The Role of Digital Health Tools in Sexual and Reproductive Health for Underserved Adolescent Girls and Young Women

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Abstract

Title: The Role of Digital Health Tools in Sexual and Reproductive Health for Underserved Adolescent Girls and Young Women

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Adolescent girls and young women around the world face significant challenges in accessing sexual and reproductive health (SRH) information and care services, particularly in low to middle-income countries. This study explores the role of digital health (DH) tools in addressing the SRH needs of this population in resource-constrained settings.

Applying a multidisciplinary theoretical lens, including concepts like empowerment theory, health equity, intersectionality, and adolescent-specific frameworks, the research examines the effectiveness of digital interventions in overcoming SRH access barriers and improving health outcomes. Through a set of interviews, six digital SRH tools and initiatives were analysed, highlighting their diverse strategies for addressing critical gaps in SRH education, engagement, and service delivery.

Findings reveal the importance of culturally relevant content, offline functionalities, and systemic integration to ensure inclusivity and sustainability. However, challenges such as digital divides, limited scalability, and sustainability gaps persist.

The revised framework proposed in this thesis emphasizes the interconnected nature of individual agency, systemic equity, and adolescent-specific needs. Key recommendations include enhancing partnerships, integrating tools into health systems, and prioritizing user-centred, culturally adapted approaches.

The study concludes that while DH tools hold significant promise in bridging SRH access gaps for underserved adolescents, their success depends on systemic integration and addressing structural inequities. Policymakers, practitioners, and developers must focus on interdisciplinary collaboration and long-term sustainability to maximize impact. This research contributes to the understanding of DH tools as part of comprehensive strategies for achieving equitable SRH outcomes globally.

Keywords: Digital health, sexual and reproductive health, adolescent girls, empowerment, health equity, underserved communities, digital interventions.

Resumo

Título: O Papel das Ferramentas de Saúde Digital na Saúde Sexual e Reprodutiva para Adolescentes e Jovens Mulheres Desfavorecidas

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Adolescentes e mulheres jovens em todo o mundo enfrentam desafios significativos no acesso a informação e cuidados de saúde sexual e reprodutiva, especialmente em países de baixo ou médio rendimento. Este estudo explora o papel das ferramentas de saúde digital (DH) no atendimento das necessidades de saúde sexual e reprodutiva (SRH) desta população em contextos de recursos limitados.

Aplicando uma lente teórica multidisciplinar, incluindo conceitos como: empoderamento, equidade em saúde, intersectorialidade e quadros específicos para adolescentes, a investigação analisa a eficácia das intervenções digitais em superar barreiras de acesso e melhorar os resultados de saúde. Através de um conjunto de entrevistas , o estudo analisa seis ferramentas e iniciativas digitais de SRH, destacando estratégias diversas para colmatar lacunas na educação, envolvimento e prestação de serviços.

Os resultados revelam a importância de conteúdos culturalmente relevantes, funcionalidades offline e integração sistémica para garantir inclusão e sustentabilidade. Contudo, desafios como a divisão digital, escalabilidade limitada e sustentabilidade persistem.

O quadro teórico revisto enfatiza a interconexão entre agência individual, equidade sistémica e necessidades específicas dos adolescentes. Recomenda-se o fortalecimento de parcerias, integração das ferramentas nos sistemas de saúde e adoção de abordagens centradas no utilizador.

Conclui-se que as ferramentas digitais de saúde apresentam um potencial significativo para reduzir lacunas no acesso à SRH entre adolescentes desfavorecidas, mas o seu sucesso depende da integração sistémica e do combate às desigualdades estruturais. Esta investigação contribui para a compreensão destas ferramentas como parte de estratégias abrangentes para alcançar resultados de saúde sexual e reprodutiva equitativos.

Palavras-chave: Saúde digital, saúde sexual e reprodutiva, adolescentes do sexo feminino, empoderamento, equidade em saúde, comunidades desfavorecidas, intervenções digitais.

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List of Abbreviations

ADDO	Accredited Drug Dispensing Outlets
AGYW	Adolescent Girls and Young Women
AMO	Ability, Motivation, Opportunity
CHW	Community Health Worker
CSE	Comprehensive Sexuality Education
DH	Digital Health
ENAPEA	Estrategia Nacional para la Prevención del Embarazo en Adolescentes (Mexico's National Strategy for the Prevention of Adolescent Pregnancy)
LMIC	Low- and Middle Income Countries
mHealth	Mobile Health
RQ	Research Question
SDG	Sustainable Development Goals
SRH	Sexual and Reproductive Health
STI	Sexually Transmitted Infections
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
WHO	World Health Organization

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1. Introduction

Adolescent girls and young women (AGYW) around the world face significant challenges in accessing sexual and reproductive health (SRH) information and care services. According to the World Health Organization (WHO), nearly everyone of reproductive age, about 4.3 billion people, will lack access to at least one essential reproductive health service during their lifetime (WHO, 2022). While some countries provide comprehensive SRH education and services, others, particularly in low- and middle-income (LMIC) settings, still struggle with cultural and socio-economic barriers, inadequate healthcare infrastructure, and restrictive policies. For example, a teenage girl in Denmark may have easy access to contraceptive options and sexual health education, while one in Peru may struggle due to stigma, lack of education, and policies that prevent open discussion of SRH matters (Goldfarb & Lieberman, 2021). These gaps go beyond basic shortcomings in healthcare. They may often reflect deeply rooted inequalities in how AGYW access fundamental healthcare services across the globe (UNFPA, 2020).

Structural barriers further exacerbate these challenges. WHO emphasizes that restrictive laws, gender-based discrimination, and the requirement of third-party authorization can prevent adolescents from accessing SRH services and information (WHO, 2015). Such legal and socio-cultural constraints perpetuate health inequities and expose AGYW to preventable health risks, including unintended pregnancies, unsafe abortions, and sexually transmitted infections (STIs) (Goldfarb & Lieberman, 2021; WHO, 2018). The WHO also advocates for rights-based approaches that address these barriers and promote equitable access to SRH services globally.

The Sustainable Development Goals (SDGs), particularly SDG 3.7 and SDG 5.6, challenge Member States to promote the closing of these gaps. SDG 3.7 relates to ensuring universal access to SRH services, including family planning, education, and the prevention of STIs. SDG 5.6 emphasizes the need for women and girls to freely and equally exercise their reproductive rights and guaranteeing access to these essential health services for all (UNFPA, 2020). However, despite these international commitments, progress remains uneven, with large disparities in SRH service access between high-income countries and resource-constrained regions (Azzopardi et al., 2019).

While not replacing other approaches, digital SRH tools, particularly those that empower users with knowledge and resources, may offer a promising path forward in addressing these challenges. These tools may act as a bridge between underserved communities and healthcare providers, helping to

address barriers such as lack of access to relevant information and information about existing care services, cultural stigma, and limited resources. The UNESCO report on digital sexuality education highlights how online platforms, apps, and virtual communities can complement traditional approaches to **comprehensive sexuality education** (CSE) (UNESCO, 2020a). By providing scalable, culturally adaptable, and affordable solutions, digital health (DH) tools could help close the SRH access gap for AGYW in resource-constrained settings.

One key sector within DH is FemTech, a growing industry focused on developing technologies that address women's health needs. FemTech products, including apps for menstruation tracking, fertility management, and sexual health education, offer personalized and accessible solutions for women, especially in regions where traditional healthcare services are inadequate (Figueroa et al., 2023). However, despite its rapid growth and potential, FemTech faces significant challenges in reaching marginalized women in low-income settings, where limited access to technology and cultural taboos still exist (Huang et al., 2022). For these technologies to be truly transformative, they must overcome these barriers and be designed in ways that are culturally sensitive and widely accessible.

A critical component of improving SRH for AGYW is CSE. CSE provides young people with accurate, age-appropriate information and the skills needed to make informed decisions about their SRH. This helps to prevent unintended pregnancies, reduce STIs, and promote healthy sexual behaviours (Goldfarb & Lieberman, 2021). Access to CSE remains limited in many low- and middle-income countries due to socio-cultural norms, lack of resources, and restrictive education policies, leaving young women vulnerable, uninformed, and unable to advocate for their health rights (Díaz-Olavarrieta et al., 2021; WHO, 2018).

In the context of these challenges, DH interventions may offer a promising path forward by empowering users with knowledge and resources, connecting underserved populations to healthcare services, and addressing critical barriers. This research aims to investigate how such interventions can bridge the SRH access gap for AGYW in resource-constrained settings. By examining their role in overcoming key obstacles and empowering underserved populations, this study aims to understand which strategies are more effective in ensuring that these solutions are inclusive, scalable, and impactful, while also assessing their potential to be effectively designed, implemented, and scaled to provide broader and more equitable access to SRH information and education. To facilitate this, four research questions (RQs) are proposed:

RQ1: How are DH interventions currently addressing the SRH needs of AGYW in resource-constrained settings?

RQ2: What are the primary barriers preventing AGYW in underserved regions from accessing SRH services, and how can DH tools help overcome these barriers?

RQ3: How effective are existing DH interventions in improving SRH outcomes for underserved adolescent populations?

RQ4: What lessons can be learned from the implementation of DH tools, and how can these insights guide the future development, scaling, and replicating of SRH interventions to ensure broader and more inclusive access?

The findings of this research can potentially contribute to the growing body of knowledge on DH by highlighting best practices and innovative strategies for addressing SRH needs in underserved communities with digital solutions. In doing so, this study may also inform the future development of digital tools and interventions for SRH in regions with intersecting barriers, such as gender inequality, socio-economic challenges, and digital illiteracy. By integrating stakeholder insights and empirical evidence, this research strives to offer actionable recommendations for designing and implementing DH interventions that are both effective and equitable.

2. Background

According to the WHO, there are approximately 1.8 billion individuals aged 10 to 24 globally, with the majority residing in LMICs (PMNCH, 2022). Adolescents face significant challenges in accessing SRH information and services, particularly in LMICs. AGYW are disproportionately affected due to a combination of barriers such as gender inequality, poverty, restrictive policies, and cultural stigma. These barriers not only limit access to relevant information and critical health services but also perpetuate cycles of poor health, inequality, and socio-economic disadvantage.

The severity of these challenges is evident in global health statistics. Every year, approximately 21 million girls aged 15 to 19 in LMICs experience pregnancy, with 12 million resulting in births (WHO, 2024b). Complications from pregnancy and childbirth remain the leading cause of death for girls in this age group, and adolescent mothers face higher risks of maternal mortality and neonatal complications compared to adult women (UNICEF, 2024). Studies highlight that adolescent pregnancy is strongly associated with lower educational attainment, limited economic opportunities, and higher rates of poverty and social exclusion, which perpetuates cycles of disadvantage (BMJ, 2009). Half of all pregnancies among adolescent girls classified as unintended, and a significant portion end in unsafe abortions (UNFPA, 2017). Children born to adolescent mothers face significant disadvantages, including low birth weight, developmental delays, and reduced level of education (Noori et al., 2022). The socio-economic impacts of adolescent pregnancy are profound, with evidence linking it to intergenerational cycles of poverty and poor health outcomes (WHO, 2024a).

STIs add another layer of complexity to the SRH challenges faced by adolescents. The WHO estimates that over 1 million STIs are acquired daily worldwide, with individuals aged 15 to 24 accounting for nearly half of these new infections (WHO, 2024c). The lack of accessible and age-appropriate SRH education and services means that many young women are unable to prevent, test for, or treat these infections effectively. In regions heavily affected by HIV with limited access to prevention tools, adolescent girls are disproportionately at risk (UNAIDS, 2024).

In addition to STIs and pregnancy-related risks, limited access to modern contraceptive methods remains a significant barrier for AGYW in LMICs. An estimated 214 million women of reproductive age in these regions have an unmet need for modern contraception, with adolescents facing unique challenges such as lack of youth-friendly health services, cultural stigma, and inadequate education

on contraceptive use (UNFPA, 2017). This unmet need not only affects the health and well-being of young women but also limits their ability to pursue educational and economic opportunities.

Efforts to address these challenges have included the promotion of CSE by global organizations such as UNESCO and UNFPA. CSE has been shown to reduce rates of unintended pregnancies, unsafe abortions, and STIs while promoting gender equality and healthy relationships (Goldfarb & Lieberman, 2021; UNESCO, 2021). However, its implementation remains inconsistent, particularly in resource-constrained regions where cultural, religious, and political resistance to open discussions about sexuality persists. As a result, many AGYW remain uninformed about their SRH rights and options.

While significant progress has been made in addressing the SRH needs of AGYW, gaps persist. These gaps highlight the urgent need for innovative, scalable, and culturally sensitive interventions that can overcome existing barriers and provide equitable access to SRH information and services. The subsequent sections will first explore the broader concept of DH, then narrow the focus to FemTech as a specialized subset of DH tools and finally examine specific examples of digital SRH tools designed to address gaps in access, education, and care in underserved regions.

2.1 Digital Health

DH refers to the integration of information and communication technologies into the delivery of healthcare services (WHO, 2024d). It includes tools such as mobile health (mHealth), telemedicine, wearable devices, health information systems, and artificial intelligence-powered healthcare solutions (Chandra et al., 2024). Through the use of these technologies, DH has the potential to facilitate patient care, optimize healthcare delivery, improve patient outcomes, and empower individuals to manage their health more effectively.

