and educators are encouraged to integrate these tools into SRH educational strategies targeting adolescents to improve their sexual and reproductive health and contribute to better public health in the region.

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Preface

I would like to express my heartfelt thanks to several people for their encouragement, guidance, and support throughout my time at Pitt Public Health and during the writing process. First and foremost, I want to thank Dr. Catherine Haggerty for your mentorship, expertise, and support during all of the modifications made while writing this essay. Thank you to my essay readers, Dr. Abimbola Fapohunda and Dr. Martina Anto-Ocrah, for your patience, encouragement, and feedback. Thank you, Dr. Nancy Glynn, for your constant encouragement, guidance, and optimistic attitude during my tenure at Pitt Public Health. I feel really lucky to have had such a wonderful support system during my graduate education.

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1.0 Introduction

The World Health Organization (2020) reported that there are more than 1.2 billion adolescents aged 10–19 years with sexual and reproductive health (SRH) problems such as sexually transmitted infections (STIs) and unplanned pregnancies many of whom face significant barriers to accessing SRH-related education. With increasing rates of SRH problems, and mental health issues among adolescents, there is a pressing, global need for effective educational tools that address adolescents' SRH needs (Melcher et al., 2023; Wadham et al., 2019). The World Health Organization categorizes 'adolescents' as those aged between 10 and 19 years, defines 'youth' as individuals aged 15 to 24 years, and 'young people' as those aged between 10 and 24 years (WHO, n.d.). As adolescents face major educational and health challenges, especially in the context of SRH-related information, this review is focused on adolescents as defined above, , noting the overlap of this age group with those of youth and young people based on the WHO's definition. Therefore, some of the data reported in this paper will reference the latter age groups as well.

There are global disparities in adolescents' access to SRH education, with those in low- and middle-income countries (LMICs) facing the greatest barriers to accessing knowledge and resources, due to socio-cultural norms, beliefs, practices and stigma; yet, these parts of the world have the greatest burden of poor adolescent SRH outcomes (Chandra-Mouli et al., 2021). For example, over 80% of all adolescents living with HIV are in the sub-Saharan Africa region, (UNICEF, 2016) which also has the highest prevalence of adolescent pregnancy globally (Kassa et al., 2018). In their review of demographic and health surveys data from 33 African countries, Melesse et al. (2020) reported that, despite improvements in SRH among adolescents in the sub-

Saharan Africa region, young people in this part of the world continue to have disproportionately high rates of unwanted pregnancies and STIs (including HIV/AIDS). Further, where there were improvements in these outcomes during the last several decades, they were minimal and not uniformly distributed.

These persistently high rates of poor health outcomes have been attributed, at least in part, to limited access to SRH education, more formally referred to as comprehensive sexuality education, in many sub-Saharan African countries (Wangamati, 2020). Comprehensive sexuality education is defined as "a curriculum-based process of participatory teaching and learning about aspects of sexuality aimed at equipping children and young people with knowledge, skills, attitudes and values that empower them to realize their sexual and reproductive health well-being and rights; develop health interpersonal relationships; reflect on the impact of their choices on self and societal well-being; and secure and protect their rights throughout their lives (Wangamati, 2020)." In a review of 24 studies on SRH literacy by Amanu et al. (2023), the authors found significant gaps in SRH knowledge among young people in the sub-Saharan Africa region. For example, seven of 13 studies focusing on young people in school found that participants were lacking in SRH knowledge. One of three studies that assessed young people's SRH knowledge in universities found that participants had poor level of SRH knowledge.

Challenges impacting access to sexuality education in the sub-Saharan Africa region include cultural and societal norms that serve as barriers to youths' access to information, especially taboos regarding open discussion of such topics as family planning, menstruation, and contraception (Soehnchen et al., 2023). Additionally, comprehensive sexuality education programs have been constrained by inconsistent funding and poor accountability (Achen et al., 2023). It is crucial to promote SRH education in order to combat the challenges faced by

adolescents, and foster a more inclusive and equitable society as these young adults age into adulthood. Additionally, universal access to sexual and reproductive health is an essential component of the sustainable development goals (Otu et al., 2021).

Digital educational tools have the potential to effectively provide SRH education for African adolescents. Such technologies utilize the widespread availability of mobile phones and internet infrastructure to innovatively address the unique challenges faced by African youth in accessing current information and resources (Hubert et al., 2021; Simuyaba et al., 2021). The use of social media platforms, websites, games, and mobile applications has become prevalent in digital education. These tools can provide instructional content with the potential to stimulate teenagers' interest in learning and promote favorable attitudes and knowledge that may lead to desirable sexual and reproductive health outcomes. These tools cover a range of themes, including STI education, mental health, sexuality education, and positive sexual education (Hubert et al., 2021). Digital educational tools have become crucial in enhancing educational opportunities among youth by providing access to a wide range of knowledge and facilitating collaborative learning experiences (Duarte, 2021).

Mobile Health (mHealth), the practice of medicine and public health that utilizes mobile devices, such as mobile phones, patient monitoring devices, and personal digital assistants, to provide health services, collect information, and promote healthcare access, efficiency, and quality, especially in LMICs, has exploded over the last few years, with mobile phones penetration reaching 90% in some LMICs (Rokicki & Fink., 2017). The increased usage of mobile phones among younger populations in LMICs presents a valuable opportunity to use mHealth as a tool to overcome barriers in accessing sexual and reproductive health (SRH) information and services (Feroz et al., 2021). However, the digital divide in Africa, characterized by limited Internet

connectivity, access to digital technologies, and economic disparities, poses significant challenges in fully leveraging these opportunities (Oshadami & Atkinson, 2022). Nolan et al. (2020) noted that the availability and effectiveness of digital educational tools are tremendously restricted by dynamic factors, including funding and resource constraints, elements of culture, and the need for continuous evaluation and adaptation.

Young people from low socioeconomic backgrounds, rural areas, and marginalized communities have limited access to digital devices and internet connectivity, which may limit their ability to fully benefit from digital educational tools on sexual and reproductive health (Nalwanga et al., 2021). The digital gender gap further exacerbates these challenges, with men being more likely to use the internet than women, especially in less developed countries. (Bogdan-Martin, 2021). Several strategies can be considered to bridge this digital divide and alleviate these challenges so that young women have the same access to SRH digital resources as young men.

Research and resource commitment need to be increased in order to develop and utilize culturally sensitive, accessible, and responsive digital pedagogical materials that suit the African adolescent population. Enhancing sexual and reproductive health education in Africa will undoubtedly result in a decrease in the incidence of sexually transmitted infections, a decline in the number of unintended pregnancies, a decrease in gender-based violence, and a positive impact on the mental health and empowerment of youth in making informed decisions regarding their reproductive health (Melesse et al., 2020).

1.1 Gaps in Knowledge

A preliminary assessment of existing research found a limited number of review articles on the use of digital tools designed for sexual health education among adolescents, particularly within the sub-Saharan African context that synthesize existing literature. A comprehensive and critical evaluation of the literature is needed to fully identify the research gaps and opportunities to guide future public health interventions.

1.2 Public Health Significance

Enhancing sexual and reproductive health education across the African region offers significant public health benefits. By improving education in this critical area, we expect notable decreases in the rates of sexually transmitted infections (STIs), including HIV/AIDS, and a reduction in unintended pregnancies, which remain alarmingly high across many African nations (Chandra Mouli et al., 2021; Soehnchen et al., 2023). Such advancements are vital for the well-being of adolescents and would aid in their transition into healthy adulthood.

Furthermore, comprehensive sexual and reproductive health education plays a pivotal role in empowering adolescents, particularly girls. It equips them with the knowledge and confidence to make informed decisions regarding their health and future, such as in choosing to use contraception or practicing safe sex, thereby fostering gender equality (Mbizvo et al., 2023; Finlay, J. E. et al., 2020). This empowerment extends beyond individual benefits, contributing to broader societal advancements such as economic development and poverty alleviation.

