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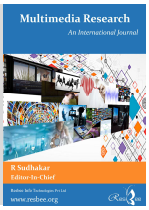

Application of Telemedicine for Healthcare Delivery in Nigeria

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Abstract: The study explores the application of telemedicine in healthcare delivery in Nigeria, the perception of medical practitioners, and its application in healthcare service delivery to the nation. An architectural framework was designed to depict the application of healthcare delivery via telemedicine. A questionnaire was set up to check the views of medical practitioners regarding the application of telemedicine in healthcare delivery. Over 100 questionnaires were given out to Medical practitioners, Patients, ICT providers, and Healthcare professionals who are policymakers. 95 questionnaires were returned and the remaining 5 could not be accounted for by the respondents. An evaluation was conducted on the collated data to check the ease of usage, Degree of relevance, and Reliability index of the application of telemedicine to evaluation performance metrics. 87.37% of the respondents preferred the application of telemedicine in healthcare delivery in terms of patient health management and satisfaction improvement. 12.63% of others preferred face-to-face opinions in terms of practice satisfaction to patients, Ease of use, Equipment setup expenses, Technical reliability, Time duration, Trust among the professionals, Diagnostic accuracy, and Patient convenience. The SRI, SDR, and SEU results obtained from the responses are 3.33, 3.02, and 2.65 respectively. The hypothesis derivative crouch coefficient ranges between 0.71 and 0.80 based on the validity and reliability of the application of telemedicine in healthcare delivery. Most medical practitioners were overwhelmed and supported the application of telemedicine and its application in healthcare practice. This study shows that medical practitioners are ready and prepared to accept telemedicine applications to improve healthcare delivery in Nigeria.

Keywords: Diagnosis; digital health; healthcare delivery; telehealth; telemedicine

Nomenclature

Acronym	Meaning
ISDN	Integrated Services Digital Network
MMS	Multimedia Message Service
MHealth	Mobile Health
EHealth	Electronic Health
WAVA	Web Service for Automatic Data Video Data Flow Adaptation
TeleMedSys	Web-based telemedical system
IT	Information Technology
ICT	Information Communication Technology
COVID-19	Coronavirus Disease
NigComSat1	Nigerian Communication Satellite 1
NASRDA	National Airspace Research and Development Agency
SRI	System Reliability Index
SDR	System Degree of Relevance
SEU	System Ease of Usage
Y	Yes
N	No
UCH	University College Hospital
OND	Ordinary National Diploma
HND	Higher National Diploma
NCE	National College of Education
IP	Internet Protocol
FCT	Federal Capital Territory
PSNR	Peak-Signal to Noise Ratio
UIQI	Universal Image Quality Index
MTATD	Mobile Telemedicine Applications for Tropical Diseases

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1. Introduction

Nigeria's health care system is based federal character of the country which comprises 36 states and Federal Capital Territory. It is further subdivided into 774 local government areas. Reports indicate that Nigeria has a very poor healthcare system resulting in persistent strikes embarked on by medical personnel, Proximity of hospitals, Poverty to afford medical care, Corruption, Greed, Revenue allocation issues, and Asset inequalities among the hospitals. This shows that a large population of Nigerians suffer from inadequate health care which needs higher attention of the government to improve the healthcare system. An economy with poor healthcare services makes poverty persist [1]. There are problems or challenges in sustaining Nigeria's healthcare system with an influx of counterfeit or fake or adulterated drugs, Poor healthcare financing, and Sustainability, Increased out-of-pocket expenditure, Inadequate basic infrastructure or equipment, Inequitable distribution, poor remuneration amongst medical personnel, bribery and corruption and shortage of staff [2].

The introduction of IT in the healthcare sector has enhanced healthcare delivery to the populace in both urban and rural areas. Nigeria gained its Independence in the late 1960s. It has been making several attempts to improve healthcare delivery to its populace [3]. Modern technologies interfacing with computers connected to telecommunication infrastructures with the provision of internet facilities have increased access to healthcare delivery where resources are not available and systems are under stress. Telemedicine plays a vital role in healthcare delivery in modern medicine [4]. It has helped most medical consultants and nurses to give medications to patients at a distance with the aid of technologies such as Telegram, Telephone conversation, Internet connectivity, Short message service, and Video conferencing depending on the patients' accessibility.[5]

Moreover, in collaborative environments, this has enhanced prescription at a distance to be easier on a real-time diagnosis of patients by the doctors and nurses with the integration of electronic healthcare services. During the COVID-19 pandemic, Nigerians get medical care through technological infrastructures such as Telephone, Internet, and Videoconferencing media from the medical consultants to the patients. Alternative (herbal) medicine is not left out in the application of telemedicine technology for herbal prescription and medication [6]. Nigeria was colonized and people also depended on indigenous medicine. However, the Introduction of Western culture has virtually changed lives. Western medicine has become an integral part of health-seeking, to the extent that Nigerians are no longer interested in indigenous herbal medicine [7].