This concept has become more important because of the rising use of the internet and mobile technologies worldwide. It offers scalable solutions to address healthcare challenges, such as improving access to care, facilitating remote consultations, and enabling personalized health management (Meherali et al., 2024). For example, telemedicine has been instrumental in connecting patients in remote or underserved regions with healthcare providers, reducing the need for travel and associated costs (Hashiguchi, 2020).

Despite these advancements, the healthcare system has historically been biased in its approach to research, diagnosis, and treatment, often excluding women's specific health needs. This systemic gender gap can be traced back to the underrepresentation of women in clinical trials and medical research throughout the 20th century. Historically, male bodies were treated as the standard in medical research, leading to diagnostic and treatment protocols that failed to account for gender differences in disease presentation, pharmacology, and health outcomes (Criado-Perez, 2019). For example, cardiovascular diseases often present differently in women than in men, yet these differences were overlooked in many early studies, which led to delayed or missed diagnoses for women (Holdcroft, 2007).

DH, while promising, is not immune to these systemic biases. Many DH innovations have been criticized for perpetuating the same inequities, particularly in the design and application of technologies. Algorithms used in diagnostic tools, for example, are often based on datasets that underrepresent women, which leads to potential inaccuracies in outcomes (Obermeyer et al., 2019). Furthermore, the rapid development of DH tools has often prioritized technological capabilities over inclusivity, failing to adequately address the diverse needs of women across different socio-economic and cultural contexts (Hendl & Jansky, 2022; Huang et al., 2022).

Women in LMICs face additional barriers in accessing DH solutions. Limited access to smartphones, internet connectivity, and digital literacy disproportionately affect women in these settings, which further exacerbates existing healthcare inequities (Chandra et al., 2024). Patriarchal norms and socio-cultural restrictions may also limit women's ability to engage with DH tools independently, creating a need for technologies that are not only accessible but also culturally sensitive and gender-inclusive (Huang et al., 2022).

While DH offers significant potential to bridge gaps in healthcare access and delivery, it must be designed with an awareness of these systemic shortcomings. A growing recognition of these issues has prompted calls for gender-sensitive approaches in the development and implementation of DH solutions. This includes ensuring diverse representation in data collection, tailoring interventions to address gender-specific health needs, and promoting equitable access to technologies (Criado-Perez, 2019).

Through addressing these challenges, DH holds significant potential to advance gender equity in healthcare by tailoring solutions to meet the unique needs of women. Among these innovations,

FemTech emerges as a promising approach to addressing gaps in women's health by focusing on their specific biological and medical needs.

2.2 FemTech

FemTech, short for female technology, covers a range of digital tools, devices, and applications that address women's unique biological and medical needs. It includes products focused on menstruation tracking, fertility, pregnancy, menopause, sexual health, and general wellness (Hendl & Jansky, 2022; Wiederhold, 2021). FemTech leverages mobile apps, wearable devices, and health platforms to empower women in managing their health and offers personalized insights into SRH. In recent years, FemTech has grown into a multi-billion-dollar industry. Driven by the increasing demand for women-centric healthcare solutions, rapid digitalization, and the rising adoption of telehealth services it is expected to reach a market value of $60 billion by 2027 (Landi, 2021). Popular applications, like *Clue* and *Flo*, are widely used by women in high-income countries to track menstruation, monitor fertility, and manage other aspects of their health. These tools offer detailed cycle tracking and fertility insights, providing convenience and autonomy for their users (Hendl & Jansky, 2022).

Despite the promise of revolutionizing women's healthcare, the majority of FemTech solutions have been designed with a focus on high-income countries and often overlook the needs of underserved populations. Most of these tools, while highly effective for women with consistent access to smartphones, stable internet connections, and healthcare literacy, fail to address the realities faced by women in resource-constrained settings (Hendl & Jansky, 2022). One of the major criticisms of FemTech is that it predominantly serves affluent, predominantly white women in high-income countries. This leads to an exacerbation of existing healthcare inequalities (Balfour, 2023).

Barriers such as digital literacy, privacy concerns, affordability, and cultural sensitivity significantly limit the equitable access and impact of FemTech tools in low- and middle-income countries. Many women in underserved regions lack the skills needed to navigate health apps, as well as access to smartphones, stable internet, and affordable mobile data (Chandra et al., 2024; Pieramico, 2022). In rural and resource-constrained communities, these challenges are further compounded by economic barriers and patriarchal dynamics, which may limit women's private and independent use of such tools. Privacy concerns are especially pronounced in conservative societies, where fear of judgment or exposure can deter women from using FemTech applications (Huang et al., 2022). Furthermore,

many tools fail to adapt to local cultural contexts or provide inclusive content that resonates with the lived realities of marginalized women (Nkabane-Nkholongo, Mpata-Mokgatle, et al., 2024). This lack of localization and cultural sensitivity excludes women in communities where SRH remains stigmatized or taboo.

While FemTech shows significant advancements in women's healthcare, these tools often fail to address the needs of marginalized women in low-resource settings. Bridging this gap requires rethinking how FemTech is designed and implemented, with a focus on scalability, affordability, and cultural adaptability. Digital SRH tools, which specifically target underserved AGYW, present an important step forward in addressing these shortcomings.

2.3 Digital SRH Tools for Underserved Populations

Digital SRH tools are an integral part of DH innovations aimed at addressing the barriers that AGYW face in accessing SRH information and services, particularly in resource-constrained settings. These tools leverage digital technologies such as mobile applications, chatbots, and online platforms to improve access to SRH education, counselling, and resources. Unlike traditional FemTech products that often prioritize affluent, high-resource populations, these digital SRH tools focus on inclusivity, adaptability, and scalability to reach underserved communities (Balfour, 2023; Pieramico, 2022).

Table 1 provides an overview of the identified digital SRH tools and offers a summary of their focus areas and approaches to addressing SRH challenges in underserved regions. These tools collectively illustrate the diversity and potential of digital interventions in bridging gaps in SRH access.

Digital Tool	Description	Country/Region	Reference
Afya-Tek	Mobile platform aimed at improving maternal and adolescent health by coordinating CHWs, ADDOs, and healthcare facilities for referrals and care.	Tanzania (Kibaha District)	(Dillip et al., 2024)
Amaze	Offers age-appropriate, engaging SRH education through videos, targeting adolescents globally. Partners with NGOs and UN agencies for global reach.	USA (Global)	(UNESCO, 2020b)
Comolehago.org	Digital platform providing SRH information for adolescents, complemented by tools for families, educators, and healthcare providers.	Mexico	(Hubert et al., 2021)
Frisky App	Delivers SRH education and support, including contraception and STI prevention, through SMS, WhatsApp, and mobile apps.	Nigeria	(UNESCO, 2020b)
Health-E You	Mobile app providing contraceptive decision support for Latina adolescents with interactive games and personalized recommendations.	USA (Latina Adolescents)	(Tebb et al., 2018, 2019, 2021)
Judies	Gamified mobile app teaching SRH topics through adventure-based learning, targeting adolescents with age-appropriate and engaging content.	Thailand	(UNESCO, 2020b)
Lily Health	Mobile chat-based platform providing personalized SRH information, now pivoted to focus on fertility education for underserved women globally.	Kenya (Global)	(UNESCO, 2020b)
My Contraception	Mobile app offering contraceptive care and education based on WHO guidelines, including reminders and evidence-based recommendations.	Morocco	(Kharbouch et al., 2021)
Nthabi	Conversational agent providing SRH education tailored to young women in Lesotho, addressing cultural and geographical barriers.	Lesotho	(Nkabane-Nkholongo et al., 2023, 2024, 2024)
Raaji	Community-driven platform offering SRH education in taboo topics, particularly for women and adolescents, through web and social media content.	Pakistan	(Khan & Azhar, 2023)
Sexualidapp	Mobile app focused on SRH rights and education for adolescents, emphasizing prevention and empowerment.	Uruguay	(MYSU & UNFPA, n.d.)
Suubi	Mobile-based platform in Uganda delivering SRH education and HIV prevention while integrating economic empowerment strategies.	Uganda	(Byansi et al., 2023)
Tabukamu	Platform providing SRH education in Turkish through digital tools, encouraging critical thinking on gender and relationships.	Turkey	(UNESCO, 2020b)
The Violet Project	Comprehensive SRH education platform offering free STI testing and digital SRH education targeted at youth, with a focus on inclusivity.	USA (Baltimore)	(Sao, et al., 2023; Sao, Yu, Abboud, et al., 2023; Sao, Yu, Barre-Quick, et al., 2023)
Vamos	Helps users locate SRH services in Latin America and the Caribbean, offering information on contraception, STI testing, and sexual rights.	Latin America, Caribbean	(UNESCO, 2020b)
You & Me	Platform for teachers in China to deliver CSE using digital resources and interactive online classes.	China	(Chen et al., 2023; Hu et al., 2023)

Table 1: Overview of 16 Identified Digital Tools and Interventions for SRH

The primary goal of these digital SRH tools is to bridge gaps in SRH access by addressing barriers such as cultural stigma, inadequate infrastructure, and limited economic resources. For example, *Raaji*, a chatbot in Pakistan, provides culturally sensitive SRH information through local languages and an anonymous interface. In this way, it allows AGYW to overcome taboos around discussing sexual health (Khan & Azhar, 2023). *Nthabi*, a conversational agent in Lesotho, delivers SRH knowledge tailored to local needs, promoting positive health behaviours while addressing the constraints of limited healthcare infrastructure (Nkabane-Nkholongo et al., 2023).

Barriers to accessing SRH information and services are well-documented in the literature. Cultural stigma remains one of the most significant challenges, especially in regions where discussing sexual health is still considered a taboo. Tools like *Raaji* directly address this by creating anonymous and safe spaces for users to learn about SRH without fear of judgment (Khan & Azhar, 2023). Limited digital literacy and access to technology further restrict the reach of digital interventions. For example, in Morocco, the *MyContraception* app incorporates multilingual support and culturally relevant content, yet adoption is affected by the lack of affordable internet access and limited familiarity with mobile apps among underserved populations (Kharbouch et al., 2021). Economic barriers add to these issues, as many individuals in low-income settings cannot afford the necessary devices or connectivity. Tools like *You and Me* in China and *Health-E You/Salud iTu* in the US have demonstrated success in reaching young people through low-cost and scalable solutions that prioritize accessibility (Chen et al., 2023; Tebb et al., 2021).

Effectiveness is a key consideration in evaluating digital SRH tools. Evidence suggests that well-designed digital interventions can significantly improve SRH knowledge, attitudes, and behaviours among adolescents. For instance, the *You and Me* platform in China reported a 20% increase in sexual health knowledge among high school students following its implementation (Chen et al., 2023). Similarly, the *Health-E You/Salud iTu* app demonstrated improved contraceptive use among Latina adolescents by providing culturally tailored information, guidance, and decision-making support (Tebb et al., 2021). These findings reinforce the potential of digital SRH tools to deliver impactful education and empower users to make informed health decisions.

Several tools exemplify innovative strategies to address specific barriers to SRH access. *Suubi*, a platform in Uganda, integrates SRH education with financial literacy training, illustrating the potential of multifaceted approaches to empower AGYW holistically (Byansi et al., 2023). *MyContraception* highlights the importance of cultural adaptability by providing contraceptive

counselling in multiple languages to be able to reach diverse user groups in Morocco (Kharbouch et al., 2021). Additionally, *Nthabi* in Lesotho employs conversational agents to deliver personalized health education, which showcases the role of artificial intelligence in addressing SRH needs (Nkabane-Nkholongo, Mpata-Mokgatle, et al., 2024).

While the literature highlights many successes, challenges still persist. Even tools designed to address economic and cultural barriers often struggle with sustainability and scalability. For instance, maintaining user engagement over time and ensuring the quality of information remain critical challenges for many digital platforms (Balfour, 2023; Dillip et al., 2024). Furthermore, the reliance on technology assumes access to devices and internet connectivity, which is not always feasible in resource-constrained settings (Pieramico, 2022).

Lessons learned from these tools offer valuable insights for future development. Cultural adaptability is essential for ensuring that tools resonate with diverse user groups, as highlighted by *Raaji* and *MyContraception*. User-centered design is another important factor, with successful tools often prioritizing privacy, accessibility, and localized content. For instance, the gamification elements in *Suubi* and the approachable, youth-centered videos of *Amaze*, which present SRH information in an engaging and relatable manner, illustrate the value of innovative and user-friendly features. (Byansi et al., 2023; Rea et al., 2022). Additionally, the role of partnerships in scaling and sustaining digital SRH tools has proven to be crucial. Collaborations between local stakeholders, international organizations, and technology developers have been instrumental in the success of interventions like *Afya-Tek* (Dillip et al., 2024).

The potential of digital SRH tools to transform healthcare delivery for AGYW in underserved regions seems relevant. However, while significant progress has been made, there is still much to learn about designing, implementing, and scaling digital interventions in a way that is inclusive, sustainable, and impactful.

2.4 Theoretical Lens

This research employs a multidisciplinary theoretical lens to contextualize its exploration of DH tools for adolescents SRH in underserved communities. The selected frameworks address critical issues such as empowerment, equity, inclusivity, and adolescent-specific health needs, providing a foundation for evaluating the broader implications of these tools.