The integration of digital tools into sexual and reproductive health education offers a promising avenue to overcome health disparities (Soehnchen C., Weirauch et al., 2023; Kaitano, 2023). Utilizing technology can extend the reach of educational materials to populations that are traditionally difficult to access, including those in rural or underserved regions. This digital approach can close the information gap, ensuring equitable access to essential health knowledge for all adolescents irrespective of their geographical location or socioeconomic status.

In summary, addressing existing knowledge gaps and leveraging digital innovations for sexual and reproductive health education in Africa are crucial. Such efforts not only enhance individual health outcomes, but also align with wider public health objectives, social equity, and sustainable development goals (UNESCO, 2023).

2.0 Objectives

The objectives of this scoping literature review were: 1) to describe the geographic and demographic distribution and 2) the types and format of digital educational tools available for delivering sexual and reproductive health education to adolescents in the sub-Saharan Africa region.

3.0 Methods

3.1 Database and Search Dates

This literature review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria (Moher et al. 2009). The argument is that by adhering to the PRISMA principles, this evaluation includes all relevant primary materials that match the review requirements (Salameh et al., 2020). To conduct this literature review, an initial literature search was conducted using the Ovid-MEDLINE database on November 22, 2023. Institutional access was granted by the University of Pittsburgh Health Sciences Library System (HSLS) and an HSLS librarian with expertise in literature review aided with the establishment of search criteria and execution. The first Ovid MEDLINE search was developed using a mix of Medical Subject Headings (MeSH) phrases and keywords. (Table 1). A search was performed using Google Scholar, PubMed, and ERIC databases. Using lines 22, 24, 26, and 28's search results from Ovid-Medline, as well as search results from Google Scholar, PubMed, and ERIC, the references were uploaded to SciWheel for article exclusion and inclusion.

3.2 Search Terms

A combination of Medical Subject Headings terms and keywords was used to develop the initial Ovid MEDLINE search. (Table 1). Using Lines 22, 24, 26, and 28's search results for the literature review, the references from these lines were uploaded to SciWheel to track and manage

the references for the exclusion and inclusion of articles. The search results were narrowed down using a combination of keywords and Boolean operators. Words including "teens," "health education," "STIs," "reproduction," "Adolescents," "mental health," and "Africa" Africa were employed.

Table 1. *Line-by-line search to retrieve titles and abstracts*

Line Number	Search String
Line 1	Adolescent/
Line 2	(adolescent* or teen* or youth).ti,ab,kf.
Line 3	1 or 2
Line 4	digital health education/ or health promotion/ or sex education/
Line 5	((health or reproduction or reproductive or sex or sexual) adj2 (education or promotion or resources or training)).ti,ab,kf
Line 6	4 or 5
Line 7	3 and 6
Line 8	hiv infections/ or acquired immunodeficiency syndrome/ or sexually transmitted diseases/ or exp sexually transmitted diseases, bacterial/ or chancroid/ or chlamydia infections/ or gonorrhea/ or syphilis/ or sexually transmitted diseases, viral/ or herpes genitalis/ or papillomavirus infections/
Line 9	(aids or hiv or (sexually adj3 transmit*) or chlamydia or gonorrhea or herpes or HPV or papillomavirus or syphilis).ti,ab,kf.
Line 10	Contraception/
Line 11	contraceptive agents/ or exp contraceptives, oral/
Line 12	reproductive behavior/ or contraception behavior/
Line 13	Safe Sex/ or Condoms/
Line 14	((birth adj control) or condom or condoms or contracepti* or (safe adj sex)).ti,ab,kf.
Line 15	8 or 9 or 10 or 11 or 12 or 14
Line 16	7 and 15
Line 17	exp africa/
Line 18	(Africa or Angola or Benin or Botswana or Burkina Faso or Burundi or Cabo Verde or Cameroon or Central African Republic or Chad or Comoros or Congo or Cote d'Ivoire or Djibouti or Eritrea or Eswatini or Ethiopia or Gabon or Gambia or Ghana or Accra or Kumasi or Tamale or Sekondi-Takoradi or Guinea or Kenya or Lesotho or Liberia or Madagascar or Malawi or Mali or Mauritania or Mozambique or Namibia or Niger or Nigeria or Rwanda or Sao Tome or Principe or Senegal or Seychelles or Sierra Leone or Somalia or Sudan or Tanzania or Togo or Uganda or Zambia or Zimbabwe).ti,ab,kf.
Line 19	17 or 18
Line 20	16 and 19

Line 21	"systematic review".pt. or "Systematic Reviews as Topic"/ or "Cochrane Database of Systematic Reviews".jn. or (evidence report technology assessment or evidence report technology assessment summary).jn. or (((comprehensive* or integrative or mapping or rapid or realist or scoping or systematic or systematical or systematically or systematicaly or systematicly or umbrella) adj3 (bibliographical or bibliographically or bibliographics or literature or review or reviews)) or (state adj3 art adj1 review) or (research adj2 synthesis) or ((data or information) adj3 synthesis)).ti,ab,kf. or ((data adj2 (extract or extracting or extractings or extraction or extraction)).ti,ab,kf. and ("review".ti. or "review".pt.)) or (((electronic or searched) adj2 database*) and (eligibility or excluded or exclusion or included or inclusion)).ti,ab,kf. or (overview adj4 reviews).ti,ab,kf. or ((review adj3 (rationale or evidence)).ti,ab. and "review".pt.) or (PRISMA or (preferred adj1 reporting)).ab. or (cinahl or (cochrane adj3 (trial or trials)) or embase or medline or psyclit or (psycinfo not (psycinfo adj1 database)) or pubmed or scopus or (sociological adj1 abstracts) or (web adj2 science)).ab.
Line 22	20 and 21
Line 23	16 and 21
Line 24	23 not 22
Line 25	(20 not 22) and english.la.
Line 26	(ghana/ or (Ghana or Accra or Kumasi or Tamale or Sekondi-Takoradi).ti,ab,kf.) and 25
Line 27	25 not 26
Line 28	limit 27 to yr="2013 - 2024"
Line 29	limit 27 to yr="2003 - 2012"
Line 30	limit 27 to yr="1993 - 2002"

3.3 Literature Search Strategy

In alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards, the methodology encompasses four phases: identification of sources, assessment of eligibility, detailed screening, and final selection for inclusion (Salameh et al., 2020). Initially, potential sources were selected by examining their titles and abstracts, ensuring relevance to the research question. This meticulous process facilitated the systematic evaluation and filtering of records, governed by rigorously defined inclusion and exclusion criteria. Ultimately, articles that advanced beyond the preliminary screening phase were subjected to a

comprehensive review of their full texts to determine their eligibility for inclusion in the scoping review, based on the established inclusion and exclusion criteria (Table 2).

Table 2. *Criteria for selecting studies on digital educational tools for adolescent sexual and reproductive health in Africa*

Inclusion Criteria	Exclusion Criteria
1. Studies specifically focused on Africa or with significant relevance to Africa	1. Studies that did not specifically address sexual and reproductive health (SRH) digital educational tools
2. Studies focusing on adolescents and youth	2. Population not African/LMICs
3. Studies that focus on digital educational tools addressing sexual and reproductive health, including STI education, mental health, sexuality, and positive sexuality	3. Studies of populations outside of the age range of adolescents and young people.
4. Studies that detail different types of digital tools (e.g., apps, websites, e-learning modules) and their formats	
5. Research that evaluates the effectiveness, user engagement, and impact of these tools	
6. Studies published between the last 10 years to ensure relevance so 2013- 2024	
7. Studies in English Language	

Figure 1 outlines the systematic and comprehensive search and selection process employed in this scoping review, focusing on digital educational tools for adolescent sexual and reproductive health in Africa. Initially, a total of 1,877 records were identified through meticulous searches across major databases, including OVID Medline, Google Scholar, PubMed, and ERIC. An additional 4 records were identified through citation searching, augmenting the pool of potential studies.

Before screening, 203 records were removed due to duplication, leaving 1,674 records for detailed screening. The screening process, grounded in rigorously defined inclusion and exclusion criteria, led to the exclusion of 1,656 records for reasons such as not directly addressing sexual and reproductive health (SRH) digital educational tools, not focusing on the African/LMIC context, targeting populations outside the adolescent age range and young people, duplications.

