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Assessing telehealth needs to develop a mobile telehealth application for rural communities; a case study of Ntungamo district

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Abstract

The advancement of technology has revolutionized various sectors, including healthcare, where telehealth has emerged as a significant innovation. Telehealth is the use of electronic information and telecommunication technologies providing care and services at a distance. This has shown tremendous potential in enhancing healthcare delivery. Rural communities face unique healthcare challenges, which lead to disparities in healthcare access and outcomes compared to urban populations. Telehealth offers a promising solution to bridge these gaps by providing remote consultations, continuous patient monitoring, and access to specialist services without the need for extensive travel. This study explored the development and implementation of telehealth services in Ntungamo District, focusing on enhancing community knowledge, identifying suitable access approaches, assessing the adoption of telehealth, and integrating these services into the local healthcare system. Using the qualitative approach, respondents were purposively identified and data collected through interviews and focus group discussions as well as analyzed using thematic exploration. The findings show respondent's willingness to use telehealth services but hindered by poor network coverage, concerns of keeping personal information private and the lack of features permitting user to access services off line. It was recommended the need for strong government policies that permit integration of complementary health services.

Key words: *Telehealth, mobile health services, health care in rural communities*

Introduction

Access to healthcare services is a fundamental right and a key determinant of overall well-being (Tzenios, 2019). Telemedicine in Uganda has seen growth, with key providers such as Rocket Health, Rocket Health, The Medical Concierge Group (TMCG), and the Uganda Telemedicine Association playing a significant role. These services have demonstrated the potential to improve access to healthcare, particularly in urban areas. However, in many rural areas, limited access to healthcare facilities and healthcare professionals remains a significant challenge (Hoffman, 2020). Ntungamo District, situated in southwestern Uganda, epitomizes these challenges due to its vast rural landscape and inadequate healthcare infrastructure (Weinhold & Gurtner, 2014). Residents often experience delayed care and poor health outcomes as a result. Telehealth services, leveraging technology to provide remote medical consultations and healthcare education, have emerged as a potential solution to address these healthcare disparities (Haimi, 2023).

The adoption of telehealth has been in existence for years; however, its rapid expansion was noted during the COVID-19 pandemic in countries worldwide. Its main aim was to revolutionize health care delivery to all. For this to happen, countries like China, United States of America and many developing countries invested in establishing infrastructure and resources. They worked on sharing sustainable strategies for implementing and adopting telehealth services of which digital literacy was a core. Investing in health care became quite cumbersome for many developing countries especially among the rural communities. Resource distribution was not easy the countries did not have high income had problems that ranged from poor established infrastructure, lack of enough financial, technological, financial and human resources. This thus threatened the access of health services (Weinhold and Gurtner, 2014).

Uganda's digital health service provision has mainly been donor reliant in the private sector. Digital health service providers such as Rocket health and The Medical Concierge Group provide these services mainly electronically. Each patient's health records are kept online and this has been able to help in reducing the need for physical storage facilities and equipment, promote easy information access and retrieval, reduce waiting times, aid decision-making, and enhance records security, thus improving health care service delivery. However, despite the above benefits, the implementation of EHRs in most low-income countries has been a challenge due to poor infrastructure characterized by electrical power interruptions, digital divide, high internet costs, and resistance to technology.

Ntungamo District in western Uganda was among those areas that grappled with limited healthcare infrastructure and workforce shortages. Intimidating barriers to timely and adequate healthcare, resulting in delayed treatment, worsened health conditions and increased healthcare expenditures as well as death were some of the limitations faced by the community members of Ntungamo district, (Ezzat, 2023). These short comings and more have derailed the provision and access of telehealth services and that is why this study aims at exploring the adoption and implementation of telehealth services to address these pressing healthcare challenges. It is assumed that adopting telehealth services will help reduce the time, financial obligations, and geographic hindrances that residents encounter by providing quick and improved-quality health care. The study is also assumed to address medical resource misdistribution, offer a potential solution to enhance healthcare access, and quality in rural Ntungamo District.

Objectives of the Study

1. To find out the knowledge levels of telehealth services in rural communities of Ntungamo District.
2. To identify a suitable approach to access telehealth services in rural communities of Ntungamo District.
3. To assess the adoption of telehealth services in rural communities of Ntungamo District.

Literature review

Telehealth System for Quick Response in Solving Health-Related Issues in Rural Communities

Telehealth has seen a remarkable evolution over the past few decades, fundamentally transforming the delivery of healthcare services (Sharma et al., 2022). Initially, telehealth was primarily used for basic consultations via telephone, which allowed healthcare providers to offer advice and preliminary diagnoses without the need for face-to-face interactions (Imlach et al., 2020). These early forms of telehealth have paved the way for more advanced systems as technology progressed. The advent of the internet and subsequent advancements in digital communication technologies has led to the development of more sophisticated telehealth systems, including video conferencing and mobile health applications (Alenoghena et al., 2023). This progression has enabled real-time visual and auditory communication between patients and healthcare providers, significantly improving the quality and efficiency of remote consultations (Senbekov et al., 2020).

As telehealth technology continues to advance, its scope has been expanded to include electronic health records (EHRs), which allow for seamless sharing and updating of patient information across different healthcare providers (Sharma et al., 2022). This integration has been crucial in ensuring continuity of care, particularly for patients with chronic conditions who require ongoing monitoring and management. The rise of mobile health (mHealth) applications has revolutionized telehealth by making it accessible via smartphones and tablets, thus increasing its reach and convenience (Taha et al., 2022). These applications enable patients to track their health metrics, schedule appointments, and communicate with healthcare providers from the comfort of their homes (Silfee et al., 2021).

According to Alenoghena et al., (2023), Technological innovation has been a driving force behind the development and enhancement of telehealth systems. High-speed internet connectivity has been fundamental, enabling the transmission of high-quality video and audio data required for effective telehealth consultations. The development of secure video conferencing platforms has allowed healthcare providers to conduct virtual visits that closely mimic in-person consultations, fostering patient trust and engagement (Breton et al., 2021). These platforms often include features such as screen sharing, which can be used to review medical records and imaging results during the consultation, enhancing the diagnostic process (Quinn et al., 2019).

In addition to video conferencing, telehealth systems have increasingly incorporated artificial intelligence (AI) and big data analytics. AI algorithms can assist in diagnosing conditions by analyzing patient data and identifying patterns that may not be immediately apparent to human clinicians (Maleki Varnosfaderani & Forouzanfar, 2024). This can be particularly useful in rural areas where specialist care is not readily available. Big data analytics, on the other hand, enables healthcare providers to analyze large datasets to identify trends and make informed decisions about population health management (Arowoogun et al., 2024). For instance, data collected from telehealth consultations can be used to track the spread of infectious diseases in rural communities and develop targeted interventions (Sandreva et al., 2024). Furthermore, the Internet of Medical Things (IoMT) has emerged as a critical component of telehealth, involving the use of connected devices that monitor patients' health metrics in real-time. These devices can send alerts to healthcare providers if any concerning changes are detected, allowing for timely interventions and potentially preventing complications (Claggett et al., 2024).