At its core is Psychological Empowerment Theory (Zimmerman, 1995), which emphasizes individuals' capacity to take control of their health decisions through agency, self-efficacy, and resource access. Empowerment extends beyond simply providing information. It involves fostering confidence and autonomy to enable adolescents to navigate SRH challenges effectively. As the foundational framework, empowerment highlights the central role of individual agency in DH interventions and anchors the lens for this research.

Building on this foundation, the Health Equity Framework (Braveman & Gruskin, 2003; Johnson, 2015) addresses structural determinants of health, such as poverty, discrimination, and unequal resource distribution. This framework highlights systemic barriers that perpetuate inequities, particularly for marginalized populations, and emphasizes dismantling these barriers to achieve equitable health outcomes. Health equity bridges individual agency with the systemic realities that shape SRH access and outcomes and highlights the importance of evaluating whether DH tools reduce or inadvertently reinforce disparities.

The WHO Digital Health Empowerment Framework (WHO, 2024d) provides actionable dimensions for translating theoretical principles into practice. Its three pillars—access, agency, and action—are complemented by privacy, cultural sensitivity, and active participation, emphasizing the role of DH tools in addressing gender disparities. This framework connects systemic considerations with practical, participatory approaches to ensure relevance, effectiveness and inclusivity, particularly in underserved regions.

The Feminist Intersectionality Framework (Figueroa et al., 2021) ensures that interventions account for intersecting identities, such as gender, geography, and socioeconomic status. By focusing on inclusivity and diverse lived experiences, this framework prevents the exclusion of marginalized groups. Intersectionality connects the systemic and individual levels of the lens and ensures that interventions are equitable and responsive to the realities of AGYW in underserved regions.

The outermost layer of the lens is informed by Adolescent-Specific SRH Frameworks (Blum & Nelson-Mmari, 2004; Mmari & Sabherwal, 2013). These frameworks highlight adolescents' unique developmental needs, including risk factors such as early marriage, stigma, and low health literacy, alongside protective factors like peer support, education, and community engagement. This layer contextualizes the broader frameworks within the realities of underserved adolescent populations and emphasizes the developmental and contextual challenges of addressing SRH needs.

Together, these frameworks form a comprehensive lens, visualized as a layered diagram, that progresses from broad principles of empowerment to specific applications for adolescent SRH (see Figure 1). Through demonstrating the interaction between individual agency, systemic equity, inclusivity, and developmental factors, this lens provides a structured foundation for evaluating and enhancing DH tools.

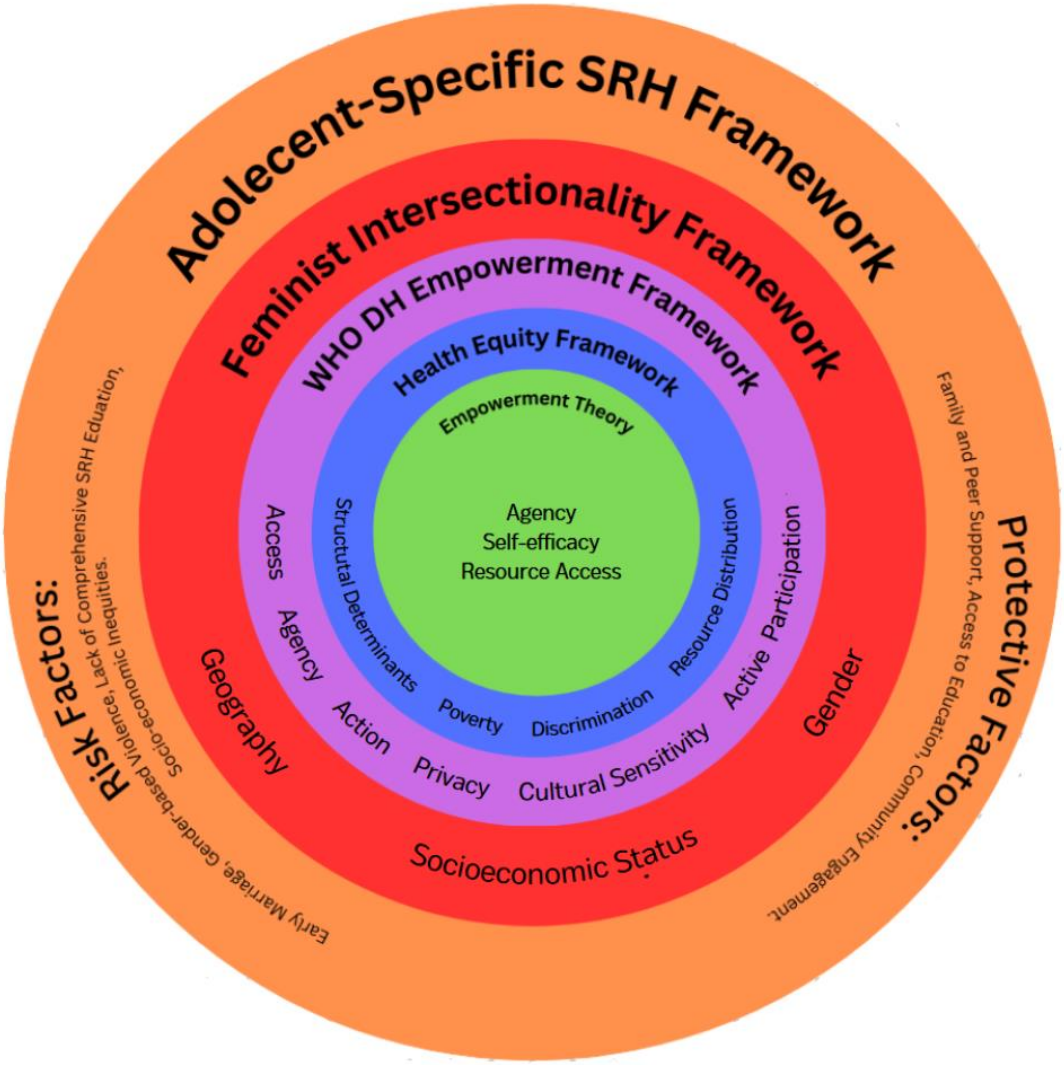

Figure 1: Proposed model for analysing DH interventions in SRH in AGYW (a priori version)

3. Methodology

This research applies a qualitative approach to investigate how DH interventions and tools can improve access to SRH information and resources for AGYW in underserved areas. Valuable insights will be gathered through in-depth interviews with key stakeholders. This qualitative approach enables a thorough exploration of real-world applications and the lived experiences of stakeholders working with SRH tools. The interviews focus on understanding the implementation, usability, scalability, and challenges of these tools in addressing barriers to SRH access. It provides a deeper understanding of digital interventions that goes beyond what quantitative data alone can offer.

3.1 Research Approach

Qualitative research enables the exploration of the experiences of different participants and the interpretation of complex issues in natural settings (Rogo, 2024; Teherani et al., 2015). The use of semi-structured interviews ensures flexibility and allows stakeholders to provide detailed and context-specific insights. Semi-structured interviews are particularly effective for understanding real-world phenomena as they allow for open-ended discussions while providing enough structure to align responses with the research goals (Kallio et al., 2016). This approach enables the capture of diverse perspectives that are critical for understanding how to scale and adapt SRH tools in diverse and resource-constrained environments.

The chosen qualitative approach is relevant not only for understanding SRH gaps but also for assisting future tool developers, policymakers, and healthcare providers. This research presents examples from different regions, each addressing unique challenges such as socio-economic barriers, digital literacy, and cultural taboos. These examples can help guide the development of more inclusive and effective digital SRH tools.

3.2 Sampling and Participant Selection

A purposive sampling strategy (Busetto et al., 2020) was employed to identify key stakeholders involved in the creation, implementation, policy development, or research of digital SRH tools. The

recruitment process was conducted via email, LinkedIn, and contact forms found on digital tool websites and targeted individuals directly involved with digital SRH interventions aimed at improving access for AGYW in resource-constrained settings. These participants include developers, program managers, healthcare providers, policy advisors, NGO representatives, and experts who contribute to or analyse digital SRH innovations.

Stakeholders representing 16 digital tools were contacted through various channels, including individual emails, general inquiry emails, and LinkedIn. From these efforts, responses were received from stakeholders representing six digital tools, and interviews were conducted with professionals holding leadership, program management, research, and policy roles. For eight tools, no responses were received, despite efforts to reach stakeholders through multiple channels. Contacts were not available for the remaining two tools. A summary of the tools, their regions, and the interview outcomes is provided in Table 2.

Tool Name	Country/Region	Interview Outcome
Amaze	USA/ Global	Associate Director
Afya-Tek	Kibaha, Tanzania	Co-Founder, Program Officer, Partnerships Officer
Comolehago.org	Mexico	Policy Managers
Lily Health	Kenya/ Global	Founder
Nthabi	Lesotho	Executive Director
The Violet Project	Baltimore, USA	Program Manager and Creative Director
Frisky App	Nigeria	No Response
Health-E You	USA	No Response
Judies	Thailand	No Response
MyContraception	Morocco	No Response
Raaji	Pakistan	No Response
Sexualidapp	Uruguay	No Response
Suubi	Uganda	Contacts not available
Tabukamu	Turkey	No Response
Vamos	Latin America and the Caribbean	No Response
You And Me	China	Contacts not available

Table 2: Summary of Digital SRH Tools and Stakeholder Engagement Outcomes

The selection process ensured a wide range of experiences, professional perspectives, and geographic diversity among participants. Through this, it captured insights from diverse cultural and policy

contexts. This variety enriched the study's findings by reflecting the multifaceted nature of digital SRH interventions globally.

Exclusion criteria were defined to exclude stakeholders working on tools that do not directly focus on SRH or AGYW, for example those addressing solely menopause, breastfeeding, or general wellness unrelated to adolescent SRH. This ensured that the sample remained aligned with the specific research aim.

3.3 Stakeholder Interviews

The interviews were designed to gather detailed insights into the usability, scalability, and sustainability of digital SRH tools. The interview script was developed systematically, starting from the RQs and then branching out to key topics. These topics were informed by a thorough literature review that provided theoretical foundations for the questions, ensuring that they addressed relevant themes such as cultural adaptability, usability, partnerships, financing, scalability, sustainability, and lessons learned. Following the framework for qualitative interview development proposed by Kallio et al. (2016), this structures approach ensured that the interview script was both comprehensive and aligned with the study's objectives. The theoretical backing and reasoning behind each question are detailed in the interview matrix (Appendix 1), which links the questions to their supporting research and objectives.

The interviews were carried out online to accommodate the geographical distribution of the stakeholders, as they were based in different countries and regions. This format also facilitated real-time discussions, enabling participants to provide detailed responses. In one instance, a stakeholder preferred to fill out the interview questions manually rather than participate in a live session, which was accommodated to ensure flexibility and inclusivity.

Each interview focused on open-ended questions to encourage stakeholders to share their experiences, insights, and strategies without restrictions. This method allowed for capturing diverse perspectives, making it ideal for understanding the complexities of SRH interventions and identifying the factors contributing to their success or limitations (Kallio et al., 2016).

3.4 Ethical Considerations

Given the sensitive nature of SRH and the focus on underserved populations, this research adheres to strict ethical guidelines. Informed consent was obtained from all participants, and they explicitly agreed to be included in the study (Rogo, 2024; Teherani et al., 2015). While individual names will not be mentioned in this thesis, participants are identified by their professional roles, the digital tools they represent, and the regions where they operate. This level of detail is necessary to provide context for the findings while respecting participants' consent and transparency in the research.

As SRH remains a stigmatized topic in many regions, participants were given the opportunity to review and approve their interview transcripts. This ensured that no sensitive information was included without their consent and that the context of their statements was accurately represented. By following these measures, the research respects both the privacy of the participants and the cultural contexts in which they operate.

3.5 Validity and Reliability

Validity and reliability are ensured through the careful design of the interview questions and the targeted nature of the participant selection. Since the interviews are directed at a limited number of key stakeholders, responses come directly from those deeply involved in digital SRH tools. This allows for the collection of high-quality and targeted data that reflects the experiences and insights of those working in the field.

Reliability will be maintained by ensuring that participants have the opportunity to review the thesis, including the analysis and discussion of their contributions, before submission. This ensures that their perspectives are accurately represented and respects their input in the research process. Furthermore, the data gathered from interviews will be compared with existing literature to validate findings and identify common trends or discrepancies.

4. Results

Results are presented per RQ organized to facilitate understanding and generate insights based on the main themes captured from each mini-case generated from evidence collected from stakeholder interviews.

4.1 Current Strategies of Digital Tools for SRH

Insights from the interviews provide a detailed understanding of the tools' current strategies and contributions in addressing the SRH needs of AGYW in underserved regions. The following sections present the findings for each tool, and highlight their unique approaches, functionalities, and areas of focus. The results are summarized in Table 3.

4.1.1 Afya-Tek

Afya-Tek digitizes the workflow of community health workers (CHWs) to streamline patient registration, screening, and referrals, creating a seamless continuum of care from households to health facilities. To address adolescent-specific SRH needs, the initiative introduced adolescent-focused clubs supervised by CHWs, providing counselling, education, and peer-led discussions outside the home. These clubs offer adolescents a private and supportive environment to engage with SRH topics comfortably. A new chatbot is also being piloted to provide SRH education and mental health resources while ensuring confidentiality and accessibility. Additionally, CHWs and private drug shops are trained to provide adolescent-friendly services, reflecting a commitment to discretion and reliability in SRH care delivery.