After the exclusion process, 18 reports were retrieved and assessed for eligibility, from which 4 additional studies were identified and included in the review alongside the initially identified studies, bringing the total number of studies included in the review to 22. This structured process, as visualized in Figure 2, underscores the depth of the literature search and the systematic approach to identifying the most relevant and recent studies on the impact of digital educational tools on adolescent sexual and reproductive health in the African context.
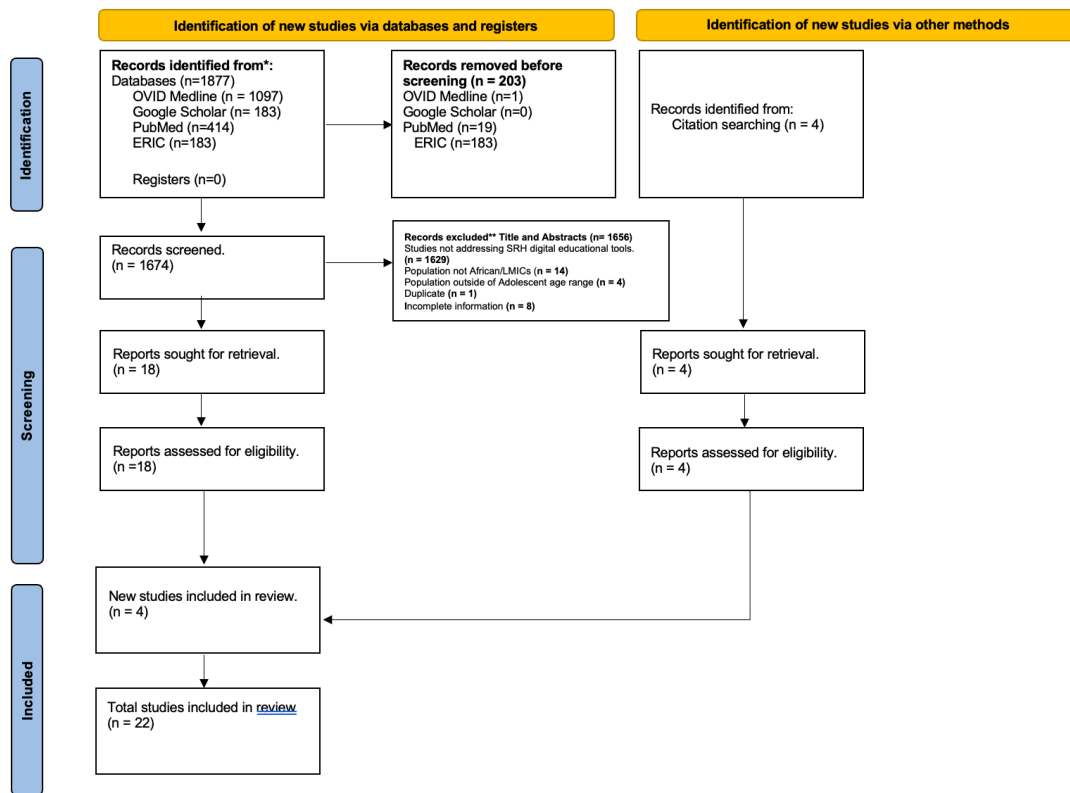

Figure 1. *Flowchart for scoping review of digital educational tools in adolescent sexual and reproductive health in Africa*

3.4 Key Classifications and Definitions

Digital tools. Digital tools are technological resources or applications utilized in the provision of information, support, and resources related to sexual and reproductive health. These tools use digital technology to enhance access, outreach, and effectiveness in the delivery of sexual and reproductive health education and services. They are available through a variety of digital platforms such as websites, mobile applications, and social media platforms (Hubert et al., 2021). The utilization of such tools has become increasingly prevalent in recent years as they offer a convenient and efficient means of accessing information and resources related to sexual and reproductive health. These tools have gained considerable popularity owing to their ease of use and convenience in terms of obtaining information related to sexual and reproductive health.

Adolescents. Adolescents are individuals in the intermediate stage of development between childhood and adulthood, commonly referred to as teenagers or young adults. This stage of life is typically marked by substantial transformations in physical structure, thinking, interpersonal relationships, and emotions (Van Ryn & Nyrongo, 2023). Although adolescents comprise the age group of interest in this study, other age groups that overlap with adolescence (youth and young people) are also mentioned. Thus, this review covers the age range of adolescents aged between 10 and 19 years, youth aged 15 to 24 years, and young people aged between 10 and 24 years (WHO, n.d.).

4.0 Results

A comprehensive review of selected studies on digital educational tools for sexual and reproductive health education among African adolescents yielded three core themes (see Table 3). These themes included the geographical focus, and target demographics (Objective 1). And the type of digital tools used (Objective 2). By examining an array of digital platforms—from social media and mobile applications to gamified learning experiences—this scoping review sheds light on innovative approaches tailored to effectively engage African youth. This exploration spans a variety of African settings, each with unique cultural, social, and infrastructural characteristics, emphasizing the importance of contextual adaptability in the deployment of digital health solutions. The focus on adolescents and young adults as the primary target demographic underlines the critical need for interventions that resonate with the experiences and challenges faced by this age group as they transition to adulthood., Collectively, these insights contribute to a deeper understanding of the efficacy and impact of digital educational tools in addressing the sexual and reproductive health needs of African youth, highlighting the dynamic interplay among technology, geography, and demographic specificity in shaping sexual and reproductive health education outcomes.

Table 3. *Summary of studies on the availability of digital sexual and reproductive health education for African adolescents*

Author(s), Year	Study Population/Region/Country	Study Design	Digital tool type	Findings
Dulli et al. (2020)	349 youths aged 15-24 years from Nigeria	Randomized Controlled Trial. Participants were randomized into two groups: those receiving the SMART Connections intervention and those receiving standard care services.	Social Media	**Primary Results:** The intervention did not significantly improve retention (50% vs. 45% retention in treatment and control groups respectively or social support but did significantly improve HIV-related knowledge (t=-2.96, p=0.003).
Fakoya et al. (2022)	111 adolescents aged 15 to 19 years from Nigeria, Tanzania, and Ethiopia	Application of youth-led participatory action research (PAR) approaches within HCD.	Youth-engaged version of Human-Centered Design (HCD) as part of the Adolescents 360 initiative.	**Primary Results**: Successful engagement of youth as project partners and action researchers. Identified opportunities to improve program empathy and responsiveness. Challenges in recruiting "extreme users" due to high competencies needed in HCD. Empathy and design standards during prototyping helped in decision-making. Real-world testing of services and products emphasized the importance of continuing youth-adult partnership.
Feroz et al. (2021)	Young people (adolescents and youth) aged 10–24 years in low-and-middle-income countries (LMICs) specifically The sub-Saharan Africa region and Asia.	Systematic Review	Mobile phones used for mHealth interventions aimed at improving sexual and reproductive health (SRH) outcomes.	Primarily used for client education and behavior change communication (n=14, 93%), followed by financial transactions and incentives, and data collection and reporting. mHealth interventions improved access to SRH services and outcomes by addressing barriers such as provider prejudice, stigmatization, discrimination, and issues of privacy and confidentiality. Included decreased technological literacy, inferior network coverage, and lower linguistic competency.