A crucial aspect of effective telehealth systems is the ability to facilitate real-time communication between patients and healthcare providers (Chauhan et al., 2024). This capability is essential for delivering timely medical advice and interventions, which can be lifesaving in emergency situations. Real-time communication tools include video consultations, instant messaging, and live chat features that enable immediate interaction (Karis et al., 2016). Video consultations, in particular, allow healthcare providers to visually assess patients, which can be critical for diagnosing conditions that require visual examination, such as skin infections or injuries (Jayadev et al., 2020).

Moreover, real-time communication enhances the quality of the patient-provider relationship (Jiang, 2019). Patients can ask questions and receive immediate feedback, which helps to alleviate anxiety and improve their understanding of their health conditions (Delgadillo et al., 2018). This interaction fosters a sense of trust and rapport between patients and healthcare providers, which is essential for effective care management (Fleig-Palmer et al., 2018). Additionally, real-time communication tools can be integrated with other telehealth features, such as electronic health records (EHRs), allowing providers to access and update patient information during consultations (Smith et al., 2020). This integration ensures that all relevant medical data is considered when making clinical decisions, leading to more accurate diagnoses and personalized treatment plans (Ahmed et al., 2020).

Remote patient monitoring (RPM) is a pivotal feature of telehealth systems, enabling continuous health data collection and analysis outside traditional healthcare settings (Muller et al., 2022). RPM systems typically include wearable devices and sensors that track various health metrics, such as heart rate, blood pressure, glucose levels, and oxygen saturation (Anand et al., 2024; Srivastava et al., 2018). These devices transmit data to healthcare providers in real-

time, allowing for continuous monitoring of patients' health status. This capability is particularly beneficial for managing chronic conditions, such as diabetes, hypertension, and heart disease, which require regular monitoring to prevent complications (Anand et al., 2024).
The data collected through RPM can be analyzed using advanced algorithms to detect early signs of deterioration, prompting timely medical interventions (Itelman et al., 2022). RPM system can alert healthcare providers if a patient with heart disease experiences an abnormal increase in heart rate, enabling them to take immediate action to prevent a potential cardiac event. This proactive approach to healthcare management not only improves patient outcomes but also reduces the burden on healthcare facilities by minimizing the need for emergency visits and hospitalizations (Hewner et al., 2018). Furthermore, RPM empowers patients to take an active role in managing their health by providing them with real-time feedback and insights into their condition (Lima et al., 2024). This engagement can lead to better adherence to treatment plans and lifestyle modifications, ultimately improving overall health and well-being.

The integration of telehealth systems with electronic health records (EHRs) is essential for ensuring that patient data is easily accessible and up-to-date (Arowoogun et al., 2024). This integration allows healthcare providers to have a comprehensive view of a patient's medical history, current treatments, and ongoing health concerns during telehealth consultations. Access to complete and accurate patient information enables providers to make informed clinical decisions, reducing the risk of medical errors and enhancing the quality of care (Sittig et al., 2020). For example, having access to a patient's EHR can help providers identify potential drug interactions when prescribing new medications, ensuring safer and more effective treatment (Wright et al., 2019).

Integrated EHRs also facilitate better coordination of care among different healthcare providers (Krousel-Wood et al., 2018). In rural areas, patients may need to see multiple specialists, each with their own set of medical records. An integrated telehealth system ensures that all relevant information is shared seamlessly among providers, preventing duplication of tests and procedures and ensuring that all aspects of a patient's care are aligned (Badowski et al., 2018). This coordination is particularly important for managing complex conditions that require input from various specialists. Additionally, integrated EHRs can support population health management by enabling healthcare providers to analyze data from multiple patients to identify trends, track health outcomes, and develop targeted interventions to address specific health challenges within the community (Brown et al., 2019
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The primary challenges in developing telehealth systems for rural areas is the lack of robust infrastructure (Bali, 2018). Limited internet connectivity is a significant barrier, as many rural communities do not have access to high-speed broadband, which is essential for conducting video consultations and transmitting large amounts of health data (Hambly & Rajabiun, 2021). The digital divide between urban and rural areas means that telehealth services may not be accessible to those who need them most (Cortelyou-Ward et al., 2020). To address this challenge, innovative solutions such as low-bandwidth telehealth applications that require minimal internet connectivity can be developed (Alenoghena et al., 2023). Partnerships with telecommunications companies to expand broadband infrastructure in rural areas can help bridge the connectivity gap (Hambly & Rajabiun, 2021).

Inadequate power supply is another critical issue in rural communities, where frequent power outages can disrupt telehealth services (Nabukenya et al., 2023). Ensuring reliable access to electricity is essential for the continuous operation of telehealth systems. Implementing solar-powered devices and backup power solutions can mitigate this challenge, providing a reliable power source for telehealth equipment. Furthermore, the lack of necessary hardware, such as computers, tablets, and smartphones, can limit the use of telehealth services. Community programs that provide affordable or subsidized devices to rural residents can enhance access to telehealth, ensuring that patients have the necessary tools to participate in virtual consultations and remote monitoring (Cook & Elliott, 2022).

Rasekaba et al., (2022) emphasizes Digital literacy is another significant barrier to the adoption and effective use of telehealth technologies in rural areas. Patients and healthcare providers may lack the necessary skills to navigate telehealth platforms, use mobile health applications, or operate remote monitoring devices. This lack of familiarity with digital tools can lead to frustration and decreased utilization of telehealth services (Tully et al., 2021). To address this issue, comprehensive training programs tailored to the needs of rural populations are essential. These programs should cover basic digital skills, as well as specific instructions on using telehealth technologies (Le et al., 2023). Hands-on workshops, video tutorials, and one-on-one support can help build confidence and competence among users (Gopal et al., 2021).

Moreover, telehealth systems should be designed with user-friendly interfaces that are intuitive and easy to navigate, even for individuals with limited digital literacy. Simplifying the user experience can reduce the learning curve and encourage more widespread adoption of telehealth services (Tully et al., 2021). Additionally, involving community health workers and local leaders in the promotion and training of telehealth can enhance acceptance and trust within the community (Bagchi, 2019). These individuals can serve as intermediaries, helping to bridge the gap between healthcare providers and patients, and providing ongoing support to ensure successful use of telehealth technologies (Cook & Elliott, 2022).

A notable example of successful telehealth implementation is the Rural Telehealth Initiative in Rwanda (Babili et al., 2023). This initiative aimed to address the healthcare needs of remote communities by leveraging telehealth technologies to provide accessible and timely medical services. The initiative involved building local capacity by training healthcare providers in the use of telehealth platforms and remote monitoring devices (Babili et al., 2023). Continuous training and robust technical support were key components of the program, ensuring that providers were confident and proficient in delivering telehealth services (Dodoo et al., 2022). As a result, the initiative achieved a significant reduction in emergency response times and improved health outcomes for patients with chronic conditions and acute health issues (Cuadros et al., 2024).