4.1.2 Amaze

Amaze addresses SRH needs by offering free, engaging educational videos that align with international guidelines and national curricula. These videos, developed with input from youth ambassadors and SRHR experts, are designed to be culturally sensitive and accessible to adolescents worldwide. *Amaze* collaborates with organizations like UNESCO, UNICEF, and UNFPA, as well as local NGOs, to ensure wide dissemination of its content. With over 70 languages supported and 1,700 international adaptations, the platform achieves significant reach and accessibility. In addition to distributing content via social media platforms like YouTube, TikTok, and Instagram, *Amaze* ensures

accessibility through extensive collaborations and partnerships with global and local organizations. These include partnerships in regions where adolescents may lack access to social media or the internet, enabling the content to reach underserved populations through offline or alternative methods. Furthermore, *Amaze* operates on an open-access model, allowing any interested parties, including NGOs, schools, or community groups, to freely adapt and use their educational videos in alignment with local needs.

4.1.3 Comolehago.org

Comolehago.org, which translates to "How do I..." in English, is a digital platform designed to provide scientifically accurate and official SRH information to adolescents across Mexico. Its name reflects how adolescents might naturally phrase questions about SRH when searching online, making it an intuitive entry point for users seeking information. As part of Mexico's National Strategy for the Prevention of Adolescent Pregnancy (ENAPEA), *Comolehago.org* is one component of a comprehensive national initiative aimed at reducing adolescent pregnancy rates and promoting SRH health. ENAPEA is a government-led strategy involving collaboration across 16 federal agencies, academic institutions, international organizations, and civil society groups, with the ambitious goal of reducing adolescent pregnancy rates in Mexico to zero for girls aged 10 to 14 and cutting rates by 50% among adolescents aged 15 to 19 by 2030.

Comolehago.org offers interactive features such as videos, infographics, georeferenced maps to help users locate adolescent-friendly health services, and a live chat function where adolescents can ask questions to trained professionals in real time. The platform also incorporates resources for parents, teachers, and healthcare providers, ensuring a holistic approach to SRH education. Offline solutions, such as USB-based resources, help expand accessibility to areas with limited internet connectivity.

4.1.4 Lily Health

Lily Health initially sought to address SRH needs by delivering personalized health advice through mobile chat services, including SMS and Facebook Messenger. This approach enabled the platform to reach users in resource-constrained settings where smartphones and internet access were limited. The service initially provided period tracking and general SRH education, adapting to the technological and infrastructural realities of underserved areas. However, *Lily Health* later pivoted to focus on fertility-related content, reflecting a shift in user demand and a narrowed scope of service delivery.

4.1.5 Nthabi

Nthabi is a conversational agent providing SRH education tailored to AGYW in Lesotho. The platform addresses a broad range of SRH topics, including STI prevention, contraceptive use, menstruation, puberty, and maternal health. It was developed through focus groups with AGYW to ensure cultural and contextual relevance. *Nthabi* offers information in Sesotho and addresses local misconceptions through myth-busting features. By incorporating culturally relevant approaches, such as local language integration and content designed to resonate with Basotho cultural norms, it bridges gaps created by geographical and cultural barriers. Lesotho's mountainous terrain and dispersed rural communities make transportation and access to healthcare particularly challenging, further highlighting the importance of *Nthabi's* mobile phone-based interface. This platform provides accessibility and convenience, allowing users to receive reliable SRH information without relying on traditional healthcare systems.

4.1.6 The Violet Project

The Violet Project primarily targets youth in Baltimore (USA), focusing on reducing health disparities by offering free, youth-centred DH resources. The platform integrates education, telehealth services, and the provision of physical products, such as menstrual hygiene supplies and safer sex kits, to address the SRH needs of adolescents. One of its key innovations is the inclusion of at-home STI testing kits with telehealth support for treatment which enables adolescents to access vital health services without visiting a clinic. The digital content is intentionally youth-friendly, accessible, and inclusive, covering topics like puberty, menstruation, and healthy relationships. The website allows users to anonymously access educational materials, order menstrual hygiene products, and engage in the "Ask Nellie" column. This feature enables users to ask questions anonymously, which are answered by staff and board-certified OB/GYNs, providing confidential and professional advice on SRH topics. Additionally, peer educators in clinics support adolescents by bridging the gap between clinical visits and SRH education.

Digital Tool	**Key Strategies and Contributions**
Afya-Tek	Digitizes CHWs' workflow to create a seamless care system; introduces adolescent-specific clubs for counselling and support. Piloting a chatbot for SRH education and mental health resources.

Amaze	Provides free, engaging SRH educational videos in over 70 languages. It is widely accessible through social media platforms and offline partnerships. Operates on an open-access model for NGOs and schools.
Comolehago.org	Offers scientifically accurate SRH information through interactive features like videos, georeferenced maps, and live chat with professionals. Part of Mexico's ENAPEA program aimed at reducing adolescent pregnancies.
Lily Health	Initially provided personalized SRH advice via mobile chat (SMS, WhatsApp), focusing on period tracking and education. Later pivoted to fertility-related content due to user demand.
Nthabi	A conversational agent delivering SRH education in Sesotho, focusing on Basotho communities in Lesotho. Combats misinformation with culturally relevant content and addresses rural access challenges.
The Violet Project	Focuses on youth in Baltimore, providing at-home STI testing kits, telehealth support, and educational content. Includes a confidential Q&A service and peer educators in clinics.

Table 3: Key Strategies of digital tools for SRH

4.2 Barriers to SRH Access and Responses

Barriers identified include insufficient SRH education, limited internet access, cultural stigma, economic constraints, and the lack of youth-friendly services (see Figure 2). Summarized findings are presented in Table 4.

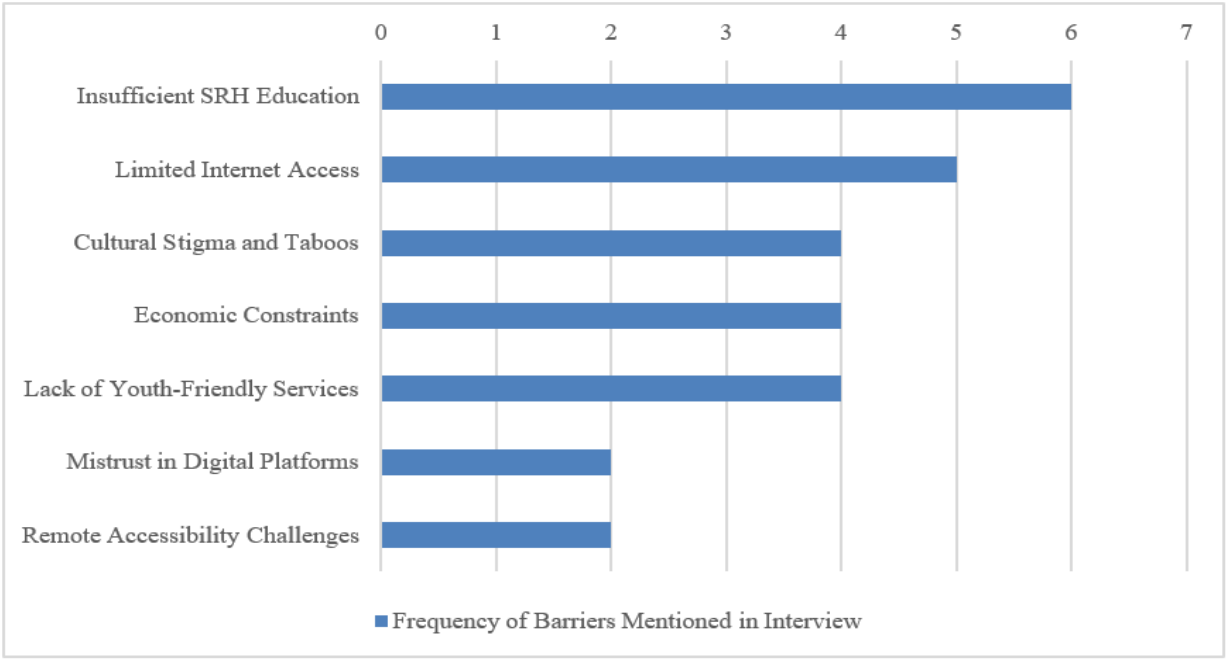

Figure 2: Barriers to SRH Service Access Mentioned by Stakeholders

Insufficient SRH education emerged as a prominent barrier and was cited by stakeholders from all tools. Representatives from *Comolehago.org* explained that adolescents in rural Mexico often lack access to accurate SRH education due to gaps in school curricula and limited community-based resources. To address this, the platform integrates educational videos and interactive infographics tailored to adolescents' needs. *Amaze* aims to fill this gap globally through free and engaging videos that are adapted into multiple languages, which ensures accessibility and cultural relevance for diverse audiences. Stakeholders emphasized that these tools provide vital SRH information otherwise unavailable in many formal education settings.

Limited internet access was another frequently mentioned challenge, especially in rural and underserved areas. For example, stakeholders from *Nthabi* noted that unreliable internet connectivity in Lesotho prevents consistent access to their mobile app. To mitigate this, the tool offers offline functionalities, which allows users to pre-download educational content. Likewise, *Comolehago.org* provides USB drives loaded with SRH materials. In this way it ensures that adolescents in areas without internet connectivity can still benefit from the platform's content.

Cultural stigma and taboos surrounding SRH were highlighted as significant barriers, particularly in conservative or rural communities where these topics are often considered inappropriate for open discussion. For instance, *Nthabi* integrates community-based awareness campaigns to address stigmas and focuses on fostering open dialogue about SRH within families and communities. The platform also ensures that its language and visual content align with local cultural norms to make its educational materials more accepted and approachable. *Amaze* on the other hand uses humour and youth-friendly content to normalize discussions about SRH and break down taboos.

Economic constraints were frequently cited as barriers, with many adolescents unable to afford the devices or data required to access digital tools. Representatives from *Afya-Tek* described how adolescents in Tanzania often lack personal smartphones or reliable internet access. To address this, the platform relies on CHWs equipped with mobile devices to deliver SRH education directly to adolescents. This approach ensures a broader reach in economically disadvantaged areas.

Lack of youth-friendly services was a critical barrier mentioned by several stakeholders. Adolescents often avoid traditional healthcare settings due to perceptions of judgment or lack of confidentiality. For example, *The Violet Project* integrates peer educators into clinics to create a supportive and non-judgmental environment for adolescents seeking SRH services. Similarly, *Afya-Tek* trains CHWs to

provide adolescent-focused services that prioritize discretion and respect. This ensures that adolescents feel comfortable accessing care.

While the above barriers were commonly noted, other challenges emerged from specific tools. For example, representatives from *Nthabi* mentioned the difficulty of reaching adolescents in remote areas who may lack not only digital tools but also basic literacy skills, requiring alternative methods of engagement. *Comolehago.org* highlighted issues with mistrust in digital platforms among some parents and community members, which they address through partnerships with local organizations to build credibility and acceptance.

Digital Tool	Barriers Identified	Responses by Tools
Afya-Tek	Cultural taboos, stigma accessing health facilities, limited digital access, privacy concerns	Equips CHWs with devices, adolescent-focused clubs, privacy-enhanced drug shops
Amaze	Digital divide, cultural sensitivities, language barriers, opposition from some groups	Provides downloadable videos and USB sticks for offline access, partners with local NGOs
Comolehago.org	Cultural barriers, limited digital access in rural areas, structural barriers from healthcare providers	Offers culturally sensitive content, anonymous live chat, georeferenced maps, offline materials
Lily Health	High cost of communication services, distance from healthcare providers, cultural pressures	Initially used SMS/mobile chat services to reach underserved users, pivoted to focus on fertility content
Nthabi	Lack of comprehensive SRH education, judgmental healthcare providers, cultural taboos, geographical challenges	Provides mobile-based SRH education in local languages, addresses taboos, private learning environments
The Violet Project	High STI rates, transportation/insurance barriers, stigma around SRH, economic barriers	Provides anonymous and free resources, at-home STI testing kits, peer educators

Table 4: Barriers to SRH Access and Responses

4.3 Effectiveness of Digital SRH Tools

The effectiveness of the digital SRH tools analysed in this research varies across interventions and reflects differences in their design, implementation, and target populations (see summary in Table 5). A common theme among stakeholders was the inherent difficulty in isolating the impact of digital tools from broader health initiatives, which often include complementary efforts such as community engagement or partnerships with healthcare providers. This complexity was particularly noted by

Comolehago.org, whose representatives explained that while the platform has contributed significantly to advancing ENAPEA, its specific impact cannot be disentangled from the overarching efforts of the whole program. Similarly, *Amaze* noted that while its videos have reached hundreds of millions of young people online, gathering concrete data on knowledge, skills, and behavioural changes remains a challenge due to resource and focus limitations.