Gonsalves et al. (2018)	705 young people aged 13-24 years in each of Kenya and Peru	Protocol of open, three-arm, individually randomized trial. Participants will be randomized into one of three arms: 1) Intervention arm receiving SRH information (using ARMADILLO) via mobile phones, 2) Control arm receiving no intervention, and 3) A third arm with variations by site (Kenya and Peru).	Mobile Phone Sexual Health Information	If proven to be effective, interventions like ARMADILLO can bridge an important gap towards achieving universal access to SRH information and education for an otherwise difficult-to-reach group.
Haruna et al. (2019)	A total of 348 secondary school participants (students) aged between 11 and 15 years from three schools were recruited to participate in this study in Tanzania.	Design-based research (DBR)	Digital gamified learning platform named "My Future Begins Today"	Improved post-test scores among participants using the gamified learning platform. Positive stakeholder and participant feedback on the gamified approach. Effective use of participatory design in developing educational tools.
Nalwanga et al. (2021)	1,086 Kyambogo University students between the ages of 18-30 years in Uganda.	Cross-sectional analysis of data from an endline survey of a randomized controlled trial (RCT) and data from use of the MPA over a 6-month period.	Mobile Phone Application	The mobile phone application (MPA) demonstrated predominantly positive (responsiveness, non-distracting in-app advertisements, and ease of use) attributes.
Ippoliti et al. (2017)	Adolescents and youth ages 10-24 years from Africa (67%), Eurasia (26%) and Latin America (13%)	Global landscape analysis. Authors issued a global call for project resources in 2014, reviewed the submissions to confirm they met specific inclusion criteria.	Mobile phones (including SMS/text messaging and mobile phone applications)	Most projects (70%) relied on text messaging to transmit SRH information. The majority of projects were based in Africa (67%), followed by Eurasia (26%) and Latin America (13%). Mobile phones were effectively used to increase the reach of SRH information and services, especially in conservative societies where SRH topics are stigmatized. Several projects have been adapted and scaled to other countries, demonstrating the scalability of mHealth interventions.

L'Engle et al. (2016)	Review targeted adolescents aged 10 to 24 years and included studies that provided results from mobile phone interventions designed to improve adolescent sexual and reproductive health (ASRH)	Systematic Review	Mobile phone interventions, primarily text messaging	Most programs (82%) utilized text messaging. An average of 41% of essential mHealth criteria were met. An average of 82% of methodological reporting criteria were met. Evidence suggests improvements in health promotion campaigns, STI screening and follow-up, and medication adherence.
Nolan et al. (2020)	6,000 youth aged 12–19 years across 8 districts in Rwanda	3-arm cluster-randomized. Arms: 1) CyberRwanda self-service; 2) CyberRwanda facilitated; and 3) control schools, which will receive the standard services that are available in the community.	CyberRwanda, a digital health intervention consisting of interactive stories, Q&As, videos, and an online shop for health products.	The study protocol describes the design and intended impact evaluation of the CyberRwanda program using a 3-arm cluster-randomized non-inferiority trial, but it does not report on the outcomes or effectiveness of the intervention.
Onukwugha et al. (2022)	Review includes 10-19 years, with consideration for interventions focusing on young people aged 10-24 years in the sub-Saharan Africa region.	Sytematic Review	mHealth/mobile health interventions	mHealth interventions were effective in improving adolescents' uptake of SRH services across a wide range of services, with the strongest evidence for contraceptive use. Interventions with two-way interactive functions and more behavior change techniques embedded were more effective. Limited data suggested interventions were inexpensive, but cost-effectiveness was not evaluated.
Patel et al. (2022)	Adolescents in low-and middle-income countries (countries not specified by authors).	Environmental scan (ES) is used to identify current SRH mobile applications (hereinafter referred to as "apps") available in the IOS App store and Android Play store.	Mobile Applications	2,165 mobile apps were initially identified, with only 8 apps meeting the inclusion criteria and assessed using the Mobile App Rating Scale (MARS) tool. The functionality subdomain scored the highest at 4.6. The information subdomain scored the lowest at 2.5. None of the assessed apps contained information on the MARS items related to evidence base and goals. "Too Shy to Ask" had the highest individual app mean score of 4.1, while "e-SRHR" scored the lowest at 2.3.

Pfeiffer et al. (2014)	60 Adolescents aged 15 to 19 years in Dar es Salaam and Mtwara, Southern Tanzania.	Mixed-methods study	Social media, with a particular focus on Facebook	Adolescents access the internet mainly through mobile phones. Facebook is the most popular internet site among the youth. Adolescents expressed interest in receiving reproductive and sexual health messages through social media. Youth role models, such as music stars and actors, are influential in delivering health messages.
Rogers et al. (2020)	Adolescents from 10 to 19 years old living in Zambia	Content analysis of the TuneMe website.	Mobile-Optimized Website (TuneMe)	The TuneMe platform provided extensive information on sexual and reproductive health and HIV. Topics on relationships, sexual rights, and citizenship were also covered, albeit to a lesser extent. Areas such as pleasure, violence, diversity, and gender received significantly less attention. Content was presented in culturally relevant contexts but sometimes portrayed mixed or problematic views on gender norms.
Rokicki et al. (2017)	756 adolescent females ages 14-24 enrolled in secondary schools in Accra, Ghana	Cluster-randomized controlled trial. **Unidirectional intervention (n=12 schools):** Participants received text messages with reproductive health information. **Interactive intervention (n=12 schools):** Participants engaged in text-messaging reproductive health quizzes. **Control (n=14 schools):** Did not receive reproductive health-related text messages.	Text-messaging program	Unidirectional intervention increased reproductive health knowledge by 11 percentage points (95% CI=7, 15). Interactive intervention increased knowledge by 24 percentage points (95% CI=19, 28), from a control baseline of 26%. No significant changes in reproductive health outcomes overall. Both interventions lowered odds of self-reported pregnancy for sexually active participants (Unidirectional: OR=0.14, 95% CI=0.03, 0.71; Interactive: OR=0.15, 95% CI=0.03, 0.86).

Soehnchen et al. (2023)	77 Young adults aged 18 to 35 years old in resource-poor regions of Kenya	Survey based on the Unified Theory of Acceptance and Use of Technology (UTAUT)	Web-based prototype designed to provide essential sexual health information.	High acceptance and usability of the digital tool among the target population. Perceived usefulness, attitude towards healthcare integrated evidence technology, and usability had a significant positive impact on acceptance and intention to use. Having the resources and knowledge necessary for the usage of a digital tool had a significant negative impact. A System Usability Scale (SUS) score of 67.3 indicates the tool's usability as "okay".
Soehnchen et al. (2023)	17 young women aged between 15 and 25 years in Kenya	Qualitative research design, with a sample size of 12 pilot phase interviews and 5 expert interviews	Web-based sexual health education app	Stigmatization around sexual health in Kenya leads to myths and lack of information. Sexual health education is not part of the Kenyan school curriculum, leading to insufficient knowledge about safe contraception, menstruation, and female genital mutilation. A digital app could support and provide education and information for universal equal access. Barriers to using a digital sexual health education app include conservative cultural background, classic text communication, and social affiliation influence.
Wirsiy et al. (2020)	398 adolescent girls aged 10 to 19 years in Cameroon	Single-centered randomized controlled single-blinded trial. **Intervention group:** Received weekly educational one-way text messages on sexo-reproductive health (199 participants) **Control group:** Did not receive the text messages (199 participants)	Mobile phone text messaging (SMS)	Significant increase in mean knowledge, attitude, and practice scores from baseline to the end of the study (from 6.03, 4.01, and 3.45 to 7.99, 5.83, and 4.99, respectively) Statistical significance in overall improvement in adolescents' perception on sexo-reproductive health as a result of the intervention ($F = 15.12$, $P = 0.023$ for knowledge; $F = 60.21$, $P = 0.001$ for attitudes; $F = 57.$, $P = 0.013$ for practices) Majority (65.3%) of participants were satisfied with the SMS service.