The success of the Rural Telehealth Initiative was also attributed to its strong community engagement and collaboration with local stakeholders (Babili et al., 2023). By involving community leaders, patients, and healthcare providers in the planning and implementation process, the initiative fostered a sense of ownership and trust (Muhayimana & Kearns, 2024) . Regular feedback from users was collected and used to refine and improve the telehealth services, ensuring that they met the specific needs and preferences of the community. This participatory approach not only enhanced the effectiveness of the telehealth services but also increased their acceptance and utilization among rural residents (Kananura et al., 2024)

Another success story is the Telehealth Revolutionary Platform in Nigeria, which focused on integrating mobile health (mHealth) applications with community health worker programs (Okolo et al., 2024). This innovative approach extended the reach of telehealth services to remote and underserved populations by utilizing mobile technology and leveraging the existing network of community health workers. The mHealth applications enabled community health workers to conduct virtual consultations, monitor patients' health metrics, and provide real-time health education and support. This integration significantly improved the accessibility and effectiveness of telehealth services, particularly for patients with limited mobility or transportation options (Qoseem et al., 2024).

Knowledge of telehealth services in rural communities

The existing level of healthcare knowledge in Ntungamo District's rural communities forms the baseline for telehealth education initiatives. Many residents have limited understanding of telehealth due to traditional reliance on face-to-face consultations and limited exposure to technology (Ngabirano & Igwe, 2024). Studies like those conducted by van Houwelingen et al., 2021 highlight the prevalent health knowledge gaps and the need for targeted educational interventions to introduce and explain telehealth concepts effectively.
Understanding local health literacy levels is crucial. In rural Ntungamo, literacy rates and educational attainment can vary significantly, impacting the effectiveness of traditional educational materials (Musinguzi, 2020). Tailoring educational content to meet the needs of different demographic groups, including women, elders, and youth, is essential for widespread telehealth knowledge enhancement.

Education and training programs are fundamental in enhancing knowledge about telehealth . These programs can range from formal training sessions for healthcare providers to community-based workshops for residents. For healthcare providers, training programs need to focus on the technical aspects of telehealth, including the use of telemedicine platforms, remote monitoring tools, and effective patient communication techniques via telehealth (Sharma et al., 2024).Community health workers play a pivotal role in educating the broader community. Programs aimed at training these workers should include comprehensive modules on telehealth benefits, usage, and troubleshooting. For example, the CHW program in Malawi demonstrated success in training community health workers, leading to increased telehealth adoption and improved health outcomes (Wahl et al., 2020).

Cultural beliefs and social norms can significantly impact the acceptance and understanding of telehealth. In many rural Ugandan communities, traditional medicine and healers play a central role in healthcare. Integrating telehealth education with respect for these traditional practices can facilitate acceptance. For instance, involving traditional healers in telehealth education efforts can bridge the gap between conventional and modern healthcare practices. Social norms, such as gender roles and community hierarchy, also influence telehealth knowledge dissemination. Engaging respected community leaders and influencers in educational campaigns can enhance credibility and acceptance. Understanding and addressing these cultural dynamics is crucial for the successful introduction of telehealth services (Bensley & Brookins-Fisher, 2023).

Community engagement is vital for effective telehealth education. Involving community leaders, local influencers, and grassroots organizations ensures that telehealth messages resonate with the community. Participatory approaches, such as community meetings and focus group discussions, allow for direct interaction with residents, providing opportunities to address concerns and clarify misconceptions. Programs like the Community Health Workers have shown that when community members are actively involved in the planning and implementation of telehealth education initiatives, the outcomes are more favorable (Wahl et al., 2020).

Leveraging technology and media is a powerful strategy to enhance telehealth knowledge. Radio programs, a staple in many rural communities, can be used to broadcast information about telehealth services. These programs can include interviews with healthcare providers, patient testimonials, and interactive Q&A sessions to engage listeners. Mobile phones, widely used even in remote areas, offer another avenue for telehealth education. SMS campaigns, mobile health apps, and social media platforms can disseminate information quickly and efficiently. Mobile Health Initiatives have demonstrated the effectiveness of SMS-based health education in increasing awareness and usage of telehealth services in rural areas (Pienaar et al., 2023).

Ntungamo District or similar regions provides valuable insights into effective telehealth education strategies. The cardiac telehealth program to support cardiovascular diagnosis and care in Northern Uganda successfully enhanced telehealth knowledge through a combination of community engagement, media campaigns, and training programs. Key takeaways from such case studies include the importance of tailored educational content, continuous community involvement, and leveraging multiple communication channels. Best practices from these case studies can inform future initiatives. These may include developing culturally appropriate educational materials, establishing partnerships with local organizations, and using technology to reach a wider audience (Bensley & Brookins-Fisher, 2023).

Several challenges can hinder the enhancement of telehealth knowledge in rural communities. Literacy levels and language barriers are significant obstacles. Educational materials must be accessible to individuals with varying literacy levels and should be available in local languages to ensure comprehension. Access to technology is another challenge. While mobile phone penetration is high, not all residents may have smartphones or internet access. Educational initiatives must consider these limitations and explore alternative methods, such as community-based telehealth hubs equipped with the necessary technology. Overcoming scepticism and building trust in telehealth services requires sustained effort and culturally sensitive approaches (Brady et al., 2023).

Enhanced knowledge of telehealth services can lead to improved health outcomes in rural communities(Wahl et al., 2020). When residents understand how to access and use telehealth services, they are more likely to seek timely medical advice and adhere to treatment. Studies show that increased telehealth awareness correlates with higher utilization rates and better management of chronic conditions. Telehealth education programs in Colombia resulted in significant improvements in maternal and child health indicators. Reducing barriers to healthcare access and empowering residents with knowledge, telehealth education can lead to a healthier and more informed community (Wahl et al., 2020). Government policies and initiatives play a crucial role in promoting telehealth education (Fox et al., 2022). The Ministry of Health has developed strategies to integrate telehealth into the national healthcare system, emphasizing the need for public awareness campaigns and training programs (Ndejjo et al., 2023). These initiatives create an enabling environment for telehealth adoption and ensure that rural populations benefit from technological advancements in healthcare. Government support for telehealth education can include funding for community outreach programs, development of educational materials, and training for healthcare providers. Collaborative efforts between government agencies, healthcare providers, and NGOs are essential for the successful implementation of telehealth initiatives (Ndejjo et al., 2023)

Future research should focus on identifying effective strategies for telehealth education in rural settings. This includes exploring innovative approaches to overcome barriers such as literacy levels and technology access (Barreiro et al., 2020). Longitudinal studies are needed to assess the long-term impact of telehealth education on health outcomes and healthcare utilization (Lewinski et al., 2022). Research should investigate the role of different stakeholders, including community leaders, healthcare providers, and policymakers, in enhancing telehealth knowledge.