ICT in health portends significant value to Nigeria by utilizing technology to make healthcare delivery more Cost-effective and efficient, Empowering people and improving services to the citizens, Power of combining medical sciences, Information sciences, and Information technology that is needed to enhance patient-centered care and connectivity [8]. To have an effective and efficient diagnosis of patients at a remote site, it has to be based on the assessment of data transmitted from the device that monitored the patient and transferred through a media link to the diagnostic center with the aid of modern technological devices. All the equipment needs to be ready for proper and effective ehealth services. ICT infrastructure is needed for an effective patient diagnosis on real-time interaction and consultation through online communication in the case of video conferencing. Telemedicine has made it convenient for patients to receive perfect medical attention at the convenience of both doctor and patient in healthcare delivery. With a quality network, telemedicine will improve healthcare delivery and hold great promise for patients in remote areas. Telemedicine is an innovative technology, and some people term it as a disruptive innovation [9] [10].

This paper designed the architectural framework of the telemedicine application. This method improves the clinical and administrative operations in emergency and non-critical cases. The videoconferencing along with the collaborative telemedicine technology helped patients from remote places. The main process involves gathering the patient's information, diagnosis, and treatment with the assistance of the support care unit. This method brought satisfactory respondents from the application users.

The paper is organized as follows: Section 2 explains the Literature review, Section 3 provides the methodology, Section 4 mentions the materials and method, Section 5 explains the Architectural Framework of Telemedicine Application, Section 6 provides research questions, Sections 7 and 8 mentions the advantages and disadvantages of the telemedicine, Section 9 explains the details of the study, Section 10represent the results, Section 11 provides the discussion, and Section 12concludes the paper.

2. Literature Review

In 2012, Emuoyibofarhe, *et al.,* [22] have accessed the readiness of health practitioners, patients, and the public towards e-health. They considered need-change readiness, engagement readiness, and structural readiness. Descriptive analysis was implemented to statistically analyze the response. The responses were analyzed through a Likert scale questionnaire and T-test. The overall output showed that health managers were not structurally ready, while the public, patients, and healthcare practitioners had some agreement but faced constraints related to structural factors, social influence, and engagement for the successful adoption of e-health.

In 2018, Ogirima [24] have employed a methodology and an architectural framework for telemedicine and prescription in herbal medicine. It was implemented using Microsoft Visual Studio and C language. The 5-point Likert scale was used for questionnaires to evaluate the design, distribution, and evaluation of user perspective. Data were analyzed using Excel. The packet loss during transmission focussed on system-centered evaluation. The ethical issues were also considered. The result achievedrelatively low packet loss rates and positive user perceptions in terms of system reliability, relevance, and ease of usage.

In 2014, Setyono, *et al.* [28] have developed a mobile telemedicine system using MMS. It consists of two components they are client and server-side applications. On the client side, adapted compression and splitting technology was used and on the server side, merging and decompressing technology was implemented. Finally, the quality of data was measured using indicators such as PSNR and UIQI.

In 2006, Ikhu-Omoregbe, *et al.* [40] have a deployable framework for MTATD. This method consists of three main modules. The Patient Unit allowed patients to access the telemedicine unit via handheld devices over a UMTS/UMTS network and the internet for collaborative healthcare delivery and education. The Physician Unit enabled healthcare providers to collaborate with patients through the telemedicine unit. This method enhanced healthcare delivery in rural areas and developing countries by providing mobile telemedicine solutions for tropical diseases.

In 2017, Adenuga, *et al.* [41] have adopted a quantitative survey using a structured paper-based questionnaire. The survey items were designed on a five-point Likert scale ranging from strongly disagree to strongly agree. The content validity, constructs, and definitions were developed. The respondents were clinicians (physicians and nurses) from Nigerian government hospitals who know telemedicine systems. From their response, we can understand that the clinician's recommendation was high.