Stakeholders provided varied quantitative and qualitative indicators of success. For example, *Comolehago.org* reported that, as part of ENAPEA, which started in 2015, adolescent pregnancies have declined from 74.5 births per 1,000 women aged 15–19 in 2015 to 58.8 in 2022. Although the digital platform is one of many components of this broader strategy, its role in providing scientifically accurate and accessible SRH content has been highlighted as pivotal in reaching underserved adolescents. Offline features like USB-based resources and printed materials were also emphasized as essential in addressing Mexico's digital divide and enhanced the tool's reach and inclusivity.

Nthabi's effectiveness was supported by findings from a quasi-experimental study involving its users in Lesotho. This study revealed a 15% improvement in SRH knowledge scores among adolescents using the app compared to a control group. Such results demonstrate the potential of conversational agents to deliver tailored and culturally relevant health education. The tool's emphasis on family planning, STI prevention, and contraceptive use was highlighted as critical to addressing the needs of its target population.

The Violet Project demonstrated significant engagement through its online platform, which provides educational materials, menstrual products, and at-home STI testing kits. The tool's metrics show high demand, with approximately 10,000 kits distributed in Maryland since its inception. Additionally, website analytics revealed high interaction rates with product ordering, which demonstrates demand for menstrual and safer sex resources, while the educational content on the website sees comparatively lower interaction rates. This finding shows the varying levels of effectiveness across different service components and point to potential areas for optimization.

In contrast, *Lily Health*, which initially targeted underserved populations with low-cost SMS-based SRH information, faced challenges in sustaining its reach and adapting to users' evolving needs. While the platform's shift to fertility-related content aligned with user demand, its limited focus on underserved adolescent populations highlights gaps in addressing broader SRH needs. The interview revealed that measuring direct effectiveness remains a challenge due to the lack of comprehensive evaluation mechanisms.

The interviews collectively demonstrate that while direct measurement of effectiveness is often limited, tools like *Nthabi*, *Comolehago.org*, and *The Violet Project* illustrate significant progress in expanding SRH access and improving outcomes for adolescents. These findings highlight the transformative potential of digital interventions while stressing the need for systematic evaluation frameworks to assess their impact comprehensively.

Tool	Effectiveness Indicators	Challenges Identified
Afya-Tek	Difficult to isolate impact due to integration within community health systems. High engagement through CHWs.	Difficult to measure long-term effectiveness due to systemic integration.
Amaze	High global reach through social media, but limited evidence on long-term behavioural change.	Limited metrics on knowledge retention and behaviour change.
Comolehago.org	Part of ENAPEA program, contributing to a decline in adolescent pregnancies. Offline features address digital divide.	Specific impact difficult to attribute due to multi-pronged strategy in ENAPEA.
Lily Health	Initially effective in reaching underserved populations via SMS, but pivot to fertility focus reduced relevance for adolescents.	Shift away from adolescent-specific focus highlights need for sustained relevance.
Nthabi	Quasi-experimental study showed 15% improvement in SRH knowledge scores among users.	Geographical and digital access barriers still pose challenges.
The Violet Project	High demand for menstrual and safer sex resources through online platform. Distributed 10,000 STI testing kits.	Higher interaction with product ordering than educational content. Optimization needed.

Table 5: Effectiveness of digital SRH tools

4.4 Lessons for Scaling and Sustainability

The results from stakeholder interviews reveal valuable lessons learned from the implementation of digital SRH tools and offer insights into guiding future development, scaling, and replication (see summary in Table 6). Stakeholders consistently emphasized that youth-centred design, fostering partnerships, ensuring financial sustainability, cultural and contextual adaptability, and adopting holistic approaches to SRH education and service delivery are critical factors that influence the success of these tools in underserved regions. While the tools vary in their objectives and execution,

shared themes emerged across the discussions, highlighting common challenges and effective strategies.

Youth-centred design was a recurring lesson across all interviews and highlighted the importance of involving adolescents in every phase of tool development, implementation, and feedback. Stakeholders emphasized that digital SRH tools must be designed with adolescents in mind, as they are the intended users. *Comolehago.org*, for instance, highlighted how they actively involved adolescents in the content creation process through focus groups to ensure that the materials were relatable and met the actual needs of their target audience. Similarly, *Amaze* demonstrated the effectiveness of working with youth ambassadors to co-create educational videos that resonate with adolescents, which enhances their relatability and appeal. These examples illustrate that meaningful adolescent engagement is not just an added benefit but a prerequisite for creating tools that are widely accepted and utilized.

Cultural and contextual adaptability was another significant factor influencing the success of digital SRH tools. Stakeholders noted that tailoring content to the socio-cultural and linguistic needs of target populations fosters trust and usability. *Nthabi* was explicitly designed for Basotho adolescents, incorporates culturally relevant content and delivers information in ways that resonate with local practices and beliefs. Similarly, *Amaze* showcased the value of localization by offering adaptable videos tailored to different cultural and regional contexts. For example, its videos can be modified to reflect local norms, such as skin tone, attire, and relevant props (see Figure 3), which makes the content more relatable for the adolescents of each region. These approaches highlight the importance of cultural sensitivity in fostering trust and usability among diverse adolescent populations.

Figure 3: Different modifications of a same video on SRH by Amaze

Strategic partnerships emerged as another essential factor for success. Stakeholders repeatedly stressed that collaborations with governments, NGOs, and private sector organizations are critical for expanding reach, securing funding, and leveraging expertise. *Afya-Tek* provided a compelling example of early government involvement, with a stakeholder noting, "From the start, we involved the government in co-designing the system... ensuring integration into national systems for scalability and sustainability." This collaboration facilitated the tool's alignment with national healthcare priorities and ensured ongoing support. *Nthabi* also highlighted the value of partnering with telecommunications providers, including exploring zero-rating options to reduce data costs and ensure consistent access for users in remote areas. *Comolehago.org's* multisectoral approach, which engaged not only health ministries but also other governmental institutions, demonstrated the transformative potential of partnerships in achieving large-scale impact.

Financial sustainability presented a persistent challenge for most tools. Many interventions rely heavily on grants, NGO funding, or research funds, which limits their ability to scale or sustain operations. For instance, *The Violet Project* highlighted the constant effort required to secure grants to maintain services such as distributing free STI testing kits. Similarly, Lily Health's representative noted, "We learned that it's crucial to decide early on whether to pursue a sustainable business model or rely on alternative funding like grants." Despite its widespread use, Lily Health had to pivot from its original focus due to financial constraints, which highlights how critical funding is to a tool's longevity. These examples show the importance of diversifying funding sources and considering long-term financial models during the early stages of development.

The importance of aligning tools with national and international frameworks was also highlighted as critical for scaling and sustainability. *Afya-Tek*, for example, demonstrated how integrating its platform with Tanzania's national healthcare guidelines enabled smooth adoption and scalability within the public health system. Comparably, *Amaze* aligns its content with internationally recognized CSE guidelines from UNESCO and WHO, which makes it easier to adapt the material across various national contexts. Stakeholders noted that alignment with established frameworks not only ensures credibility but also facilitates broader adoption and integration into national systems.

Finally, stakeholders highlighted the need for a holistic approach to SRH education and service delivery. *Comolehago.org* exemplified this by addressing not only adolescents but also the network of actors who influence their access to information and services, including parents, teachers, and healthcare providers. One stakeholder remarked, "The focus is not only on adolescents but also on

teachers, parents, and healthcare providers, because it is a network of actors that affects access to information and services." The platform's geolocated directories for adolescent-friendly healthcare services demonstrate how such a comprehensive approach can enhance access and effectiveness. This finding highlights the importance of creating an ecosystem that supports adolescents at every level, which ensures that information and services are accessible and reliable.

These lessons collectively demonstrate that the success of digital SRH tools relies on engaging adolescents, fostering strategic partnerships, ensuring financial sustainability, adopting culturally sensitive approaches, aligning with established frameworks, and embracing holistic strategies. Through integrating these insights into the design and implementation of future interventions, digital SRH tools have the potential to become more inclusive, impactful, and scalable and ultimately bridge gaps in access for underserved populations.

Digital Tool	Key Lessons
Afya-Tek	Early government engagement ensures scalability and sustainability. Integration into public healthcare systems is critical.
Amaze	Youth-centred content and adaptability are essential for global reach. Partnerships enable localization and inclusivity.
Comolehago.org	Multisectoral partnerships and offline adaptations enhance accessibility. Aligning with national frameworks ensures impact.
Lily Health	Sustainability challenges highlight the importance of diverse funding sources. Pivoting to meet user needs can affect relevance.
Nthabi	Cultural adaptation and local language integration foster trust. Partnerships with telecom providers reduce data costs.
The Violet Project	Providing discreet services like at-home STI kits improves access. Peer educators bridge gaps in SRH education and care.

Table 6: Lessons for Scaling and Sustainability

5. Discussion

Each RQ is analysed in depth, highlighting alignments with existing theories, identifying gaps, and proposing considerations for future strategies and frameworks. By applying the theoretical lens introduced in Chapter 2.4, the discussion evaluates these strategies and barriers through the perspectives of empowerment, equity, inclusivity, and adolescent-specific frameworks, highlighting both strengths and areas for improvement.

5.1 How are DH interventions currently addressing the SRH needs of AGYW in resource-constrained settings?

A central theme emerging from the analysis is how tools foster empowerment by equipping adolescents with the knowledge and agency to make informed SRH decisions. *Afya-Tek* integrates CHWs into adolescent-specific clubs that provide counselling, peer-led discussions, and mental health support, creating localized care systems. This aligns with the Empowerment Theory's focus on fostering agency, self-efficacy, and resource access (Zimmerman, 1995). *The Violet Project* enhances agency through at-home STI testing kits supported by telehealth services, which enables private and confident engagement with SRH resources. However, tools like *Nthabi*, while culturally tailored to Basotho adolescents, rely heavily on pre-set content, which limits opportunities for active adolescent participation, a key element of empowerment.

From a health equity perspective, tools like *Comolehago.org* address systemic barriers by providing offline SRH resources and geolocated directories for adolescent-friendly healthcare services. These efforts align with the Health Equity Framework (Braveman & Gruskin, 2003; Johnson, 2015), addressing inequities related to digital access and infrastructure. However, challenges remain in ensuring inclusivity for rural adolescents, as offline users lack access to features like live chat and interactive geolocators. *Amaze* mitigates these challenges through local partnerships that distribute its educational videos offline, demonstrating a dual approach to inclusivity. Yet, its reliance on digital infrastructure may still exclude adolescents in the most resource-constrained settings.

The WHO DH Empowerment Framework emphasizes access, agency, and action in practical implementations. Tools such as *Amaze* demonstrate these dimensions by using engaging and youth-friendly content, fostering SRH literacy among adolescents globally. *Afya-Tek* trains CHWs to

provide adolescent-friendly services, emphasizing privacy and cultural sensitivity, which aligns with the WHO framework's emphasis on creating active and participatory health environments.

Inclusivity, as emphasized by the Feminist Intersectionality Framework, ensures that digital interventions address the diverse needs of adolescents based on intersecting identities such as gender, geography, and socioeconomic status (Figueroa et al., 2021). *Nthabi* incorporates local languages and cultural norms to resonate with Basotho communities, addressing geographic and cultural barriers. However, tools like *Lily Health* have struggled to maintain relevance for underserved adolescent due to their shift toward fertility-focused services, highlighting the risks of failing to address the intersectional needs of marginalized groups.

The Adolescent-Specific SRH Frameworks emphasize developmental needs and protective factors like peer support and education (Blum & Nelson-Mmari, 2004; Mmari & Sabherwal, 2013). Tools such as *Amaze* excel in aligning with these frameworks by incorporating humour, peer influence, and gamified content that resonates with adolescents' cognitive and social realities. *Comolehago.org* takes a broader approach by involving parents, teachers, and healthcare providers to create a supportive ecosystem that normalizes SRH education. However, *Nthabi's* reliance on static content overlooks interactive features that encourage self-expression and dialogue.

These tools collectively illustrate the potential of DH interventions to bridge gaps in SRH access for underserved adolescents. By aligning with empowerment, equity, inclusivity, and adolescent-specific frameworks, tools like *Afya-Tek*, *Amaze*, and *Comolehago.org* demonstrate innovative strategies that address critical barriers. However, challenges such as sustaining relevance, addressing digital literacy gaps, and ensuring comprehensive offline accessibility highlight areas for improvement.

5.2 What are the primary barriers preventing AGYW in underserved regions from accessing SRH services, and how can DH tools help overcome these barriers?

The findings reveal several barriers that prevent AGYW in underserved regions from accessing SRH services, including cultural stigma, economic constraints, limited digital literacy, and the absence of youth-friendly services. These barriers are deeply rooted in structural and systemic inequities, aligning with the Health Equity and Feminist Intersectionality Framework. This section critically

discusses how these barriers intersect with the theoretical lens introduced in Chapter 2.4 and evaluates the extent to which DH tools address or fail to mitigate them.

One of the most pervasive barriers is cultural stigma surrounding SRH, which discourages adolescents from seeking information or services. This aligns with the Feminist Intersectionality Framework, which emphasizes addressing intersecting cultural norms that marginalize adolescents. Tools like *Nthabi* challenge stigma by delivering culturally tailored, myth-busting content that fosters trust and relatability. *Amaze* uses humour and youth-friendly content to normalize SRH conversations and reduce stigma. However, humour may not resonate equally across all cultural contexts, highlighting the need for further adaptation. While these tools demonstrate progress in tackling stigma, broader community strategies are needed to promote systemic attitudinal shifts.