Approaches to Access Telehealth Services in Rural Communities

Accessing telehealth services in rural communities like Ntungamo District involves addressing various logistical, technological, and socio-economic challenges (Akiteng et al., 2018). Rural areas often lack the necessary infrastructure and resources that are more readily available in urban centers, making it essential to develop tailored approaches that consider these unique constraints. One of the primary barriers to telehealth access in rural areas is the lack of reliable telecommunications infrastructure. Developing robust internet and mobile network coverage is critical. Studies have shown that investing in infrastructure improvements, such as expanding broadband access and enhancing mobile network coverage, can significantly increase telehealth utilization. Tipre et al., (2024) found that rural regions with better internet connectivity experienced higher rates of telehealth adoption and usage. Leveraging low-cost, scalable technological solutions can bridge the gap in telehealth access. Mobile health (mHealth) applications, for instance, can be used to deliver healthcare services through smartphones, which are increasingly common even in remote areas. Solutions such as SMS-based health information dissemination and mobile app-based consultations have shown promise in enhancing access to healthcare services. The mHealth Initiative in Bimaru states of India successfully utilized these technologies to provide maternal and child health services, demonstrating their potential for broader application in rural healthcare (Saleh et al., 2024)

According to Maphosa et al., (2024), The hub-and-spoke model, where a central hub (typically a well-equipped healthcare facility) provides telehealth services to multiple satellite locations (spokes) in rural areas, has proven effective in Malawi. This model allows for the efficient allocation of resources and expertise, ensuring that even remote communities have access to specialized care (Saleh et al., 2024). For instance, the Telehealth Hub Model implemented in Region connected rural clinics to a central hospital, improving access to specialist consultations and reducing patient travel time and costs (Maphosa et al., 2024).

Training and utilizing Community Health Workers (CHWs) to facilitate telehealth services can be an effective approach. CHWs can act as intermediaries, helping patients navigate telehealth platforms, ensuring adherence to treatment plans, and providing basic healthcare services (Wu et al., 2024). This has demonstrated how empowering local health workers with telehealth training can enhance healthcare delivery in underserved areas, leading to improved health outcomes and increased telehealth utilization (Vu et al., 2024).

Government policies play a crucial role in enabling telehealth access. Policies that support infrastructure development, provide funding for telehealth initiatives, and create incentives for healthcare providers to adopt telehealth can significantly enhance access (Naik & Sarkar, n.d.). Ensuring that telehealth services comply with regulatory standards is essential for their sustainability. Policies that address issues such as data privacy, patient consent, and licensure for telehealth providers are critical. Clear regulatory frameworks can encourage more providers to offer telehealth services, knowing that they are operating within legal and ethical boundaries (Vu et al., 2024).

Identifying and implementing cost-effective telehealth solutions is vital for sustainability. Telehealth models that minimize costs for both providers and patients, such as shared telehealth platforms or public-private partnerships, can ensure long-term viability.Cost-Sharing Model allows multiple healthcare providers to share the costs of telehealth infrastructure, making it affordable for smaller clinics to participate. Securing funding and grants from government bodies, NGOs, and international organizations can support the initial setup and ongoing operation of telehealth services. The Funding Initiative in Limpopo, Malawi provided grants to rural health clinics for telehealth equipment and training, significantly enhancing their capacity to deliver remote healthcare services (Vu et al., 2024).

The telehealth adoption in Rwanda has demonstrated how a combination of infrastructure development, community engagement, and supportive policies led to a significant increase in telehealth access and utilization. Key factors included community involvement, targeted training programs, and ongoing support from local and national government. Implementing these best practices in Ntungamo District can help ensure the successful rollout and sustained use of telehealth services. Ensuring that telehealth services are affordable and accessible to all community members is crucia. This can involve subsidizing telehealth costs for low-income families, providing free or low-cost telehealth access points in community centers, and offering flexible payment options. Also, conducting educational campaigns to raise awareness about telehealth services and how to access them is essential. These campaigns should be culturally sensitive and delivered in local languages to ensure broad reach and understanding. The Telehealth Awareness Campaign in Rwanda has successfully used radio broadcasts, community meetings, and printed materials to educate rural populations about telehealth, resulting in increased utilization and patient satisfaction (Saleh et al., 2024).

The adoption of telehealth services in rural communities

Adoption of any service would be measured by the level of transfer of knowledge among users. This has been noticed among the rigor trainers of trainers use to share knowledge about a service in an area especially among those who have just moved to the area where it is used. The number of new activations and time spent using the services as well the frequency of use are some of the indicators that show that a service is being adopted. For a service to be adopted well and embraced to ensure its sustainability, the average duration spent on it is also put into consideration. The availability and quality of technology infrastructure are critical for telehealth adoption. This includes reliable internet connectivity, access to telehealth-compatible devices, and user-friendly telehealth platforms. Studies have shown that regions with better technological infrastructure tend to have higher telehealth adoption rates. In rural areas with robust internet access, there was a significant increase in telehealth usage compared to areas with poor connectivity. Digital literacy among both healthcare providers and patients determines the telehealth adoption (Singh & Walters, 2024). Training programs that enhance digital skills can significantly impact the willingness and ability of rural populations to use telehealth services (Le et al., 2023).

Cultural beliefs and attitudes towards telehealth can influence its adoption. In some rural communities, there may be skepticism or resistance to using technology for healthcare, preferring traditional face-to-face consultations instead. Engaging community leaders and conducting culturally sensitive awareness campaigns can help mitigate these barriers. The Cultural Engagement effectively increases telehealth acceptance by involving local leaders in promoting the benefits of telehealth. Telehealth systems should be interoperable with existing healthcare systems for seamless adoption. This involves integrating telehealth platforms with electronic health records (EHRs) and other healthcare management systems. Successful integration can streamline workflows and improve the overall efficiency of healthcare delivery (Ogunsakin & Anywansedo, 2024).

The cost of telehealth services and the economic status of the population are significant factors. In many rural areas, the affordability of telehealth services can be a barrier to adoption. Subsidizing telehealth costs or implementing low-cost telehealth solutions can enhance accessibility. The engagement and readiness of healthcare providers to offer

telehealth services are crucial for adoption. Providers need adequate training, resources, and support to integrate telehealth into their practice effectively It was highlighted that the importance of provider attitudes towards telehealth, with positive perceptions linked to higher adoption rates (Le et al., 2023).

Government policies and regulations that address licensing, reimbursement, and data privacy can create a conducive environment for telehealth. For example, the Telehealth Policy Framework in India provided guidelines and incentives for telehealth adoption, leading to widespread uptake in rural areas. Reimbursement for telehealth services is a critical factor influencing adoption by healthcare providers. Policies that ensure telehealth services are reimbursed at par with in-person visits can encourage providers to offer telehealth options (Le et al., 2023).

Methodology

The study adopted the experimental design, which included the use of randomized methods. The unit of randomization involved using either the intervention group that used telehealth services consistently or the control group that had not used the services. The progress of each group was then be compared. The cross-sectional research design was used to gather data from a sample of the population at a specific point in time, allowing for a comprehensive snapshot of respondents' perspectives. Through the adoption of the qualitative research approach, respondents were purposively chosen and data collected through the key informant interviews and focus group discussion methods.