Akande et al. (2024)	1,280 in-school adolescents ages 15–17 years in Nigeria	cluster randomized controlled trial. **Intervention group**: Received the m-Health-based intervention. **Control group:** Did not receive the m-Health intervention	m-Health-based sex education programme	Significant improvements in sexual and reproductive health (SRH) knowledge and attitudes in the intervention group. No significant change in risky sexual behaviour scores in the intervention group. Being female was associated with better SRH knowledge post-intervention. Being male was linked to more risky sexual behaviours. Higher class level was associated with lower risky behaviour.
Rokicki & Fink. (2017)	756 adolescent girls and young women aged 14-24 years in Ghana	Randomized controlled trial. Unidirectional intervention (text messages with reproductive health information) Interactive intervention (engaged adolescents in text-messaging reproductive health quizzes) Control (no intervention)	Interactive mobile phone quiz (mHealth intervention)	The mHealth intervention was effective in engaging adolescent girls across sociodemographic strata. Participants showed increased health knowledge regarding sexual and reproductive health (SRH). The intervention reached adolescents who may be at higher risk of poor SRH outcomes.
Haruna et al. (2018)	120 lower secondary school students (11–15 years of age) in Tanzania	randomized controlled trial. 1. Game-Based Learning (GBL) 2. Gamification 3. Control Group (Traditional Teaching)	Game-based learning and gamification platforms	The study explored the effectiveness of game-based learning (GBL) and gamification in improving sexual health education among adolescents. It found that these methods significantly enhanced motivation, attitude, knowledge, and engagement (MAKE) towards learning about sexual health compared to traditional teaching methods.
Kaba et al. (2019)	250 adolescents and young people aged 18–24 years at the University of Ghana, Legon in Accra, Ghana.	Cross-sectional analytical study	Mobile phones (including smartphones)	99% of participants owned mobile phones, with 58% being smartphone users. Male young adults and those who owned a smartphone were more likely to use mobile phones for STIs education and prevention. The study suggests high mobile phone penetration among young adults, with a belief in the efficacy of mobile phone programs for STIs education and prevention.

| Ippoliti et al. (2021) | Adolescents aged 12–19 years in Rwanda. | Human-centered design (HCD) approach | CyberRwanda, a web-based digital health platform | Over 1,000 Rwandan youth, caregivers, teachers, health care providers, and government stakeholders engaged. Revealed participants' beliefs, behavioral preferences, and experiences related to family planning and reproductive health (FP/RH). Designed for urban and peri-urban young people and pharmacy staff. |

4.1 Geographical Focus

Figure 2 presents the map of Africa and shows the countries covered in included studies in green. The geographical scope of research on digital interventions for sexual and reproductive health education spans a diverse array of settings in the sub-Saharan Africa region, each offering unique insights into the challenges and opportunities inherent in deploying technology-based solutions within various cultural and infrastructural contexts. This geographical diversity is not merely a backdrop for

Figure 2. *Map of Africa showing countries included in reviewed studies in green*

these studies, but a critical factor that shapes the design, implementation, and impact of digital health interventions across the continent.

In Nigeria, Dulli et al. (2020), Fakoya et al. (2022), and Akande et al. (2024) highlighted the country's engagement with digital platforms to address sexual and reproductive health among youth and adolescents. Feroz et al. (2021) and Ippoliti and L'Engle (2017) also included studies from Nigeria. Nigeria, with its vast population and significant digital penetration, represents a critical context for understanding how social media and participatory design can be harnessed to meet young people's health education needs. The focus on Nigeria underscores the potential of digital tools to transcend traditional barriers to health education, leveraging the widespread use of social media and mobile phones among the youth. Besides Nigeria, this study included some other countries in West Africa, such as Ghana (Feroz et al., 2021; Onukwugha et al., 2022; Rokicki et al., 2017; and Alhassan et al., 2019), Senegal (Ippoliti & L'Engle, 2017), and Mali (Ippoliti & L'Engle, 2017).

The reviewed studies extend beyond West Africa to include Kenya, as illustrated by Gonsalves et al. (2018), who explored the impact of mobile phone-based sexual health information among young people, as well as Soehnchen, Weirauch, et al. (2023) who assessed acceptance of a digital tool for delivering sexual health education. Some other authors, namely Feroz et al. (2021), Ippoliti and L'Engle (2017), Onukwugha et al. (2022), and Soehnchen, Rietz, et al. (2023) also included studies that were done in Kenya in their reviews. Kenya's inclusion in this body of research is indicative of its role as a hub for technological innovation and digital health initiatives in East Africa. Nalwanga et al. (2021) performed a cross-sectional analysis to assess utilization of a mobile phone application by university students in Uganda, another East African country. Haruna et al. (2019) focused on secondary school participants in Tanzania, utilizing a gamified learning

platform to engage students in sexual and reproductive health education. This emphasis on educational settings highlights the potential of integrating digital tools into formal education systems, showing how gamification can enhance learning outcomes and engagement among school-aged youth. Data from Tanzania, Rwanda, and Ethiopia, which are also East African countries, were included in studies by Fakoya et al. (2022), Feroz et al. (2021), Haruna et al. (2018; 2019), Ippoliti and L'Engle (2017), Ippoliti et al. (2021), Onukwugha et al. (2022), Nolan et al. (2020), and Pfeiffer et al. (2014). The cross-regional approach of Gonsalves et al. (2018), encompassing participants from both Kenya and Peru, further emphasizes the global relevance of digital health interventions and the importance of considering diverse cultural and infrastructural landscapes in their design and deployment.

This study also included some countries in southern Africa, including South Africa, Mozambique, and Zambia. For example, Rogers et al. (2020) performed a content analysis of TuneMe, a mobile-optimized website that offers extensive information on sexual and reproductive health and HIV. Importantly, the content was presented in culturally relevant contexts. In addition to that study, Feroz et al. (2021), Ippoliti and L'Engle (2017), and Onukwugha et al. (2022) included data from southern African countries in their systematic reviews.

Democratic Republic of Congo (Feroz et al., 2021) and Cameroon (Wirsiy et al., 2020) were two Central African countries included in this study. Collectively, these studies paint a picture of a continent actively engaging with digital technologies to overcome the challenges in delivering sexual and reproductive health education. The wide geographical reach of this research, from the populous country of Nigeria to the tech-savvy environments of Kenya, reflects the varied landscapes in which these digital interventions are implemented. Each setting provides unique insights into the interplay between cultural norms, technological accessibility, and health education

needs, contributing to a richer understanding of how digital tools can be adapted and scaled across African contexts.

In conclusion, the geographical diversity represented in this body of research not only enriches our understanding of the potential and challenges of digital health interventions in Africa, but also underscores the importance of contextually adapted solutions. By examining the implementation and impact of these digital tools across various African settings, researchers and practitioners can gain valuable insights into the factors that drive the success and scalability of health education interventions, thus paving the way for more inclusive and effective public health strategies.

4.2 Target Demographics

Among the studies reviewed, there was a notable emphasis on youth and adolescents, spanning ages 10-24 reflecting the critical importance of reaching these age groups with effective, accessible, and engaging health education. Although the focus of this study is the adolescent age group, they are often included in broader age groups such as young people and youth. For instance, Dulli et al. (2020) concentrated on youths aged 15-24 years in Nigeria. The authors performed a randomized controlled trial using social media as a platform to deliver sexual health interventions (SMART Connections). Similar populations were targeted by Gonsalves et al. (2018) in Kenya and Rokicki et al. (2017) in Ghana. Similarly, Fakoya et al. (2022) engaged adolescents aged 15 to 19 years from Nigeria, Tanzania, and Ethiopia, incorporating youth-led participatory action research with a human-centered design to create interventions that resonate with the lived experiences and preferences of young individuals. The authors directly engaged the target

demographic in the study design process. In Rwanda, Nolan et al. (2020) analyzed data from 6,000 youth aged 12-19 years in a cluster-randomized trial and Rogers et al. (2020) studied a similar age group (10 to 19 years old) in Zambia.

Further broadening the demographic spectrum, Feroz et al. (2021) extended their review to young people aged 10–24 years, in the sub-Saharan Africa region and Asia. The sub-Saharan African countries in that study included Tanzania, Nigeria, Ghana, Uganda, and Kenya. The authors performed a comprehensive review of mHealth interventions, identified a wide range of options, and elucidated their applications, as well as barriers and facilitators for adoption.

The inclusive age range spanning from early adolescence to young adulthood acknowledges the diverse needs and challenges faced by individuals as they navigate through different stages of the early life course, emphasizing the importance of tailoring interventions to meet these varying requirements.

The more expansive approach of Gonsalves et al. (2018) by including young people aged 13-24 years in Kenya and Peru, illustrating the global relevance of digital sexual health interventions and the need to consider cross-cultural applicability and customization in their design and implementation. This cross-regional study underscores the universal challenges related to sexual health education, while acknowledging the specific nuances that different cultural contexts bring to the fore.