In 2012, Imouokhome, *et al.* [42] have presents an architecture as a framework for the adoption of ICT tools for healthcare delivery in Nigeria. They used mobile devices such as mobile telephones and the Portable Telemedicine Kit. It also discussed the use of mobile phones and smartphones, Bluetooth, Wireless Fidelity (WiFi), etc., for transmitting e-health data and facilitating services. They used real-time telemedicine (synchronous) and store-and-forward (asynchronous) technologies in healthcare delivery. This method was successfully deployed in various countries such as India, Bosnia, Ghana, Kenya, Uganda, the United States, Europe, and Asia.

In 2013, Hassan, *et al.* [43] have implemented a generic system architecture of a wireless sensor network consisting of multiple tiers. In the first tier, intelligent sensor devices were used for capable of sensing, processing, and transmitting vital physiological signals wirelessly. The second tier was a personal server where a personal digital assistant (PDA), smart phone, or personal home computer was used. The server acts as the interface between the wireless sensor network and the remote medical care servers. Finally, the third tier encompasses a series of remote medical care servers and related health services, such as physicians, caregivers, and clinics. These servers receive data from the personal server and serve as the backbone of the entire architecture and storing electronic records of remotely monitored patients. This method ensured efficient, secure, and cost-effective remote healthcare monitoring.

In 2018, Olayinka, *et al.* [18] have introduced an application for web-based and desktop-based telemedicine. Initially, they analyzed the existing method of healthcare delivery in developing countries, specifically focusing on Nigeria, to identify major problems associated with healthcare delivery. Then A framework was developed based on web-based and desktop-based applications. The web-based telemedicine application was database-driven and allowed patients to access basic healthcare services and leave messages for doctors through the Internet. The desktop-based telemedicine application enabled real-time audio-visual communication between local doctors and remote specialists. Finally, this application was tested, and good latency was achieved, which would help reduce the cost of healthcare delivery.

2.1 Review

Author	Methodology	Advantage	Disadvantage
Emuoyibofarhe *et al.,* [22]	Likert scale questionnaire and T-test.	• With identifying readiness levels, we can obtain information for decision-making and resource allocation for e-Health innovations. • Reduced the sense of risk associated with e-Healthcare by building strong, flexible, and responsive e-healthcare structures.	• Sample size was not explicitly mentioned. • Does not discuss the methodology and information of the timeframe.
Ogirima [24]	5-point Likert scale	• Reliable and relevant platform. • Framework integrated with multiple features. • Minimum packet loss during telediagnosis.	• There was an inefficiency in data compression and transmission. • Doesn't address the real-time challenges. • Specific to certain regions. • The respondent rates for SRI, SDR, and SEU are moderate.
Setyono, *et al.* [28]	MMS	• Allows transmission for larger data sizes. • MMS enhanced message delivery and data quality.	• Implementation and experimental results were not explicitly discussed. • No information on scalability and adaptability.
Ikhu-Omoregbe, *et al.* [40]	MTATD	• Cost-effective medical services. • Quicker turn-around time for consultation. • Provide early diagnosis.	• Technological limitation in MTATD.
Adenuga,*et al.* [41]	Five-point Likert scale	• Data were standardized and easy to administer. • Provided a granularity in measuring attitude and perception.	• Limitations in data entry error, missing data, and difficulty in data analysis and storage. • The samples were not explicitly mentioned
Imouokhome, *et al.* [42]	ICT tools	• Provide preventive medicine and early health-risk detection. • Low-cost information and communication technology with improved quality of services.	• Faced challenges in the connectivity and network coverage in remote areas. • Required significant investment in infrastructure, training, and support system.
Hassan, et al. [43]	Wireless sensor network	• Enable remote monitoring and timely feedback. • Efficient, secured, and cost-effective method. • Enable real-time monitoring of patient's health.	• Lack of legal framework and strategic policy in place. • Inadequate IT infrastructure, equipment, and application in rural areas.
Olayinka, *et al.* [18]	Web-based and desktop-based telemedicine	• Allowed remote medical centers to access medical resources. • Reduces the need for physical travel. • Offers opportunities for continuous medical education in remote areas.	• Lack of infrastructure and inadequate power supply. • Not suitable for all medical conditions.