Based on the target population of 150 respondents, data was collected from a total of 132 respondents as shown in the table below.

Table 1: Category of respondents who took part in the study

	POPULATION (N)	SAMPLE (n)	SAMPLING TECHNIQUE
Healthcare providers	20	19	Purposive sampling
Patient	50	44	Purposive sampling
Community leaders	10	10	Purposive sampling
Policy makers and health administrators	70	59	Purposive sampling
TOTAL	**150**	**132**	

Krejicie and Morgans table 1970 sample size determination

The data was entered and analyzed using SPSS version 25 and exported for presentation in tables and charts. The dataset is available in Excel and SPSS-compatible CSV format to support transparency and reproducibility of results.

Findings

To bridge the research and development sections, it is important to note that the identified needs and challenges (such as poor network, travel costs, and demand for chronic care support) directly informed the design of system features such as offline functionality, low-bandwidth optimization, and multilingual communication tools.

Research Findings

Socio-Demographic Characteristics of Participants

A total of 132 respondents participated in the study out of a target number of 150. This gave a response rate of 88%. This implies that the results are a good representation of the respondents in the study area. The socio-demographic analysis provided a contextual understanding of the population likely to adopt telehealth. Data were analyzed in SPSS to generate descriptive statistics (frequencies and percentages). Table 2 below shows the demographic characteristics of the respondents that took part in the study. It highlights the gender, age, education level and occupation of respondents. The reason why the demographics were requested for was to ensure the right respondents are taking part in the study.

Table 2.Demographic Characteristics of Participants

Characteristic	Category	Frequency	Percentage
Gender	Male	65	49.2%
	Female	67	50.8%
Age Group	18–25 years	20	15.2%
	26–35 years	27	20.5%
	36–45 years	33	25.0%
	46+ years	52	39.3%
Education	No formal	7	5.3%
	Primary	40	30.3%
	Secondary	52	39.4%
	Tertiary	33	25.0%
Occupation	Farmer	59	44.7%
	Trader	26	19.7%
	Student	13	9.8%
	Health Worker	20	15.2%
	Other	14	10.6%

Primary data 2025

Adults over the age of 40 form the largest group (39.3%), consistent with the higher healthcare demand in this age bracket. Farmers and secondary school graduates represent the largest categories, emphasizing the need for a user-friendly interface and health education. Previous studies (e.g., WHO, 2021) have similarly shown that rural communities above 40 years of age often experience chronic conditions and therefore benefit most from digital health services. This implies that the respondents identified to take part in the study are those that are able to provide information in respect to the study objectives.

Qualitative Findings on Telehealth Needs and Challenges

Out a total of 12 key informant interviews and 3 Focus Group Discussions (FGDs), each consisting of 6–8 participants. The responses from the interviews and Focus Group Discussions were transcribed and coded thematically using NVivo 12. The following dominant themes emerged:

Theme 1: Knowledge and Perceptions of Telehealth

Respondents were asked if they were aware of telehealth and what they thought of it. Most reported limited prior knowledge. One respondent remarked: *"We did not know doctors could treat us through the phone, but this would reduce the long trips to the hospital."* Another added: *"I thought treatment always requires physical contact, but if this works, it will help many people."* This reflects findings by Adepoju et al. (2020), who observed that awareness is often low in underserved regions.

From the FGDs, participants similarly expressed minimal awareness but showed readiness to learn. A participant in FGD 1 noted: *"At first, I thought telehealth was only for educated people, but even us in the village can use it if it is explained well."* This implies that awareness campaigns and community education will be essential to support adoption.

Theme 2: Barriers to Healthcare Access

Respondents were asked if they faced any form of barriers while accessing health care services and a number of responses were highlighted but not limited to long travel distances, transport costs, and delays were recurrent issues. One patient in an interview shared: *"I travel two hours to see a doctor; sometimes I return without being treated due to long queues."*

Another respondent emphasized: *"Transport is expensive; sometimes I have to choose between going to the hospital and buying food."*

From the FGDs, participants agreed that poor network coverage and high mobile data costs were also critical barriers to telehealth. These findings align with literature highlighting transportation, costs, and connectivity as major bottlenecks to rural healthcare.

Theme 3: Desired Features and Functionalities

Respondents suggested features such as multilingual chat, affordable consultations, offline use, and nearby doctor availability. One participant remarked: *"If the app is in our local language, many people will use it."* Another respondent stated: *"It should allow us to consult even when the internet is off, because our network is not reliable."*

From the FGDs, participants also emphasized the importance of data security and trust in doctors. This demonstrates the need for contextualized, user-driven design.

Quantitative Findings on Telehealth Adoption

Using the survey method of data collection, the respondents were given a questionnaire each to fill out. The survey data were analyzed in SPSS to assess access to devices, internet use, willingness to adopt telehealth, and perceived benefits and barriers. Findings showed that **59.8% (n=79)** of respondents accessed telehealth services through smartphones, while **40.2% (n=53)** reported not owning a smartphone. In terms of internet use, **44.7% (n=59)** reported using the internet daily, **25% (n=33)** weekly, **20.5% (n=27)** rarely, and **9.8% (n=13)** never. Very few respondents mentioned using other devices such as basic feature phones or shared computers at community centers.

Table 3. Access and Willingness to Use Telehealth

Variable	Category	Frequency	Percentage
Smartphone Access	Yes	79	59.8%
	No	53	40.2%
Internet Use	Daily	59	44.7%
	Weekly	33	25.0%
	Rarely	27	20.5%
	Never	13	9.8%
Willingness	Yes	99	75.0%
	No	33	25.0%

Primary data 2025

Table 4. Perceived Benefits and Barriers to Telehealth

Perceived Benefits (n=132)	%	Frequency
Saves time	35	46
Reduces travel costs	30	40
Faster access to doctors	20	26
Better record management	15	20
Perceived Barriers (n=132)	**%**	**Frequency**
Poor network coverage	35	46
High data costs	25	33
Low awareness of telehealth	25	33
Trust concerns	15	20

Primary data 2025

Table 4 presents the perceived benefits and barriers to telehealth. The most frequently mentioned benefit was saving time (35%), followed by reducing travel costs (30%). This shows that respondents value telehealth mainly for its ability to ease access and cut down on delays and expenses. Faster access to doctors (20%) and better record management (15%) were also highlighted, demonstrating expectations for efficiency and improved continuity of care.

On the barriers side, poor network coverage (35%) and high data costs (25%) emerged as the most significant challenges, consistent with infrastructure constraints in rural settings. Low awareness (25%) and trust concerns (15%) further highlight the need for sensitization and community engagement.