Economic constraints also restrict adolescents' access to devices, data, and digital tools. This reflects broader systemic inequities highlighted by the Health Equity Framework. *Afya-Tek* addresses this challenge by equipping CHWs with mobile devices to deliver SRH education directly to adolescents in low-resource settings. *Comolehago.org* mitigates economic constraints by providing offline USB drives with SRH content, ensuring that resources are accessible even without internet connectivity. However, offline users miss out on interactive features like live chats and geolocators. Sustainable offline innovations, such as zero-rated mobile apps, remain critical for bridging this divide.

Limited digital literacy and connectivity further hinder access. Tools like *Nthabi* offer offline functionalities to mitigate connectivity issues but do not fully address digital literacy gaps. *Comolehago.org's* geolocated service directory remains underutilized in areas with poor internet access. These findings align with Empowerment Theory, which emphasizes equipping users with the skills to navigate digital tools effectively. Improving digital literacy through training and user-friendly interfaces is essential for maximizing the impact of DH tools.

Another significant barrier is awareness. Many adolescents are unaware of available DH tools or how to use them. A representative from The Violet Project noted, "I think the biggest problem is that people don't know what they don't know. They don't realize that the resources are there or how to use them." This highlights the importance of awareness as a foundational step in fostering agency, as emphasized by Empowerment Theory. Without proactive outreach strategies, DH tools risk failing to reach those who need them most. To address this, tools like *Comolehago.org* engage through school outreach programs and peer ambassadors. *Amaze* leverages social media platforms to amplify global reach, though these strategies may exclude adolescents in regions with limited connectivity.

The absence of youth-friendly services remains a critical challenge. Adolescents often avoid traditional healthcare settings due to fears of judgment or confidentiality breaches. DH tools offer an alternative by creating safe spaces for adolescents to engage with SRH resources. *The Violet Project* integrates peer educators into clinics to foster non-judgmental environments, while *Afya-Tek* trains CHWs to deliver adolescent-friendly services. These efforts align with the Adolescent-Specific SRH Frameworks which emphasize the need for supportive environments tailored to adolescents' developmental needs.

The barriers identified validate the Health Equity Framework's focus on systemic determinants of health and the Feminist Intersectionality Framework's focus on compounded inequities faced by marginalized groups. While DH tools offer innovative approaches to addressing these barriers, their effectiveness is constrained by broader systemic issues, including limited integration into healthcare systems, insufficient funding for scaling, and persistent digital divides. Addressing these challenges requires a dual approach: enhancing the design of DH tools to address individual barriers while advocating for systemic changes to dismantle structural inequities. Key strategies include expanding offline access, fostering partnerships with governments and telecommunications providers, and investing in adolescent-friendly healthcare infrastructure.

5.3 How effective are existing DH interventions in improving SRH outcomes for underserved adolescent populations?

The findings reveal that DH tools contribute significantly to improving SRH outcomes for AGYW, although their impact varies depending on several factors. A recurring theme is the importance of systemic interdependencies and partnerships in achieving effectiveness. Tools like *Comolehago.org*, as part of Mexico's ENAPEA strategy, integrate offline resources, adolescent-friendly service locators, and partnerships with healthcare providers to reduce barriers to SRH access. This comprehensive approach demonstrates how systemic integration amplifies impact. Similarly, *The Violet Project's* combination of at-home STI testing with telehealth services and healthcare follow-ups illustrates the value of supportive ecosystems in achieving tangible outcomes. These examples align with the WHO DH Empowerment Framework, which emphasizes action-oriented dimensions like access and active participation. However, the framework could be expanded to account for the critical role of partnerships and systemic interdependencies in sustaining impact.

Another significant challenge is measuring effectiveness. Stakeholders reported difficulties isolating the impact of digital tools from broader initiatives, such as community engagement or policy integration. For instance, while *Comolehago.org* has been credited with contributing to a decline in adolescent pregnancies in Mexico, this outcome cannot be attributed to the platform alone due to its integration within ENAPEA's multi-pronged strategy. The absence of robust evaluation frameworks limits the ability to assess long-term effectiveness comprehensively. Current evaluations often rely on short-term metrics like knowledge retention or user engagement, which, while valuable, fail to capture sustained behavioural or systemic changes. Longitudinal studies and mixed-method evaluations could address this gap by providing a more nuanced understanding of how digital tools' long-term influence on SRH outcomes.

The Adolescent-Specific SRH Frameworks provide valuable insights into aligning tools with adolescents' developmental needs. *Amaze* excels in this area, using youth-centred visuals, humour, and gamified content to engage adolescents in ways that resonate with their cognitive and social realities. This approach aligns with frameworks emphasizing supportive environments tailored to adolescents' developmental stages. Conversely, tools like *Lily Health*, which pivoted to fertility services, risk reduced impact among underserved adolescents by failing to address their unique needs. This highlights the importance of keeping tools adaptable and relevant to evolving priorities.

Health equity offers another lens for evaluating effectiveness by assessing how well tools address systemic barriers and promote inclusivity. Tools like *Nthabi* and *Comolehago.org* have made significant strides in targeting underserved populations with culturally tailored content and offline functionalities. For example, *Nthabi* delivers SRH education in Sesotho and address local misconceptions, while *Comolehago.org* provides USB drives loaded with SRH materials for adolescents in rural areas. However, offline users often miss out on interactive features like live chats or geolocated service directories, creating partial rather than comprehensive solutions. These findings reveal gaps in the practical application of the health equity framework, particularly in addressing the digital divide and resource-intensive adaptations. Expanding the framework to include considerations of resource allocation and scalability could enhance its applicability to real-world interventions.

The findings also highlight the interconnected nature of empowerment, equity, and adolescent development frameworks. *The Violet Project* demonstrates how combining elements of like privacy, cultural sensitivity, and developmental alignment, can achieve tangible outcomes like increased STI testing rates. However, persistent systemic barriers, including cultural stigmas and economic

constraints, emphasize the need for interdisciplinary approaches. Programs like ENAPEA exemplify the value of integrating education, healthcare, and policy to create holistic, sustainable solutions. These multi-sectoral strategies provide a blueprint for leveraging DH tools as part of broader systemic change.

While DH tools hold significant promise for improving SRH outcomes, their effectiveness depends on systemic integration and addressing both individual and structural barriers. Empowerment, health equity, and adolescent development frameworks provide valuable lenses for understanding their impact, but further evolution is needed to address gaps in scalability, adaptability, and systemic interdependencies. By fostering interdisciplinary collaboration, implementing robust evaluation methods, and designing adaptable tools, stakeholders can maximize the potential of DH interventions to achieve sustainable, transformative outcomes for underserved adolescents.

5.4 What lessons can be learned from the implementation of DH tools, and how can these insights guide the future development, scaling, and replicating of SRH interventions to ensure broader and more inclusive access?

A key lessons is the importance of partnerships in scaling digital SRH tools. Across all cases, collaborations with governments, NGOs, and private sector actors were pivotal for sustainability and replication. *Afya-Tek's* early engagement with national governments ensured integration into public healthcare frameworks, securing funding and aligning with national strategies. *The Violet Project's* partnerships with healthcare providers and community organizations extended its outreach and addressed gaps in adolescent access to STI testing and SRH education. These examples reflect the WHO DH Empowerment Framework's emphasis on systemic integration and collaborative action (WHO, 2024d). Successful scaling requires alignment with systemic priorities, shared resource mobilization, and trust-building among stakeholders.

User-centred design also emerged as a critical enabler of effective interventions. Tools involving end-users in the design process were more likely to resonate with their target populations. *The Violet Project*, for instance, refined its STI kits based on feedback from youth focus groups to meet adolescent preferences. This approach aligns with the Empowerment Theory's focus on fostering participation and agency among users. *Amaze* engaged adolescents and educators to develop culturally relevant and youth-friendly content that normalized SRH education. However, tailoring

tools to specific cultural and regional contexts poses scalability challenges, as these adaptations can be resource-intensive. This raises a broader question: how can digital tools balance cultural relevance with cost-effective scaling?

Cultural adaptation is vital for tool acceptance but presents challenges during scaling. Tools like *Nthabi* and *Comolehago.org* address cultural and contextual factors but replicating these approaches across diverse regions requires significant investment in localized content development. *Comolehago.org's* offline resources reach rural populations effectively but lack interactive features available online. These findings highlight the need to embed cultural adaptation within broader systemic strategies to ensure equitable access during scaling. The Feminist Intersectionality Framework emphasizes the importance of considering intersecting identities and local contexts when replicating interventions.

The digital divide remains a persistent challenge in scaling SRH tools. While *Comolehago.org* and *Nthabi* provide offline alternatives, these solutions often lack the participatory features available to online users. This highlights the need for systemic investments in digital infrastructure, including partnerships with telecommunications providers and government-led initiatives to improve connectivity and digital literacy. Bridging the digital divide is essential to ensure scaled interventions do not inadvertently exclude the most underserved populations. These efforts align with the Health Equity Framework's emphasis on dismantling structural barriers to access.

Capacity building is another critical factor for scaling and sustaining digital SRH tools. Training healthcare providers, educators, and community leaders to integrate digital tools into healthcare systems enhances their impact. *Afya-Tek's* training programs for CHWs illustrate how empowering local actors improves the functionality and reach of digital tools. *Comolehago.org's* engagement with parents, teachers, and healthcare workers strengthens its ability to cascade SRH education to underserved adolescents. These examples align with the Adolescent-Specific SRH Frameworks' emphasis on creating supportive environments that extend beyond the end-user to include all stakeholders in an adolescent's ecosystem.

Interdisciplinary approaches are essential for scaling and replicating digital SRH tools. Programs like ENAPEA combine digital tools with systemic strategies, such as policy advocacy, community engagement, and healthcare integration. These coordinated efforts ensure that digital tools operate within broader ecosystems rather than as standalone solutions. This reflects the WHO DH

Empowerment Framework's call for systemic integration and the Health Equity Framework's focus on structural determinants of health.

These lessons collectively highlight that scaling digital SRH tools requires a multifaceted approach. Prioritizing partnerships, user-centred design, cultural adaptation, capacity building, and systemic integration ensures that interventions are both impactful and inclusive. However, challenges such as sustainability, the digital divide, and resource intensity persist. Addressing these gaps will require continued research, innovation, and collaboration. By applying the insights gained from existing tools, future interventions can move closer to achieving equitable and inclusive SRH access for underserved adolescents worldwide.

5.5 Revised Framework

A revised theoretical lens framework (Figure 4) can be conceptualized incorporating the key findings and insights gained, enhancing the initial model (Figure 1) to reflect the complexities of implementing and scaling DH tools for SRH in underserved adolescent populations. By refining the dimensions of each layer and emphasizing their interrelationships, the framework provides a dynamic and actionable structure for evaluating and guiding DH interventions.

At its core, the Empowerment Theory emphasizes Agency, Self-efficacy, and Resource Access, with the additions of Awareness and Community Engagement. These reflect the importance of ensuring adolescents are informed about available tools and the role of local actors in fostering empowerment. This core influences every outer layer, ensuring that individual agency serves as the foundation for systemic and contextual interventions.

The Health Equity Framework, in the second layer, builds on the empowerment foundation by addressing systemic barriers like Poverty, Discrimination, and Resource Distribution. New dimensions, such as Digital Literacy and Sustainability, highlight the structural realities that shape access and long-term viability of DH tools. This layer connects to the core by contextualizing individual empowerment within broader systemic constraints.

The WHO DH Empowerment Framework, forming the third layer, emphasizes Access, Agency, Action, and additional dimensions like Scalability and Integration into Health Systems. This layer provides actionable strategies for aligning systemic interventions with individual empowerment,

bridging the gap between theoretical principles and practical implementation. It complements the health equity layer by operationalizing its goals within healthcare systems and communities.

The Feminist Intersectionality Framework, in the fourth layer, addresses Gender, Geography, and Socioeconomic Status, emphasizing the compounding effects of intersecting identities. This framework ensures that systemic strategies and individual interventions are inclusive of marginalized groups, connecting structural inequities with diverse lived experiences.

The Adolescent-Specific SRH Framework, in the outermost layer, contextualizes the broader frameworks within the developmental realities of adolescents. Expanded Risk Factors include Digital Divide and Awareness Gaps, while Protective Factors incorporate Stakeholder Involvement to reflect the critical role of parents, educators, and healthcare providers in creating supportive ecosystems. This layer brings together all inner frameworks, emphasizing how systemic strategies and individual empowerment intersect to address adolescent-specific needs.

The relationships between these layers are integral to the framework's effectiveness. The Empowerment Theory underpins the entire structure, influencing systemic strategies (Health Equity, WHO DH) and contextual needs (Intersectionality, Adolescent-Specific Frameworks). The Health Equity Framework and WHO DH Empowerment Framework have a reciprocal relationship, as equity-driven systemic changes must align with scalable, actionable pathways. The Feminist Intersectionality Framework enriches both systemic and individual approaches by ensuring inclusivity, while the Adolescent-Specific Framework integrates these dynamics into the developmental and contextual realities of underserved adolescents.

This revised framework provides a comprehensive and interconnected lens for designing and evaluating DH tools. It bridges individual empowerment with systemic considerations, ensuring that interventions address the diverse and complex needs of underserved adolescent populations.