3. Methodology

Telemedicine gives room to healthcare providers to evaluate, diagnose, and treat patients at remote geographical locations using information technologies and telecommunication technologies with the ability to collect, store, and exchange medical data about patients. These help in remote monitoring of patients, improving administration and management of healthcare for decision making, integration of health data systems, and sharing patients' information among other medical practitioners to facilitate their collaboration efforts in diagnosing [11] [12] [13]. Healthcare providers are willing to use modern technologies with sufficient knowledge of telemedicine applications to provide the same diagnoses information compared to those performed on traditional face-to-face. Telemedicine application does not pose any threat to traditional face-to-face medical care but it depends on both practitioners and patient willingness for the mode of medication [14] [15] [16]. In the United States of America, medical care is delivered with proximity between the provider and patient. Currently, American medicine is gradually moving to developing care models that include remote services [17]. For proper medical diagnosing and

patient care, telemedicine applications and ICT infrastructures are needed for the provision of medical services to sites that are at a distance from the provider. Therefore, Effective assessment of telemedicine is an alternative to traditional face-to-face patient care [18].

Telemedicine and eHealth have drastically improved the standard of healthcare deliveries in Nigeria through the application of modern technology that facilitates teleconsultation for patients to have a Better, Reliable, and Secured healthcare service from physicians or medical consultants at distant where no physical healthcare infrastructure is available [19]. The technology has reduced Patient visits and the Cost of traveling from Doctors and patients. Patient information is readily available in real-time with the aid of ICT device connectivity that provides healthcare information about a patient and exchange of healthcare information across geographical distances among physicians and other health workers working round the clock to medication to patient technological devices. It is explained in Figure 1 [20]. The Telemedicine Unit of the NASRDA, Nigeria uses Nig Com SAT1 to perform tele-surgery at designated hospitals (Figure 2) across the country making use of experts from various University college hospitals such as Ibadan, Jos, Abuja, Port-Harcort, Zaria, and Maiduguri [21].

In Nigeria, most patients use telephones to get medical attention from tele-consultants. Patients are guided on how to send an SMS via telephone to get medication at a distance. Acknowledgment of patients' requests via Mobile SMS Service from a dedicated mobile phone number with the identity of the ailment is shown in Figure 3. This technology has shaped educated Nigerians through Internet access at home [22].