SPSS Cross-Tabulation Analysis

To further explore patterns in telehealth adoption, a series of cross-tabulations were conducted using SPSS. These were intended to assess whether socio-demographic characteristics (such as age and education) and access factors (such as smartphone ownership) influenced willingness to use telehealth. The results provide insights into whether particular sub-groups are more or less likely to adopt the system, thereby informing targeted interventions. The rationale for conducting these cross-tabulations was to determine whether background characteristics (age, education level) and technology access (smartphone ownership) significantly shaped respondents' willingness to adopt telehealth. Identifying such associations helps in tailoring awareness campaigns and system features to the needs of different groups.

Age Group × Smartphone Ownership

Smartphone ownership was fairly consistent across age groups. χ^2 (3, N=132) = 2.84, p = 0.42. No significant relationship was found. This suggests that access to smartphones is not restricted to a specific age bracket, implying broad potential for telehealth uptake if infrastructure issues are addressed. It was found that smartphone ownership was relatively evenly distributed across age groups. This indicates that no particular age group is excluded from potential telehealth adoption, provided connectivity challenges are addressed. Among those who owned smartphones, most respondents indicated they mainly used them for communication (voice calls, SMS, and WhatsApp) and information access (social media, browsing, and health information). This suggests that introducing telehealth through smartphones would align with existing usage patterns and could be easily adopted.

Smartphone Access × Willingness to Use Telehealth

Willingness was high among both phone owners and non-owners, but slightly higher for those with phones. χ^2 (1, N=132) = 2.67, p = 0.10. This result approached significance, suggesting phone ownership may influence willingness. Practically, this indicates that improving smartphone penetration could further enhance adoption.

The willingness to use telehealth was high in both groups, though

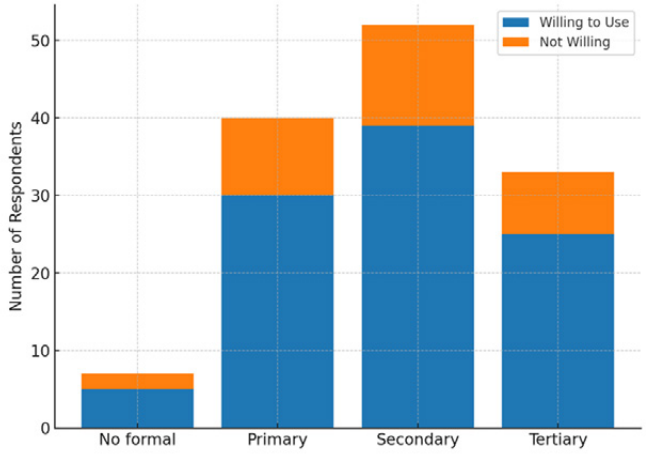
slightly higher among smartphone owners. Those willing to adopt cited convenience, reduced travel, and faster access to doctors as their main reasons. On the other hand, respondents who were unwilling raised concerns about poor network coverage, data costs, and trust in remote consultations. This implies that increasing smartphone penetration and improving infrastructure could further raise willingness levels.

Education Level × Willingness to Use Telehealth

Willingness was similarly distributed across education levels. χ^2 (3, N=132) = 0.07, p = 0.99, indicating no significant relationship. This shows that telehealth appeal cuts across education levels, highlighting inclusivity potential.

Figure 1 illustrates the distribution of willingness to use telehealth across different education levels. The analysis found no significant relationship between a person's education level and their willingness to adopt the app (p=0.99). This implies that the app's appeal extends to people with various educational backgrounds, highlighting its potential for inclusivity.

Figure 1: Cross-tabulation of Education Level and Willingness



Source: Primary data 2025

The Telehealth Application Development

System Requirements

The respondents were asked about the features they would require in a telehealth system. From the interviews, about 70% highlighted the need for low data consumption and offline functionality. Approximately 60% emphasized the importance of multilingual support, while 55% mentioned trust and data security.

From FGD 2, participants specifically agreed on the need for:

- Affordable consultation fees
- Integration with nearby health facilities
- Ability to keep patient records for follow-up
- Option to contact a doctor in emergencies

These requirements informed the system design and were categorized into functional and non-functional requirements.

Functional Requirements:

- o User login & registration (Firebase Authentication)
- o Appointment booking & scheduling
- o Secure chat and video consultations (WebRTC)
- o Electronic medical record management
- o Location-based doctor requests (Google Maps API)

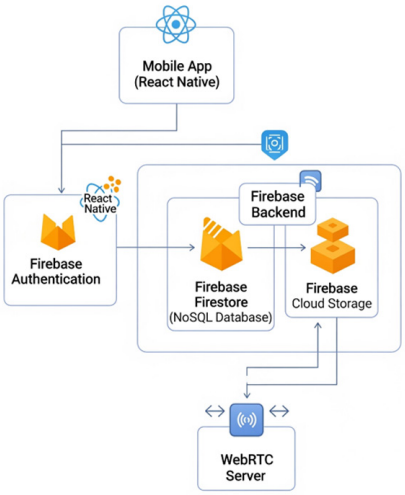
Non-Functional Requirements:

- o Simple interface for low-literacy users
- o Optimized for low bandwidth environments
- o Secure, encrypted communication
- o Scalability for larger populations

System Architecture and Implementation

The app was designed in React Native (JavaScript, VS Code) for cross-platform compatibility. Firebase (Firestore & Authentication) was used as the backend, with WebRTC enabling real-time consultations. Google Maps API powers geolocation features as shown in Figure 2 below.

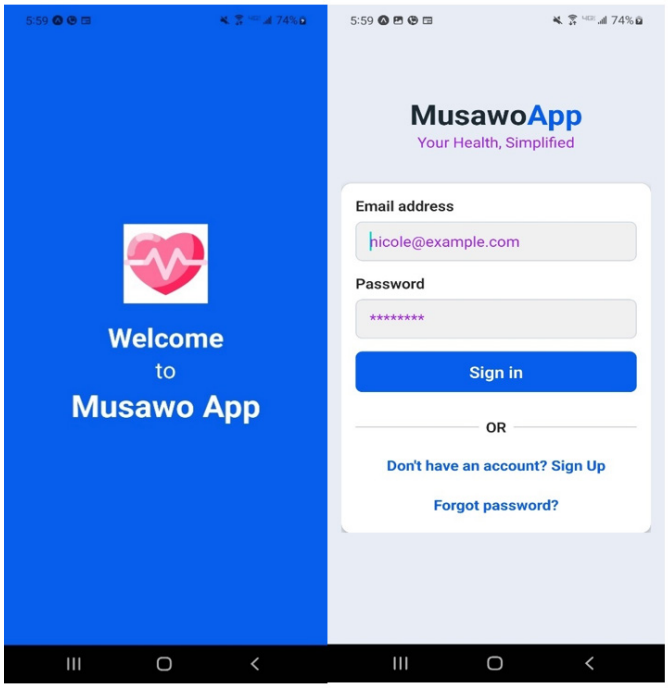
Figure 2: System Architecture Diagram



Splash screen & login

The MusawoApp features a splash screen that greets users with a "Welcome to Musawo App" message and a heart icon. Following the splash screen is a login screen where users can enter their email address and password to sign in. This login and registration functionality is handled by Firebase Authentication. Users also have the option to sign up for a new account or recover a forgotten password from this screen.