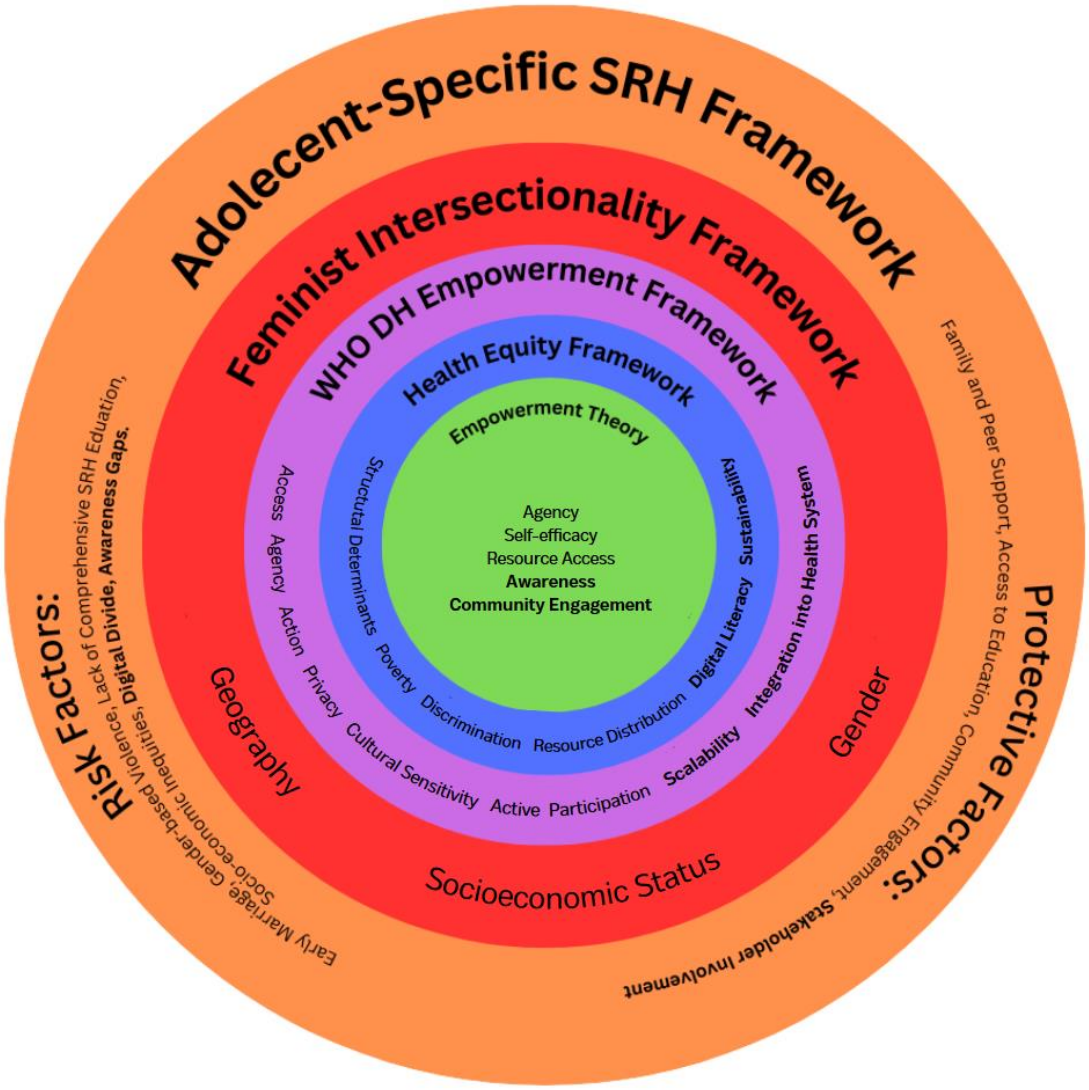

Figure 4: Proposed model for analysing DH interventions in SRH in AGYW (revised version)

5.6 Implications and Recommendations

For projects, the findings highlight the importance of stakeholder engagement and co-design to ensure interventions meet the unique needs of their target populations. Tools like *Comolehago.org* and *Afya-Tek* demonstrate how involving adolescents, educators, and healthcare providers in the design phase leads to user-centred and contextually relevant tools. Flexible approaches are also crucial for addressing the digital divide, such as distributing USB-based content or offering pre-downloaded modules for offline access. However, these technical solutions must be embedded within systemic strategies, such as integrating tools into education programs and healthcare delivery frameworks, to enhance their sustainability and impact.

For policymakers, creating enabling environments is essential for scaling and sustaining digital SRH tools. Integrating these tools into national healthcare strategies, as exemplified by *Afya-Tek* and Mexico's ENAPEA (*Comolehago.org*), ensures alignment with broader priorities while securing necessary funding and support. Investments in digital infrastructure and partnerships with telecommunications providers, such as subsidizing internet access or offering zero-rated platforms, can help close connectivity and literacy gaps. Additionally, promoting adolescent-friendly healthcare services is vital. The WHO framework emphasizes the need for safe, confidential, and accessible spaces tailored to adolescents' developmental needs, aligning with practices like *The Violet Project's* use of peer educators to foster supportive environments. Policymakers should prioritize the integration of these practices into healthcare systems to complement digital tools and create cohesive service networks.

For practitioners and NGOs, capacity building is a critical enabler for integrating digital tools into service delivery systems. Training healthcare providers, educators, and CHWs ensures tools are effectively used to bridge knowledge and access gaps. *Afya-Tek's* CHW training programs exemplify how empowering local actors can extend the reach of digital interventions. Outreach and visibility must also be prioritized to raise awareness and ensure accessibility. Tools like *Amaze* demonstrate the potential of global digital campaigns, while local initiatives, such as *Comolehago.org's* school programs, adapt tools to cultural and regional contexts, ensuring they resonate with their intended audiences.

These findings emphasize the need for interdisciplinary approaches that integrate digital tools into broader systemic efforts across education, healthcare, and technology sectors. Stakeholders must prioritize equity, recognizing that the ultimate success of digital SRH tools lies in their ability to reach underserved populations. Sustained investments, innovative approaches, and coordinated efforts are essential for addressing systemic barriers and creating inclusive, scalable solutions that transform adolescents' access to SRH services worldwide.

5.7 Limitations and Future Work

While this research provides rich, contextualized insights into digital SRH tools, it is limited by the absence of robust quantitative data, such as longitudinal assessments or controlled comparisons. This restricts the ability to draw definitive conclusions about the long-term effectiveness of the tools in improving SRH outcomes. Future research could employ mixed-method approaches, combining quantitative metrics with qualitative insights, to better evaluate DH interventions' impact.

A significant challenge lies in isolating the specific contributions of digital tools within broader strategies. Tools integrated into multi-faceted initiatives, such as *Comolehago.org* within ENAPEA, highlight the importance of systemic interdependencies but complicate the evaluation of individual tools' effectiveness. Future studies could adopt systems-based evaluation frameworks that assess collective outcomes rather than isolating single interventions.

Despite efforts to bridge structural barriers, such as the digital divide, through offline adaptations, these solutions remain incomplete. Adolescents in resource-constrained settings often face additional challenges, including limited digital literacy, unreliable infrastructure, and restricted access to adolescent-friendly healthcare services. Future research could explore strategies to create more equitable access, such as integrating tools with broader infrastructure initiatives or leveraging low-cost mobile technologies and offline-enabled platforms. Additionally, examining how tools can address intersectional inequities, including those faced by LGBTQ+ adolescents or adolescents with disabilities, would provide deeper insights into fostering inclusivity.

From a theoretical perspective, the frameworks applied in this research revealed valuable insights but also highlighted gaps. For example, the empowerment framework focuses on individual agency but could be expanded to incorporate systemic interdependencies that influence SRH access. The health equity framework addresses structural determinants but overlooks operational challenges, such as scaling culturally tailored interventions or managing resource-intensive offline adaptations. Refining these frameworks to better account for practical realities would enhance their applicability to DH tools.

Finally, this research focused on a specific subset of tools and regions, limiting its generalizability. Expanding the scope to include a broader range of tools and geographic contexts would enrich understanding of best practices and innovative approaches. Future studies could also explore emerging technologies, such as artificial intelligence and machine learning, to enhance functionality, adaptability, and scalability in digital SRH interventions.

In summary, future work should focus on generating robust, generalizable evidence, refining theoretical frameworks, and exploring innovative solutions for scalability, inclusivity, and sustainability.

6. Conclusion

This thesis explored the role of DH tools in addressing SRH needs for AGYW in resource-constrained settings, applying a multidisciplinary theoretical lens that included empowerment, health equity, and adolescent development frameworks. While these tools demonstrate transformative potential, they are not standalone solutions but integral components of broader socio-technical systems.

DH tools enhance access, engagement, and inclusivity, as demonstrated by *Amaze's* culturally resonant, youth-centred content and *Comolehago.org's* integration within Mexico's ENAPEA strategy. Tools like *Afya-Tek* and *Nthabi* address critical inequities through systemic partnerships, offline capabilities, and culturally tailored content. However, persistent gaps, such as digital divides, limited scalability of tailored interventions, and insufficient evaluation mechanisms, highlight areas for improvement.

The AMO framework (Ability, Motivation, Opportunity) offers a lens for understanding the effectiveness of these tools (Blumberg & Pringle, 1982). DH tools enhance ability by providing accessible and user-friendly SRH information, increase motivation through stigma-reducing strategies, and create opportunities via systemic partnerships and localized adaptations. However, challenges such as infrastructure gaps and the resource intensity of offline solutions highlight the importance of aligning operational realities with empowerment principles.

A socio-technical perspective highlights the interdependence of digital tools with cultural, policy, and infrastructural ecosystems. Programs like ENAPEA illustrate how aligning digital tools with national strategies and partnerships amplifies their impact, emphasizing the need for multi-sectoral collaboration to address SRH challenges comprehensively.

Theoretical frameworks like empowerment and health equity proved valuable but require refinement. For instance, empowerment must better account for systemic interdependencies, and health equity needs to address practical barriers like scalability and resource allocation. Future research should employ longitudinal studies and mixed-method evaluations to provide more robust evidence of effectiveness. Expanding research to include diverse populations, such as LGBTQ+ adolescents and those with disabilities, and exploring emerging technologies like AI, can further enhance adaptability and scalability while preserving cultural relevance.

In conclusion, DH tools represent a promising avenue for improving SRH outcomes among underserved adolescents. Their success lies in systemic integration, addressing structural inequities,

and refining theoretical approaches. This thesis contributes to the field by critically analysing DH tools and providing actionable insights for future innovations.

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Appendix 1

Research Question	Topic	Theory/ Main Idea	Interview Question
Background Interviewee			**1.** Can you tell me more about your professional background? Specifically, where do you currently work, and what key roles or experiences have shaped your career? *Goal:* To understand the interviewee's broader professional context and how it may shape their responses.
			2. How did you first become involved in digital health, particularly in relation to sexual and reproductive health (SRH)? *Goal:* Focus specifically on their experience in digital health and SRH to contextualize their involvement in this area.
1. How are digital health interventions currently addressing the SRH needs of adolescent girls and young women in resource-constrained settings?	Digital tools for SRH access to information and services	**Crawford (2024):** Digital health has the potential to harness gender inequity by enhancing access to healthcare in a discreet, convenient, and cost-effective manner, especially for underserved women. **Nigenda (2016):** The evidence shows that mobile and electronic health can strengthen SRH systems and improve access to health services in the population, particularly when they are aligned with the populations and providers' needs. By providing information in a discreet manner, HITs have the potential to overcome cultural taboos that prevent informed discussions about SRH issues. **Nigenda (2016):** The use of HITs can reach poor and marginal populations, enabling access to health services regardless of geographical location. **Onukwugha (2022):** mHealth innovations have been proposed as a solution to improving access to and use of health services among the underserved population, especially in settings with poor healthcare infrastructure. (…) mHealth can offer timely, accurate and non-judgemental SRH information and services to adolescents. **Hubert (2021):** Efforts to use digital resources for addressing SRH themes have been successful for promoting safer-sex attitudes and positive norms related to safe-sex practices. They have also been found to reinforce the use of and adherence to contraceptive methods, broaden SRH knowledge, delay sexual initiation, prevent high-risk sexual practices, and boost self-efficacy. **Diaz-Olavarrieta (2021):** Sexual and reproductive health information is best learned using new technologies such as the Internet, even among disadvantaged populations such as adolescents attending rural schools. **UNESCO (2021):** (…) digital tools are being harnessed to strengthen sexuality education (…).	**3.** Can you describe the specific digital tool(s) you worked with, especially in relation to providing access to SRH information and services for adolescent girls and young women? *Goal:* To understand the function of the tool. *Follow-up:* If multiple tools are involved, please specify each one and its role.