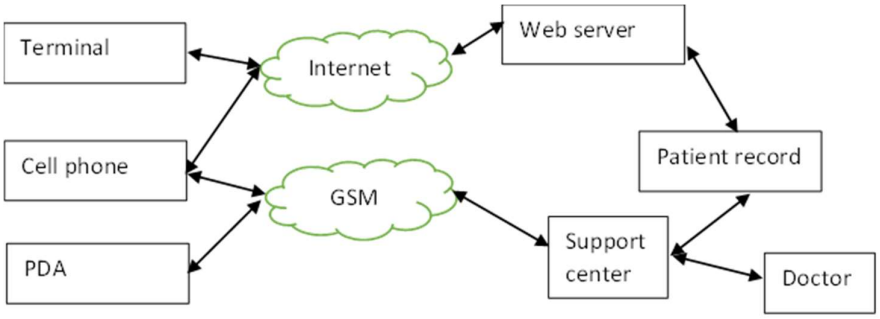

Fig.1. *Basic concept of the e-health system [20]*

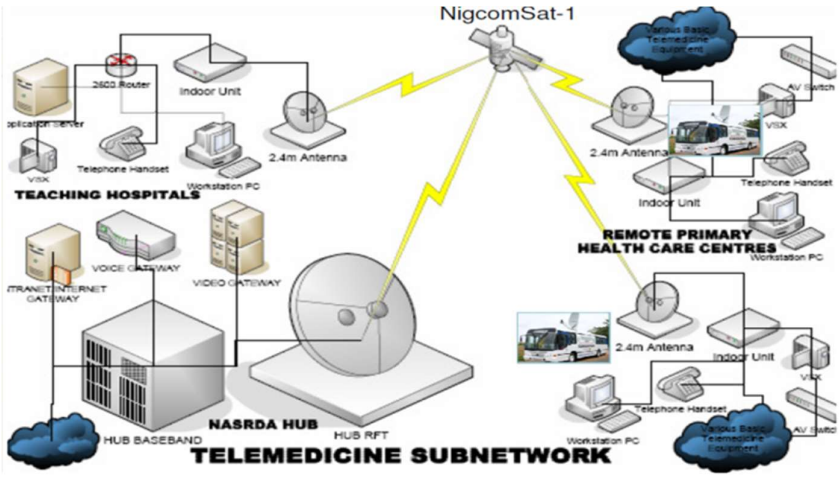

Fig. 2. *Nig Com SAT 1 Telemedicine Network [21]*

Fig. 3. *Acknowledgement of patients' requests via Mobile SMS Service [22]*

Many researches has been conducted on physicians' e-health readiness and preparedness on the telemedicine application implementation for the distribution of the technology among the hospitals in Iran and Nigeria for healthcare services to patients [23] [24]. In Nigeria, some hospitals with electronic medical facilities have integrated telemedicine into healthcare services to render services to patients at a distance [25]. A web-based telemedical system (TeleMedSys) which consists of a patient management system and a medical device system was made available to the doctor and the patient-side assistant during treatment via an Internet browser. The local and remote web application combinations enable a seamless integration of the medical devices required at the patient's location into the doctor's remote station based on browser technology. In remote areas where there is a geographical limitation, telemedical stations have been considerably used due to satellite connectivity, proper power supply with solar panels, and ready-to-use teleconsultation equipment are very highly needed and not easily available or affordable as shown in Figure 4 [26].

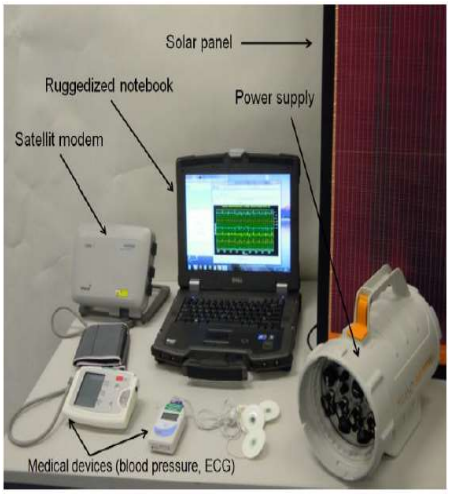

Fig. 4. *Device components of the Patient Station for the TeleMedSys[26]*

The research was conducted based on patients' imagery to determine the quality of adaptation of the encoding type that is used for the resolution and compression rate using the WAVA principle for telediagnosis of Cardiovascular Diseases in a collaborative and adaptive approach. The results of the proposed study show that practitioners benefit from a very high level of information availability and performance results validate the shared data among themselves on remote diagnosis. This principle adaptation determines marks and reports the best quality or capacity for data to meet the requirements of the devices as shown in Figure 5.[27].

Fig. 5. *WAVA principle used for Telediagnosis of Cardiovascular Diseases[27]*

A videoconference systematization and experimentation were conducted focussing on the modalities necessity of equipment for both audio and video capturing with the reproduction. A communication link for connection was adopted with similar equipment through ISDN or IP for proper real-time interaction. For a successful videoconference, Video and audio quality is essential. An experiment was conducted using videoconferencing equipment in radiology to know the remarkable impact on costs of medical care delivery for the population; videoconference represents an invaluable tool for physicians in education and knowledge updating [28].

A mobile telemedicine system framework was designed for telediagnosis using MMS technology. The research model was to send messages to patients in remote areas who do not have access to medication to enhance the capability of MMS technology in message delivery. The experimental results show that the designed framework can be used to develop a practical mobile telemedicine system [29]. Medical consultants recognize that the application of modern technologies may require different skills extra knowledge for the use of computer system acquisition skills, the manner of approaches to the information specified, and the relationship between the medical practitioner and the patient [30] [31].

Advancements in information technology, telecommunication, and network technologies have led to the emergence of a revolutionary new paradigm for health care that some refer to as e-health in modern medicine [32]. In Nigeria, currently, alternative or complementary (herbal) medicine is trying to apply modern technology in healthcare delivery to patients at remote distances [5] [33]. A digital stethoscope was used to hear the heartbeat of a patient. This equipment was placed or connected to the patient through the telephone line and the doctor at the specialty center thereby hearing the heartbeat on the system or the telephone directly. In the case of videoconferencing, the voice can be heard through a voice-enabling instrument attached to the Polycom. This has features such as an echo-canceller and noise reduction units that can enhance better transmission of the heartbeats [34] as shown in Figure 6.