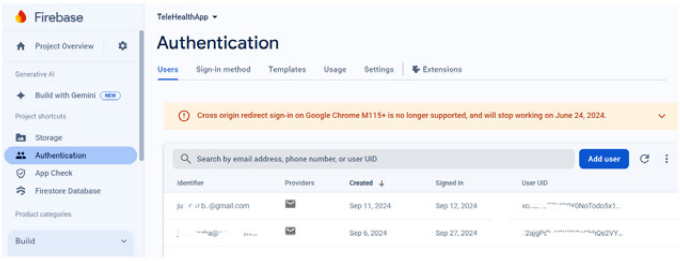
Figure 3: Musawo App splash screen and login screen



Authentication

Figure 4 shows the Firebase Authentication dashboard for the MusawoApp, which is the backend service used for user login and registration. The image displays a list of users with their email addresses and sign-in methods, confirming that the authentication system is actively managing user accounts. This feature is a key part of the app's functional requirements, providing a secure way for users to log in and access their respective interfaces. The dashboard also includes options for searching, adding, or managing users.

Figure 4: Firebase Authentication

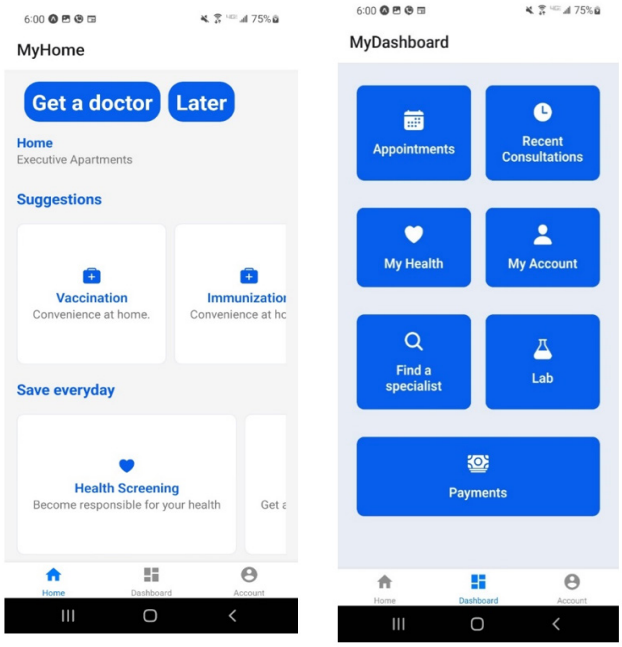


Patient dashboard & booking

The MusawoApp features a patient dashboard that provides quick access to various health-related services. Users can click on "Get a doctor" to initiate a request for a consultation. The dashboard also includes a section for "Suggestions" and a "Save everyday" section with options like "Health Screening". From the dashboard, patients can access dedicated sections for: Appointments, Recent Consultations, My Health, My Account, Finding a specialist, Lab services, Payments

Patients can also use a "Location-based doctor request map" which integrates with the Google Maps API. This feature allows them to find and request consultations with doctors who are near them, which is especially useful for ensuring faster access to healthcare in emergencies.

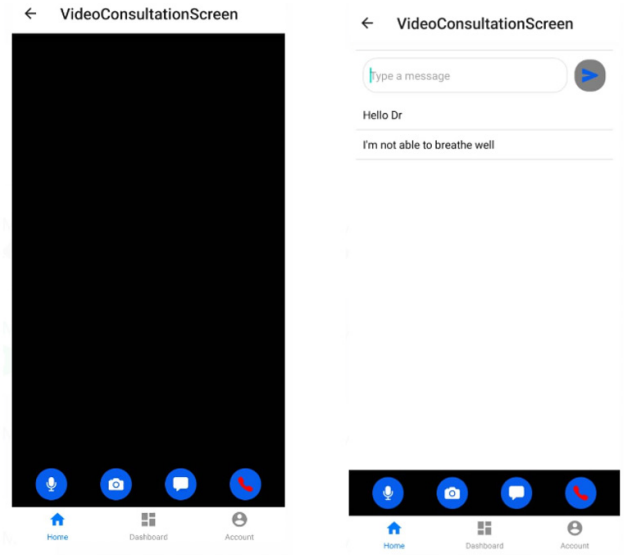
Figure 5: Dashboard



Video consultation interface

Video consultations in MusawoApp are enabled through WebRTC, which facilitates low-latency video, audio, and chat communication between patients and healthcare providers. This allows users to have face-to-face interactions with healthcare professionals remotely.

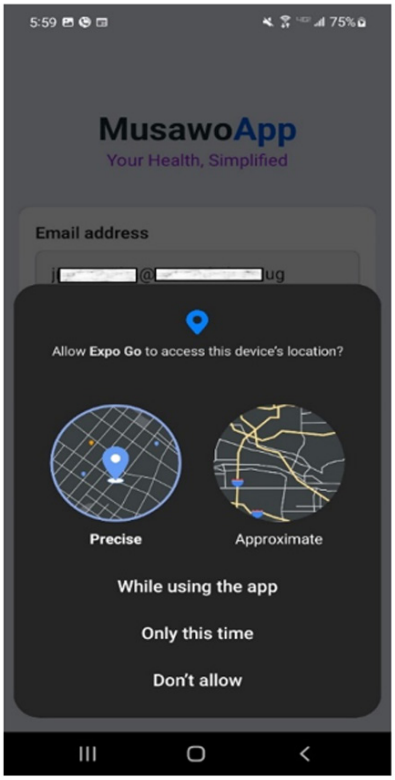
Figure 6: Video consultation and a chat screen



Location-based doctor request map

MusawoApp integrates the Google Maps API to provide location-based doctor requests. This feature enables patients to request consultations with doctors near them, ensuring faster access to healthcare in emergencies.

Figure 7: Allow Location while using the App



Usability and Acceptability Testing

UAT was conducted with 25 participants (15 patients, 10 healthcare workers). **The System Usability Scale (SUS)** yielded an average score of **82/100,** demonstrating strong usability.