Research Question	Topic	Theory/ Main Idea	Interview Question
2. What are the primary barriers preventing adolescent girls and young women in underserved regions from accessing SRH services, and how can digital health tools help overcome these barriers?	Barriers to SRH information and service access	**Morris (2015):** A series of multifaceted barriers currently prohibits good sexual and reproductive health for adolescents. At the political level, ASRH is low priority, and there are often restrictive laws and policies in place. Various societal, cultural, and religious factors create an inhibitive environment for discussion of ASRH as many societies hold a deeply embedded sense of disapproval of adolescent sexual activity; this is often demonstrated through the stigmatization of sexual health concerns. **Morris (2015):** Economic and physical accessibility restrict adolescents' access to services where they do exist. On a personal level, young people's care-seeking behavior may be restricted because of fear (of people finding out and other confidentiality issues that may result in violence), embarrassment, lack of knowledge, misinformation and myths, stigma, and shame. **Onukwugha (2022):** Globally, adolescents and young people face enormous barriers accessing Sexual and Reproductive Health information and services (…) These barriers such as lack of awareness of available services, lack of confidentiality, service providers' attitudes, social norms and values, and restrictive policies operate at different levels. **Alomair (2020):** Fear of stigmatization and being labelled as having pre-marital sexual relations among unmarried women acted as the main barrier to accessing contraception and seeking SRH information and services. **Graham (2021):** Most women had mobile phones; however, barriers to accessing online content included intermittent internet access, low computer literacy, inadequate privacy, and the need for translation. **WHO (2018):** Community norms and traditions have a powerful influence on health. (…) in relation to adolescent sexual and reproductive health, norms and traditions hinder rather than help. **Sewak (2023):** One of the main barriers young adults face in seeking sexual health is their inability to gain accurate and trustworthy sexual health information and services. This is due to restrictive policies, teachers', and parents' reluctance to openly discuss sexual health issues, parental control, limited income, and lack of confidentiality. **Chen (2023):** A few identified barriers to providing sexuality education to Chinese students include public hesitation to talk about sex, fear that CSE leads students to explore sex and, most importantly, a lack of well-trained sexuality education teachers, especially in resource-constrained areas. **Castleton (2024):** Toolkits and their applications cannot be standardized worldwide, with differences in culture, religion, gender, and resources limiting or facilitating diverse teachings of SRH.	**4.** What are the primary barriers preventing adolescent girls and young women in your region from accessing SRH information and services? *Goal:* Identify barriers such as lack of digital literacy, cultural taboos, or limited access to technology.
		Nigenda (2016): By providing information in a discreet manner, HITs have the potential to overcome cultural taboos that prevent informed discussions about SRH issues. **Hubert (2021):** Digital strategies allow adolescents to learn and to resolve doubts without the risk of being stigmatized. **Mehta (2020):** Improve accessibility and relevance of resources and interventions with technological solutions, such as peer-to-peer video conferencing, or online interventions through applications via Web or mobile technology. (…) other opportunities—such as online STI testing, online contraception ordering, and distribution of abortifacient pills—that can overcome geographic or social barriers. **Hubert (2021):** Digitally-driven educational interventions are able to reach populations in areas marked by scarce resources owing to the rapidly expanding access to mobile phones and Internet technologies, even in rural areas. **Nigenda (2016):** …barriers (…) included a lack of information and a perception of high cost of the HIT, poor access to the internet and the technology, and low prevalence of cell phones. Respondents included (as facilitators) community organizations, governmental programs, health care providers aware of the technology, and international organizations. **Luigi-Bravo (2023):** These matters need to be addressed in addition to the specific implementation requirements of digital health interventions. They range from ethical and safeguarding issues like the protection of users' data from third parties to accessibility in communities with poor internet and data or where the population has a low digital literacy.	**5.** How did the digital tool(s) you worked with help overcome these barriers to access SRH information and services? *Goal:* Understand how the digital tools specifically addressed these challenges.

Research Question	Topic	Theory/ Main Idea	Interview Question
3. How effective are existing digital health interventions in improving SRH outcomes for underserved adolescent populations?	Usability and effectiveness of digital tools	**Chandler (2020):** Higher levels of engagement with sexual and reproductive health mHealth interventions through consistent use have been associated with participants having greater overall health knowledge and improved health behaviours. Therefore, hindrances to user engagement (…) must be identified and addressed to promote the optimal use of mHealth tools. Doing so can increase knowledge levels, incite behaviour change, and reduce adverse sexual and reproductive health outcomes. **Nkabane (2024):** Adaptations of interventions using appropriate cultural cues have a higher probability of acceptability and usability. Culturally responsive interventions are effective in enhancing knowledge acquisition, attitudes, and satisfaction since they respect cultural diversity and the sociocultural factors that may affect health. **Soehnchen (2023):** Despite a potential accessibility of digital sexual health educative tools, and willingness to share and engage with sensitive information, lasting user engagement is crucial. **Nkabane (2023):** Nthabi's persona as a nurse, as well as the incorporation of storytelling as a persuasive feature to promote engagement, was a new innovation in the Nthabi adaptation. These stories of engagement appear to be important in enhancing user experience and encouraging long-term usage, as indicated by the majority of research findings. **Nkabane (2023):** The study demonstrates that involving stakeholders in the adaptation process can increase the acceptability of systems. **Flanders (2017):** Finding out whether and how online resources are relevant to the sexual health needs and experiences of young sexual minority women is integral to developing effective, useful online resources that have the potential to address the sexual health inequities. **Onukwugha (2022):** The results showed that mHealth interventions were effective and improved adolescent's uptake of SRH services across a wide range of services. **Nielsen (2020):** Mobile health (mHealth) has been shown to be effective in increasing knowledge of sexual health among youth.	**6.** How would you assess the usability of the tool among the target population, particularly adolescent girls and young women? *Goal:* Explore how user-friendly the tool is, focusing on whether it meets the needs of the population in terms of accessibility and ease of use. *Follow-up:* Was any feedback collected on usability? How was it used to improve the tool? **7.** Was the effectiveness of the tool in delivering SRH information measured in any way? If so, how? *Goal:* Determine whether effectiveness was tracked through metrics or assessments and how it was evaluated.

Research Question	Topic	Theory/ Main Idea	Interview Question
4. What lessons can be learned from the implementation of digital health tools, and how can these insights guide the future development, scaling, and replicating of SRH interventions to ensure broader and more inclusive access?	Lessons learned from implementation	**Hendl (2022):** The integration of users into app provider/developer teams could play an important role in paving the way towards creating technologies which would contest gender oppression and structural inequalities, including in the tech industry, and promote more empirically informed, collective and structural notions of user empowerment. **Soehnchen (2023):** User involvement is a prerequisite for high acceptance, sustainable development, and successful implementation. **Timilsina (2024):** Addressing barriers such as poor knowledge, limited access, and negative attitudes while leveraging facilitators such as peer support and digital tools is essential for promoting and enabling effective SRH self-care among women. **Figueroa (2023):** Local community workers can play an important role in helping women with access to and use of digital health services. However, (women's) community organizations are not often included in the DHT design, evaluation, and implementation process. **Crawford (2024):** Researchers must address gendered differences related to health, social, and economic disparities concurrently with an unwavering focus on the protection of human subjects when addressing the unique needs of underserved women while utilizing digital health methodologies. **Arbeena (2024):** Understanding women's goals and experiences with these apps, particularly in societies where menstruation is stigmatized, will aid in designing interventions and support systems to improve their menstrual health and overall well-being. **Huang (2022):** To effectively promote adolescents' SRH in LMICs, it is critical to consider a comprehensive integrated approach of service development that addresses developmental, GBV targeting IPV, and service needs that address sexual health promotion.	**8.** What lessons have emerged from the implementation of the tool? *Goal:* Focus on lessons learned from the implementation process, rather than personal lessons. *Follow-up:* How can these lessons be applied to future digital tools or SRH information projects?
		Nielsen (2020): To attract young users and have them engage with a sexual health app, it is important to involve youth in intervention development. (…) It is important to use input from youth when developing a smartphone intervention since the success of the intervention largely depends on the level of engagement and usage by youth. **Anto-Ocrah (2023):** The patient, and all parties involved in their care, must trust this "new" digitally-based model of care enough to deem it worthy of adoption. This trust-gaining experience is crucial for the (economic) sustainability of several digital interventions, and is the first step in the adoption and acculturation of the digital intervention for the individual's needs. **Soehnchen (2023):** User involvement is a prerequisite for high acceptance, sustainable development, and successful implementation. **Figueroa (2023):** To achieve a gender equitable digital health ecosystem, marginalized groups such as racial or ethnic minority women and women with low-income or education should be included as users, developers, and investors of DHTs (digital health technologies). **Timilsina (2024):** Peer support, an increasing number of service sites, and access to and use of digital (health) tools emerged as the facilitators of SRH self-care.	**9.** What factors contributed to the success (or limitations) of this project? *Goal:* Be direct in asking what made the project successful or challenging. *Follow-up:* Was it due to support, user engagement, cultural adaptation, or other factors?

Research Question	Topic	Theory/ Main Idea	Interview Question
4. What lessons can be learned from the implementation of digital health tools, and how can these insights guide the future development, scaling, and replicating of SRH interventions to ensure broader and more inclusive access?	Scalability and replicability	**Hubert (2021):** Expanding and investing in digital interventions to improve SRH is a cost-effective pursuit given that their replicability and scalability potentially broadens their capacity for attracting an increasingly large number of adolescents of different age ranges and needs. Establishing multidisciplinary and inter-institutional synergies among the health and educational sectors, among others, would maximize the benefits of SRH interventions in achieving a healthy sexuality and preventing unintended pregnancies among adolescents. **Nigenda (2016):** The expansion of these technologies around the world offers a promising picture and LAC health systems should take advantage of this opportunity to launch innovations that could help close the gap between SRH services and populations. **UNESCO (2021):** In India, responsibility for sexuality education is decentralized to state level. In the State of Jharkhand, local government commitment, as well as a strong government-NGO partnership, has been key to scaling up sexuality education. **Nkabane (2024):** These tools have tremendous potential to impact large-scale health promotion efforts as a cost-effective and scalable solution to address public health challenges, such as delivering sexual health education.	**10.** How replicable is this tool in other regions or contexts? *Goal:* Frame the question as asking for concrete factors affecting replicability. *Follow-up:* What specific adaptations would be necessary for the tool to succeed elsewhere?
		Walter (2020): Utilizing HIT as an implementation modality has the potential to increase scalability, improve fidelity of information, and reduce staff training time. **Hubert (2021):** Expanding and investing in digital interventions to improve SRH is a cost-effective pursuit given that their replicability and scalability potentially broadens their capacity for attracting an increasingly large number of adolescents of different age ranges and needs. Establishing multidisciplinary and inter-institutional synergies among the health and educational sectors, among others, would maximize the benefits of SRH interventions in achieving a healthy sexuality and preventing unintended pregnancies among adolescents. **Nkabane (2024):** These tools have tremendous potential to impact large-scale health promotion efforts as a cost-effective and scalable solution to address public health challenges, such as delivering sexual health education. **Alomair (2020):** There is an urgent need for interventions addressing modifiable barriers to SRH education and services to improve knowledge, informed choice, and access to services to facilitate better sexual and reproductive wellbeing for Muslim women.	**11.** What are the challenges or opportunities in scaling this tool within its current region or beyond? *Goal:* Focus on specific barriers to scaling, such as infrastructure or financing.

Research Question	Topic	Theory/ Main Idea	Interview Question
4. What lessons can be learned from the implementation of digital health tools, and how can these insights guide the future development, scaling, and replicating of SRH interventions to ensure broader and more inclusive access?	Sustainability and long-term perspective	**Nigenda (2016):** Most of the technologies were developed through collaborative work between government bodies, universities, and/or health care organizations. This demonstrated the relevance of the development and implementation, through a partnership approach, of electronic and mobile health in low and middle-income countries. **Figueroa (2023):** To ensure that digital health interventions are accessible, useful, and effective for women from diverse backgrounds, partnerships with multiple stakeholders in DHT design and evaluation are crucial. One approach is the quadruple helix model, in which regulatory bodies work with academics, industry, civil society, and citizens to develop digital health policies that can increase access to DHTs (e.g. providing digital devices and high-speed internet), and ensure they are safe and effective. These partnerships can also enable guidelines to evaluate the safety and quality of health apps for clinicians and citizens. **Luigi-Bravo (2023):** Partnerships with these health systems must be intentional, inclusive, and sustained to achieve synergy. Including SRH providers and organizing advocates throughout the (…) process through early engagement in feasibility and acceptability studies, co-design, and implementation can help these allies take ownership of digital health innovation to complement their work.	**12.** What kind of support did you receive during the project (e.g., government, organizational), and how did that impact the tool's success or sustainability? *Goal:* Address both financial and non-financial support, including governmental or institutional backing.
		Anto-Ocrah (2023): Plans for scale up and long-term sustainability must involve government buy-in and financial stewardship, lest these innovations, no matter how culturally appropriate they are, will die in their infancy. **Nielsen (2020):** The lack of long-term sustainability is a problem with the short-duration interventions.	**13.** What are the prospects for sustaining this tool beyond its initial implementation? *Goal:* Gauge long-term sustainability and what factors are needed for continued success.
Broader Experience Interviewee			**14.** Based on your experience in digital health, what advice would you offer to developers or organizations creating future digital tools for SRH information and services? *Goal:* Gather forward-looking advice based on their general experience in the field, not limited to one tool.
			15. Is there anything else you would like to add regarding digital tools and SRH information for adolescent girls and young women? *Goal:* Provide an open space for additional insights or thoughts.