Finally, Haruna et al. (2019) involved secondary school participants from Nigeria in the development of a digital gamified learning platform. This engagement not only emphasizes the educational context as a critical setting for sexual health education, but also showcases the potential of gamification as a strategy to enhance learning outcomes and retention among school-aged youth.

Collectively, these studies reflect a strategic and inclusive approach targeting diverse demographic groups within the realm of digital sexual and reproductive health education. By focusing on adolescents and young adults across a variety of settings, these interventions aimed to bridge gaps in access and engagement, ultimately contributing to more informed, healthy, and empowered communities.

4.3 Digital Tool Types and Effectiveness

The landscape of digital tools deployed for sexual and reproductive health education in various African contexts is as diverse as it is innovative. This array of digital interventions not only signifies a shift towards more accessible and engaging formats for health education but also reflects the adaptability of health practitioners and researchers to leverage technology to meet the needs of their target populations.

Social media emerged as a significant platform in this digital toolbox, with Dulli et al. (2020) exploring its utility among youths aged 15-24 years in Nigeria. The authors engaged potential participants through social media given youths' increasing access to mobile phones and social media in low- and middle-income countries. This study's innovative use of social media platforms underscores the potential of these digital spaces to foster engagement and deliver health interventions in formats that are both familiar and accessible to young audiences. This approach recognizes the integral role of social media in the daily lives of youth, positioning it as a critical channel for health education.

By further expanding the digital horizon, Fakoya et al. (2022) introduced a youth-engaged version of Human-Centered Design (HCD), which is particularly noteworthy for its participatory

nature. This method not only engages adolescents in the design process but also ensures that the resulting digital tools are deeply aligned with their needs, preferences, and context. Such participatory approaches enrich the digital tool landscape by prioritizing user-centered design principles, thereby enhancing the relevance and effectiveness of health interventions.

Mobile phones, as highlighted by Feroz et al. (2021) and Gonsalves et al. (2018), serve as another pivotal medium for digital health interventions, offering a range of applications, from text messaging to more complex health information delivery systems. The ubiquity and accessibility of mobile phones make them an ideal platform for reaching a wide audience, particularly in regions where mobile technology may be more readily available than traditional healthcare services. These studies highlight the versatility of mobile phones in delivering tailored health education and interventions, from SMS-based information dissemination to more interactive app-based learning experiences.

The digital gamified learning platform developed by Haruna et al. (2019) represents an innovative leap in engaging and educating secondary school participants in Nigeria. By harnessing the engaging power of gamification, this approach not only enhances learning outcomes, but also introduces an element of fun and interaction that can significantly increase participant engagement and information retention. Such gamified platforms offer promising avenues for making health education more appealing and effective for younger people.

Collectively, these digital tools, from social media and participatory design to mobile phone applications and gamification, reflect a dynamic and multifaceted digital ecosystem for sexual and reproductive health education. Each tool, with its unique features and applications, contributes to a broader strategy aimed at enhancing the accessibility, engagement, and effectiveness of health interventions in different African settings. These diversified digital tools

not only address the varied needs and preferences of target demographics, but also showcase the potential of technology in transforming health education and empowerment.

4.4 Factors Affecting Interpretation

In synthesizing the reviewed articles on digital health interventions for sexual and reproductive health (SRH) education among adolescents, several factors emerge that affect the interpretation and comparability of these studies. These elements include variations in the study design and sample sizes.

4.4.1 Variations in Study Designs

The reviewed articles exhibited a wide range of study designs, from randomized controlled trials (RCTs) to cross-sectional analysis and qualitative studies. RCTs, such as those conducted by Gonsalves et al. (2018) and Rokicki et al. (2017), represent the gold standard for evaluating intervention effectiveness because of their ability to minimize bias and potentially establish causal relationships. However, the complexity and cost associated with RCTs often limits their scope and scale (Hariton & Locascio, 2018). The RCTs reviewed had varying limitations. In the study by Gonsalves et al. (2018), potential variability in mobile phone access and usage between participants, may have affected the intervention's reach and effectiveness. Similarly, the study by Rokicki et al. (2017) was restricted to female students limiting generalizability. Studies such as Haruna et al. (2019) employed participatory design approaches and engaged end-users in the development process to ensure that the interventions were user-friendly and contextually relevant. Systematic reviews, while synthesizing extensive datasets for comprehensive analysis, may still

confront limitations associated with publication bias and heterogeneity in study methodologies, as demonstrated by Feroz et al. (2021).

This variation in study design impacts the robustness of the literature. While RCTs provide strong evidence of intervention effects, the broader array of study designs reflects the field's adaptability and diverse contexts in which these interventions are applied. However, the reliance on less rigorous designs may weaken the overall evidence base in some instances, highlighting the need for more RCTs and systematic reviews to consolidate the findings.

4.4.2 Sample Size

The sample sizes varied among the reviewed studies. For example, the study conducted by Pfeiffer et al. (2019), targeted a sample of 60 adolescents. Despite its valuable insights into the use of social media among adolescents in Dar es Salaam for sexual and reproductive health (SRH) information, this study did not possess the statistical power necessary to detect small but significant effects, raising concerns about the validity of its findings. Conversely, larger-scale research, exemplified by Nalwanga et al. (2021), encompassed a broader demographic survey of 1,086 university students of varying backgrounds, to evaluate the utilization of mobile phone applications to improve access to contraception and sexual and reproductive health services. Their findings, which highlight a significant improvement in access to and utilization of SRH services among the target population, offer more robust evidence of intervention effects due to the larger sample size.

4.4.3 Coverage of STI Education

The integration of digital technologies into the realm of sexual and reproductive health education presents a promising avenue for addressing the pervasive issue of STIs among African teenagers. This literature review synthesizes the findings from 22 distinct studies, each exploring different digital interventions aimed at improving STI education and related health outcomes. The reviewed studies encompassed a range of digital tools, including social media platforms, mobile health (mHealth) interventions, and gamified learning applications, highlighting the diverse methods through which digital technology can engage adolescents and facilitate access to crucial health information.

Dulli et al. (2020) explored the use of social media-based support groups for youth living with HIV infection in Nigeria. Although the intervention did not significantly improve retention rates, it underscores the potential of social media to facilitate peer support and information-sharing (Dulli et al. 2020). Conversely, Feroz et al. (2021) provided a comprehensive review of mHealth interventions across several regions, demonstrating their effectiveness in client education and behavioral change concerning sexual health. This diversity in digital platforms, from social media to mobile apps, suggests a broad canvas for intervention strategies that can be tailored to different contexts and adolescent needs.

The incorporation of adolescents in the design and implementation of digital tools, as shown in studies by Fakoya et al. (2022) and Haruna et al. (2019), indicates the value of participatory approaches in creating more relevant and effective educational interventions. Fakoya et al. (2022) highlighted how youth-led participatory action research (PAR) enhances the design process, leading to more engaging and meaningful health education experiences. Similarly, Haruna et al. (2019) developed a digital gamified platform to improve knowledge retention among

secondary school participants, emphasizing the effectiveness of interactive and engaging digital content in education.

These studies collectively indicate that digital tools can overcome traditional barriers to STI education, such as stigma and limited access to resources. Gonsalves et al. (2018) discussed the potential of mobile phone-based sexual health information to reach diverse populations, including those in Kenya and Peru, suggesting a similar potential for African teenagers. The anonymity and privacy afforded by digital platforms can empower adolescents to seek information and services without fear of stigma, thereby promoting more proactive and informed health behaviors.

While the potential of digital interventions is evident, the reviewed studies highlight several challenges, including the need for more robust evidence on the effectiveness of various digital tools and the importance of involving adolescents in the development process to ensure relevance and engagement. The limitations identified in these studies, such as recruitment challenges and the need for more comprehensive outcome measures, underscore the importance of continued research and innovation in this field.