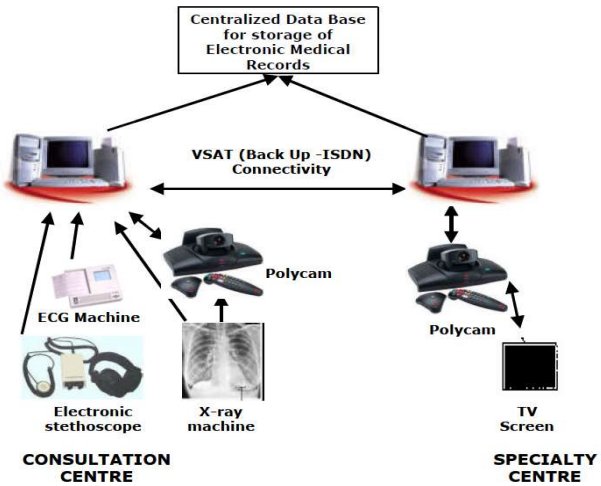

Fig. 6. *Telemedicine Network [34]*

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The procedure of workflow for medical consultants attempting telemedicine culture-based treatment in healthcare services is shown in Figure 7. This provides ultra-edge facilities and attention at each step of telemedicine implementation. This starts with the capturing of patient's detailed information, including the telehealth supportive care unit. The setup assists the medical practitioner in the patient's proper diagnosis and treatment at maximum care. Telemedicine with other modern technology infrastructures has improved clinical and administrative operations through telecommunication in case of emergency care in both critical and non-critical situations. Therefore, telemedicine application is a solution for healthcare improvement and quality of treatment for both patients and doctors for effective services [10].

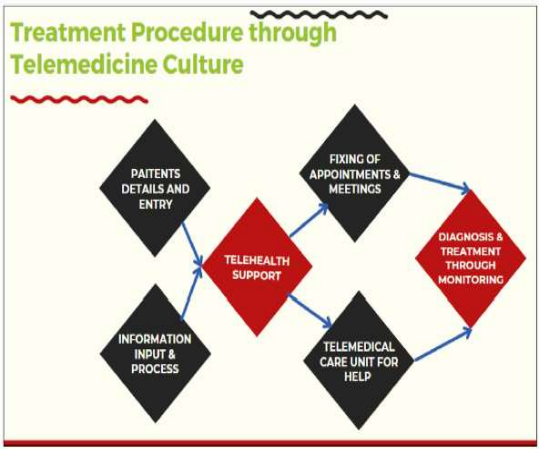

Fig. 7. *Workflow treatment process through telemedicine support [10].*

The structure of the Nigerian healthcare system has provided more and better healthcare facilities in the cities where the most privileged social class resides than those in the rural areas which are predominantly inhabited by the peasants. In most cases within the cities, there are hospitals and clinics designed and reserved for the bourgeois class. For example, the National Hospital in the Federal capital, Abuja is reserved specifically for senior government officials, bureaucrats, businessmen, high chiefs, and professionals like professors and bankers who are wealthy enough to afford the costof services it offers. Mere general hospitals built by the government to serve all Nigerians are not as properly equipped as those reserved for wealthy individuals. Therefore, the telemedicine technological practice will depend on the structure of each state's determination of the character of its social services through policy-making and implementation [35].

In America, during the COVID-19 pandemic, synchronous telemedicine visits, either through phone or video have increased drastically. The Physicians at Harvard Medical Faculty Physicians, Beth Israel Deaconess Medical Center, is one of the foremost academic teaching hospitals in Boston, Massachusetts. It quickly adopted telehealth into the center though there were reported technical challenges during video visits and occasionally converted video visits to the telephone. Patient outreach has been suggested to facilitate successful video visits, and during the launch ambulatory telehealth visits of over 500,000 at the medical center since the onset of the COVID-19 pandemic. A program was implemented to address the transition from telephone to video visits. However, patient navigators were characteristically identified as staff that will guide patients in the coordination of care, appointment adherence, and discharging plan [36].