Table 5: Usability Test Results

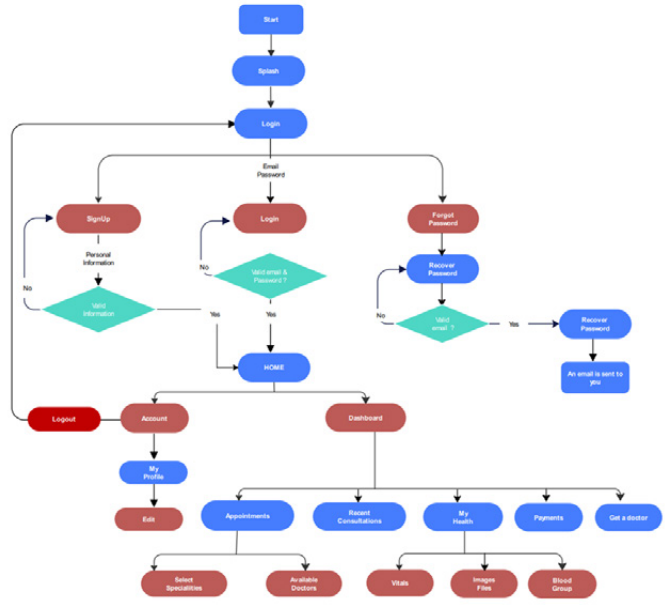
Feature	Rating (1–5)	Feedback Summary
Registration/Login	4.6	Smooth, quick authentication
Appointment Booking	4.5	Clear layout; reminders needed
Video Consultation	4.2	Good quality, but data intensive
Chat Messaging	4.7	Fast and reliable
Location-based Requests	4.3	Useful, network-dependent

Source: Primary data 2025

System Flow and Database Structure

The flowchart below provides a high-level view of the MusawoApp's system workflow, illustrating the interactions between users (patients and doctors), the system backend (Firebase and Firestore), and the communication layer (WebRTC). The flow begins with user authentication, after which patients and doctors are directed to their respective interfaces. Patients can book appointments, request consultations, and access medical records, while doctors manage appointments and update patient records. All interactions are securely managed through Firebase and Firestore, with video consultations powered by WebRTC.

Figure 8: System flow



Database Collections:-

Users: ID, Name, Contact, Role, License Verification
Appointments: AppointmentID, PatientID, DoctorID, Date/Time, Status
Medical Records: RecordID, PatientID, Medical Notes, Files

Security Testing

Security was prioritized through: - HTTPS and WebRTC secure channels
Role-based access control
Compliance alignment with **HIPAA/GDPR**

Summary

Findings revealed that **59.8% of respondents owned smartphones** and **75% expressed willingness** to adopt telehealth, despite persistent infrastructure and cost challenges. Adults over 40 formed the largest age group, highlighting the need for targeted features for chronic care management. MusawoApp was designed to address these gaps with secure video consultations, multilingual support, and geolocation services. Usability testing validated its practicality and acceptability, demonstrating potential scalability for rural Uganda and similar contexts. The complete survey dataset has been provided in **Excel** and **SPSS formats** for further academic review and replication.

DISCUSSION OF FINDINGS

Socio-Demographic Characteristics and Telehealth Adoption

The study revealed that adults aged 46 years and above formed the largest respondent group (39.3%), which highlights the importance of designing a system accessible to older users. This finding aligns with the World Health Organization (WHO, 2021), which emphasized that older adults in rural communities often present with chronic conditions, making them a critical group for telehealth interventions. The survey also found that farmers (44.7%) and those with secondary education (39.4%) were the largest occupational and educational categories, respectively, showing that telehealth adoption is not limited to highly educated or urban populations. These demographics suggest that telehealth solutions must be designed for simplicity and inclusivity. This is consistent with Adepoju et al. (2020), who found that underserved populations embrace digital health if systems are user-friendly and affordable. Moreover, the age distribution suggests that telehealth should integrate features for **chronic disease follow-up, medication reminders, and interfaces friendly to older adults,** ensuring that this high-need group is not excluded.

Access to Smartphones and Internet Use

A majority of respondents (59.8%) reported owning smartphones, while 40.2% did not. Daily internet use was recorded at 44.7%, with another 25% reporting weekly use. These figures are encouraging, as they show that a significant proportion of the population already has access to technology that can support telehealth. The cross-tabulation analysis revealed that smartphone ownership was relatively consistent across age groups, confirming that access is not restricted to the young. This aligns with Kay et al. (2011), who noted that technology adoption in health does not strictly follow age patterns, especially where there are significant community health needs.

Willingness to Adopt Telehealth

Willingness to use telehealth was high, with 75% of respondents expressing readiness across all demographic groups. Interestingly, willingness was not significantly influenced by education level ($p = 0.99$), highlighting the inclusivity of the proposed system. Even respondents without formal education expressed readiness to use telehealth, provided that instructions are simple and local languages are supported. The results further showed that willingness was slightly higher among smartphone owners (80%) than non-owners (68%). Although the difference was not statistically significant ($p = 0.10$), this suggests that smartphone penetration could positively impact adoption rates. This finding echoes the conclusions of Namatovu (2019), who emphasized that expanding mobile ownership increases digital health uptake in Uganda. The fact that willingness was not dependent on education means that **telehealth can reduce inequalities in healthcare access,** provided the system is affordable and user-centered.

Perceived Benefits of Telehealth

Respondents identified saving time (35%) and reducing travel costs (30%) as the main benefits. These findings reflect existing literature (Kay et al., 2011), which highlights that time and cost savings are the strongest motivators for telehealth adoption in rural areas. Additional benefits such as faster access to doctors (20%) and improved record management (15%) show that respondents also value efficiency and continuity of care.

Perceived Barriers to Telehealth

While the perceived benefits are encouraging, the study also identified significant barriers. The major barriers were poor network coverage (35%) and high data costs (25%). These infrastructural and financial challenges remain consistent with findings from Adepoju et al. (2020) in sub-Saharan Africa. Low awareness (25%) and trust concerns (15%) were also raised, underscoring the importance of community sensitization and trust-building between health workers and patients. The qualitative findings from interviews and focus group discussions reinforced these results, with participants emphasizing transport costs, long waiting times, and poor connectivity as persistent challenges. Addressing these barriers is critical not only for **initial adoption** but also for the **long-term sustainability** of telehealth interventions.

Implications for System Design

The MusawoApp was designed directly in response to these findings. Its offline functionality and low-bandwidth optimization address network and cost challenges. Multilingual communication and a simple interface cater to low-literacy users, while secure video consultations and record management respond to trust and efficiency concerns. This demonstrates the importance of **user-driven design,** where system features directly reflect the needs and expectations of the intended users.

Conclusions and recommendations

Conclusions

The study concluded that 75% of respondents were willing to use telehealth, indicating readiness if key barriers are addressed irrespective of there age and education levels. The hindering factors included the poor network coverage and data costs as well as concerns about privacy and lack of information. Another limiting factor was centered around the inability of respondents accessing services offline.

Recommendations

The study suggests that the government should expand rural network infrastructure and strengthen as well as provide platforms to strengthen and ensure privacy and build trust in telehealth services. The training of community health workers as “telehealth ambassadors” to raise awareness in local languages and build trust within communities as well as integrate telehealth as a complementary service inclusive of chronic care and follow-up visits. If issues can be addressed through community engagement and sensitization in local languages, it is assumed to have positive outcomes. This therefore confirms that telehealth adoption in rural Uganda is not only feasible but also urgently needed. With strategic investment in infrastructure, community sensitization, and user-centered design, telehealth can significantly reduce access barriers and improve healthcare delivery for underserved populations. The MusawoApp prototype demonstrates that when digital health solutions are grounded in local realities, they can contribute meaningfully to the achievement of universal health coverage and the strengthening of primary healthcare systems.

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