Digital technologies offer a promising platform for enhancing STI education among African teenagers with the potential to improve knowledge, attitudes, and behaviors related to sexual health. The reviewed studies underscore the importance of innovative, engaging, and adolescent-centered approaches to digital health interventions. As the digital landscape continues to evolve, so too should our strategies for leveraging these tools address critical public health challenges among vulnerable populations.

5.0 Discussion

5.1 Digital Interventions and Sexual and Reproductive Health Education

The intersection of digital interventions and SRH education represents a burgeoning field of research that is aimed at enhancing the well-being of adolescents and young adults. This literature review underscores the multifaceted approach of recent studies that address these aspects through innovative technological solutions. The reviewed studies demonstrated the potential of digital interventions for assessing and delivering SRH education among adolescents in the sub-Saharan Africa region but revealed several critical gaps in knowledge that warrant further investigation.

First, longitudinal studies that assess the long-term effects of digital sexual health interventions on adolescent behaviors and health outcomes are lacking. While some research has been conducted on the immediate effects, such as improved knowledge, the enduring impact of these interventions on actual behaviors and health outcomes over time remains largely unexplored (Soehnchen et al., 2023).

Secondly, the accessibility and inclusivity of digital tools for sexual health education has not been thoroughly evaluated. In many African regions, technological disparities present significant barriers to accessing digital educational resources, particularly for adolescents from marginalized communities or those living in rural areas (Huang, KY., Kumar, M., Cheng, S. *et al.,* *2022).* This highlights the necessity for research examining the effectiveness of digital tools across various socioeconomic and geographical backgrounds. Moreover, the integration of culturally sensitive content into digital sexual health education has not been sufficiently addressed in the

literature. Cultural norms and values play a crucial role in shaping sexual health behaviors and attitudes among African adolescents (Achen et al., 2023). However, there is a scarcity of evidence on how digital tools are adapted to respect and integrate these cultural considerations effectively (Kaitano, 2023).

Finally, there is a gap in the active participation of adolescents in the development and evaluation of digital sexual health tools. Involving adolescents in the creation and assessment of these tools can provide essential insights into their preferences, needs, and challenges, which can significantly enhance the relevance and effectiveness of digital interventions (Decker et al., 2022). To optimize digital interventions for adolescent sexual health education in Africa, there is a pressing need for research that addresses these gaps, focusing on long-term outcomes, accessibility, cultural sensitivity, and adolescent engagement in the development and evaluation processes.

This literature review underscores the multifaceted approach of recent studies that address the intersection of digital interventions and SRH education through innovative technological solutions. Dulli et al. (2020) explored the use of a social media-based support group to improve HIV treatment retention among youth in Nigeria. Although its primary aim was not mental health, the intervention facilitated social support and peer interactions, indirectly benefiting mental well-being by reducing isolation and stigma associated with HIV (Dulli et al., 2020). Furthermore, sessions on sex and relationships within the study imply engagement with positive sexuality by providing safe spaces for discussions about sexual health and relationships, vital for fostering a healthy understanding of sexuality among youth. Fakoya et al. (2022) demonstrated an innovative application of youth-led participatory action research (YPAR) for designing sexual and reproductive health programs. This approach empowers adolescents to enhance their sense of

agency and self-esteem, which are crucial for their mental health. The emphasis on human-centered design and participatory methods indirectly supports the development of positive sexuality by addressing consent, healthy relationships, and sexual pleasure within broader sexual and reproductive health education (Fakoya et al., 2022). Feroz et al. (2021) conducted a systematic review of the use of mobile phones to improve young people's sexual health, primarily focusing on client education and behavioral change interventions. While the study's direct link to mental health or positive sexuality has not been explicitly mentioned, the emphasis on educational and behavioral outcomes suggests an underlying contribution to positive sexuality by enhancing knowledge and behaviors related to sexual health (Feroz et al., 2021).

Gonsalves et al. (2018) and Haruna et al. (2019) used digital platforms for sexual health education, with the former focusing on mobile phone-based information and the latter on a digital gamified learning platform. By promoting sexual health knowledge and safe behaviors, these interventions indirectly contribute to a positive sexuality framework by empowering youth with the information necessary to make informed decisions about their sexual health. Additionally, by engaging youth in a supportive and educational context, these interventions can have a positive impact on mental health, although not directly assessed in these studies.

While the reviewed literature primarily targets improvements in sexual and reproductive health knowledge, behaviors, and treatment retention through digital interventions, there is a significant, albeit indirect, focus on mental health and positive sexuality. These studies collectively underscore the importance of integrating mental health and positive sexuality into sexual and reproductive health interventions and suggest a holistic approach to adolescent and young adult health. Future research should explicitly incorporate, and measure outcomes related to mental health and positive sexuality to fully understand the impact of these interventions.

5.2 Significance of Digital Education in Africa

The growing incidence of sexual and reproductive health concerns among African youth underscores the need to develop digital educational tools to address this issue. As Guse et al. (2012) highlighted, a significant amount of reproductive health information is unreliable, resulting in a substantial knowledge gap that needs to be filled. By utilizing digital platforms, young people can acquire dependable information on sexual and reproductive health, including topics incorporated into their educational curricula.

Many African countries have yet to capitalize on digital educational resources, in part due to their limited Internet connectivity and lingering skepticism towards such tools (Delaporte, 2023). According to Soehnchen, Rietz et al. (2023), the primary obstacles for providing SRH education in general include a dearth of fundamental infrastructure in healthcare, cultural factors deeming reproductive health information taboo, and the stigma associated with seeking out reproductive health information. Though some may believe that teenagers are too immature to be exposed to sexual and reproductive health education, evidence demonstrates that many adolescents are sexually active and thus need robust and accessible educational programs (Nolan et al., 2020). Digital educational platforms have emerged as a means of providing adolescents with crucial information that can facilitate informed decision making. Interactive methods such as games and websites can help engage a larger number of teenagers (Rokicki et al., 2017).

One issue that merits attention is the lack of information regarding sexual and reproductive health among African adolescents. Many young people in the African region are unfamiliar with information regarding contraceptives, family planning, HIV, and sexually transmitted infections (Rogers et al., 2020). The use of digital educational tools may help bridge this knowledge gap by providing relevant information. Rogers et al. (2020) noted that adolescents are likely to be drawn

to new digital education tools that are engaging, culturally appropriate, and available in their local language.

Recent research has demonstrated the potential of digital educational tools to address reproductive health challenges faced by adolescents (Haruna et al., 2019). Soehnchen, Rietz et al. (2023) suggested that teenagers who have been informed about their reproductive health and can access all necessary information through mHealth services are not hindered by distance or cost. Digital educational tools may offer greater security and reliability in providing information (Soehnchen et al. 2023).

Digital education in Africa is essential. According to Onukwugha et al. (2022), the use of digital educational tools such as mobile apps, websites, text messaging, and online games can help address issues such as unplanned pregnancies, increased rates of STIs, and inadequate information about sexual and reproductive health. The main advantage of digital tools is their ability to provide information regardless of user location. Additionally, these tools are user friendly and can be easily understood by teenagers. By utilizing digital tools appropriately, health disparities can be reduced, healthy and safe sexual behavior can be promoted, and the overall well-being of adolescents in Africa can be improved.

5.3 Limitations of Digital Educational Tools

While the use of digital platforms for sexual and reproductive health education has increased, it is important to acknowledge the challenges and limitations inherent in these methods. Research has indicated significant infrastructure issues that may limit the availability and effectiveness of digital technologies, especially in remote or underserved areas, where consistent

Internet access and technology are critical (Soehnchen et al., 2023; Waldman & Stevens, 2015; World Health Organization [WHO], 2020). These challenges include the low adoption rates of mobile phones, insufficient network coverage, weak satellite signals, and constrained bandwidth. However, innovative solutions like the AI-backed phone system discussed in a recent Reuters article could help bridge this digital divide (Sanni et al., 2024). This system provides information and advice through voice calls, without requiring a smartphone or internet connection, making it accessible to those without reliable internet or who cannot afford smartphones and data plans (Sanni et al., 2024). By utilizing an artificial intelligence model to understand natural language queries and provide relevant information from a knowledge base, such technologies have the potential to make sexual and reproductive health education more accessible in underserved areas with limited technology infrastructure (Sanni et al., 2024). Consequently, there is a pressing need to bridge the digital divide and enhance health infrastructure to ensure that all teenagers can access essential information on sexual matters and reproductive health (Aruleba and Jere 2022).

The reviewed studies demonstrated that digital educational tools, including social media, mobile applications, and gamified learning platforms, are promising for educating African youth about sexual and reproductive health. These tools leverage benefits such as user engagement, customization, and privacy to potentially enhance learning outcomes. Notably, interventions employing mobile phones for health information and digital games designed using participatory approaches have shown promising results in improving knowledge among adolescents. However, challenges persist, including issues with user retention, the cultural and contextual relevance of content, and the need for robust methodological designs to effectively assess their impact. For instance, one study found that social media interventions did not significantly improve retention or social support metrics among Nigerian youths, indicating a gap in achieving desired outcomes

(Dulli et al., 2020). Furthermore, limitations such as the digital divide, linguistic barriers, and accuracy of content remain significant obstacles to the widespread adoption and effectiveness of these technologies. To harness the potential of digital educational tools to enhance sexual and reproductive health outcomes among African adolescents, it is imperative to address these challenges by designing educational interventions to target young girls and young women and ensuring the cultural and contextual appropriateness of the content can pave the way for more effective and empowering health education interventions in Africa.

5.4 Strengths of Literature Review

The collection of studies reviewed showcases several strengths of mobile health (mHealth) applications for sexual and reproductive health (SRH) education among adolescents. Importantly, the geographical distribution of reviewed literature is representative of the sub-Saharan Africa region, offering unique insights into the challenges and opportunities inherent in deploying technology-based solutions within an array of cultural and infrastructural contexts. A notable strength across many studies is the innovative use of technology to bridge the gaps in SRH knowledge and accessibility. For example, Feroz et al. (2021) and Nalwanga et al. (2021) highlighted the effective use of mobile phones to deliver critical SRH information directly to young people, thus improving their knowledge and attitudes toward sexual health. Additionally, studies by Gonsalves et al. (2018) and Nolan et al. (2020) demonstrate the potential of digital platforms to facilitate personalized and interactive learning experiences, which are crucial for engaging adolescents.

The integration of human-centered design principles in the development of mHealth applications, as discussed by Fakoya et al. (2022) and Haruna et al. (2019), represents a critical strength. This approach ensures that digital solutions are user-friendly, culturally sensitive, and tailored to the specific needs of adolescents, thereby enhancing user engagement and satisfaction. Moreover, the adoption of randomized controlled trial designs in studies such as those by Nalwanga et al. (2021) and Rokicki et al. (2017) underscores the commitment to rigorous scientific methods to assess the effectiveness of these interventions.

5.5 Limitations of Literature Review

Despite these strengths, the reviewed literature has several limitations. A common issue is the challenge of ensuring the long-term engagement and retention of adolescents in mHealth programs, as noted by Dulli et al. (2020). Variability in technological access and literacy among target populations, particularly in lower- and middle-income countries, poses significant challenges to the scalability and inclusivity of these interventions. Studies such as those by Feroz et al. (2021) and L'Engle et al. (2016) indicate limited evidence of the effectiveness of mHealth applications beyond knowledge improvement, highlighting a gap in understanding their impact on actual behavioral change.

The geographical and demographic scope of these studies is often limited, as seen in the work of Gonsalves et al. (2018) and Nolan et al. (2020), restricting the generalizability of the results. Patel et al. (2022) did not specify countries included in their study, only indicating that they are LMICs. Additionally, the findings of Haruna et al. (2019) highlight the challenges of the participatory design approach, such as balancing user needs with feasible technological solutions.

5.6 Impact on Public Health Policy and Practice

The integration of digital educational tools into public health policy and practice is essential to address the sexual and reproductive health needs of African adolescents. Stakeholders and policymakers must prioritize the development and implementation of digital platforms that are accessible, culturally sensitive, and tailored to the unique context of young people in Africa. Bridging the digital divide is a critical step towards ensuring that all adolescents, regardless of their socioeconomic status or geographic location, have equitable access to Internet and mobile health (mHealth) services.

Collaboration among technology designers, scholars, and educators is vital for creating and disseminating content that resonates with the target audience. By providing adolescents with accurate and culturally relevant information about sexual and reproductive health, they are empowered to make informed decisions that affect their well-being. The public health relevance of such initiatives is underscored by their potential to improve health outcomes, reduce rates of sexually transmitted infections and unintended pregnancies, and promote gender equality and empowerment.

Supporting the argument for the efficacy of digital tools in health education, Rokicki, S., and Fink, G. (2017) present evidence on the beneficial impacts of mHealth services in disseminating sexual and reproductive health information. The rapid increase in Africa's adolescent population coupled with the growing penetration of digital technology presents a unique opportunity to leverage these tools for substantial public health benefits. When leveraged effectively, digital educational tools have the potential to significantly improve knowledge, attitudes, and behaviors regarding sexual and reproductive health among adolescents.

The public health relevance of this essay lies in its call for action to integrate digital educational tools into the fabric of sexual and reproductive health education for African adolescents. By advocating policies that support the development and implementation of culturally sensitive, accessible, and engaging digital health interventions, this study underscores the potential of technology to enhance public health outcomes. Such interventions not only contribute to the immediate goal of informed health decision-making among youths, but also align with the broader public health objectives of fostering a healthier, more informed generation capable of navigating the complexities of sexual and reproductive health with confidence and competence.

5.7 Recommendations for Future Research

Future research should prioritize the development and evaluation of digital educational tools that are deeply rooted in the cultural and linguistic contexts of African adolescents. This involves embedding local beliefs, practices, and moral frameworks in the design of these tools. Understanding and respecting cultural nuances can enhance the relevance and acceptance of sexual and reproductive health (SRH) information among young people, particularly in communities where SRH topics are traditionally considered taboo (Henderson 2023).

There is a pressing need for studies exploring the integration of digital SRH education into school curricula. Research should investigate effective strategies for embedding comprehensive SRH education within the formal education system, including topics on healthy relationships, positive sexuality, mental health, gender equality, and consent. This approach ensured that adolescents received timely and accurate SRH information in a structured manner. Additionally, future studies should assess the impact of improved access through the use of digital tools integrated into the school curriculum on adolescents' SRH knowledge, attitudes, and behaviors.

Addressing the digital divide is critical to ensuring equitable access to digital SRH educational resources. Future research should explore innovative solutions to overcome barriers related to internet connectivity, affordability, and digital literacy. This includes evaluating the effectiveness of low-cost data plans, offline digital tools, and internet infrastructure development in rural and underserved areas. Studies should also examine the design features that make digital tools more appealing and user-friendly for adolescents, such as interactive games, quizzes, and simulations, to effectively engage them in learning about SRH.

Policy makers play a crucial role in the successful implementation of digital SRH educational tools. Future research should guide the development of evidence-based policies that

are culturally appropriate, accessible, and behavior-change-oriented. This includes policies that support the integration of SRH education into school curricula, and the provision of resources to bridge the digital divide. By aligning digital tool development with policy initiatives, researchers can facilitate the adoption of these tools and contribute to positive behavioral changes among African adolescents.

By focusing on these key areas, future research can provide valuable insights into the design, implementation, and impact of digital educational tools on SRH among African adolescents. Including parents in the design and implementation of digital tools and gaming could have lasting benefits for family dynamics. Culturally relevant, accessible, and engaging digital tools have the potential to significantly improve SRH outcomes in young people across the continent. Policymakers, educators, and public health researchers must collaborate to ensure that digital innovations in SRH education are grounded in evidence, culturally sensitive, and widely accessible to all adolescents, regardless of socioeconomic status or geographical location. Policymakers, and educators, are encouraged to integrate digital tools into sexual and reproductive health educational strategies that target adolescents, to improve sexual and reproductive health of this age group and contribute to improving public health in the sub-Saharan Africa region.

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