As Nigeria has grown to be dependent on technological advancement following the increase in the broadening of computing, ICT infrastructures, and other mobile devices, there is a need to have the right to affordable healthcare and medical facilities provided by our local laws. The solution to Nigeria's healthcare services is to improve the standard of living which is greatly centered on the government's political will to implement an e-healthcare infrastructure across the 36 States and the (FCT), Abuja through the creation of an implementable policy document [37]. There is a mal-distribution of healthcare facilities in Nigeria, mostly because the decisions on the nature and location of services are usually politically motivated rather than evidence-based. Therefore, the development and sustainability of the healthcare system in any democratic setting need effective legislation. Access to health should be seen as the right of an individual and if the policy remains public funding and provision, then suitable legislation should be put in place to protect the health consumers from being underserved [38]. A centralized database needs to be designed for storing health-related information of all Nigerians linked together

using data mining techniques, data integration, and information sharing among medical practitioners across the States and FCT [39].

Telemedicine technology gives accessibility to treatment options. This includes primary care consultations, psychotherapy, physical therapy, telediagnosis, telemonitoring, telenursing, telerehabilitation, and many more. Telemedicine provides treatment through the use of wireless technologies such as laptops and Smart phones linked with ICT infrastructures. Video conferencing is used in telemedicine to allow the practitioners to visualize the patient's improvement. In some cases, patients receive treatment through email or phone messages. Telemedicine is significantly helpful in a situation where a patient has to maintain physical distance during the COVID-19 pandemic or difficulty in visiting a healthcare service center [6] [10].

4. Materials and Method

The review of the study was mainly on English language publications. An online search was conducted on health informatics, telemedicine, telecommunications, DSS, application of computers in healthcare services literature. This section gives an architectural framework, the factors and challenges that could hinder telemedicine are discussed, and the benefits of telemedicine in healthcare delivery. A survey questionnaire was developed to elicit from respondents their experience with telemedicine healthcare delivery. The area, sample size, mode of data collection, method, and the required tools needed for the data analysis are discussed in this section.

5. An Architectural Framework of Telemedicine Application

The combination of the two architectural designs gave the overall architecture framework for the developed Collaborative WAVA-based Telediagnosis system as shown in Figure8. The framework highlights the components used in the developed system along with the interactions amongst the components. It is assumed that the medical practitioners (teleconsultants) could have different types of connections to the system depending on media link capability. Therefore, practitioners can receive the same data when switched to the adapted solution through the adaptation of the WAVA principle which sends back the adapted data as shown in Figure 8.

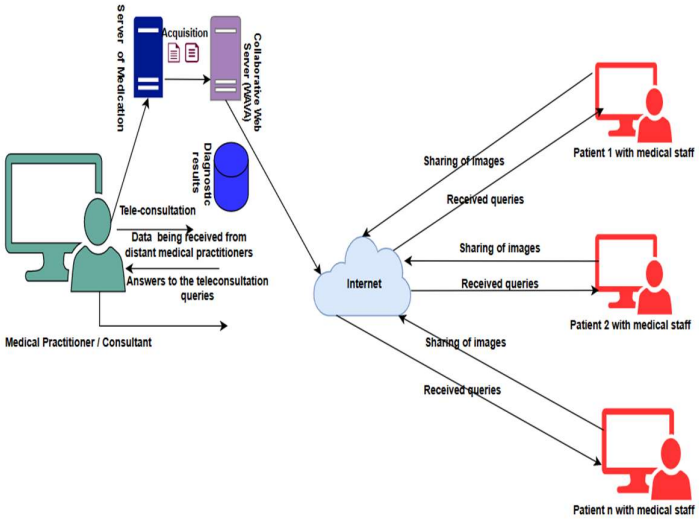

Fig. 8. *Telemedicine Architectural Framework Collaborative Telediagnosis*

The components of the designed architectural framework comprise the following:-

a. **Medical Professional/consultant:** Supervises the teleconsultants based on the type of treatment to be given to the patients.
b. **Collaborative Web Server (WAVA):** These allow collaboration to take place within the system as it is expected to send/receive information through internet devices to computing devices amongst teleconsultants.
c. **Medication server:** This is where the recorded information about patients, images, and results of video conferences are kept.

d. **Interpreters:** Health workers who serve as an intermediary between patients and medical who interpret the language spoken by patients to practitioners to avoid any form of language barrier.
e. **Patients:** These are people in need of medical attention.
f. **Tele-consultants:** Specialized practitioners who provide medication to patients.
g. **User Interface:** This serves as an intermediary between the patients and the medical practitioners. Users supply their requests or inquiries using the user interface while the medical consultant on the other end also makes his/her response known to the patients using the same user interface.
h. **Diagnostic Results and records:** Information about patient medication.
i. **Internet connectivity:** This provides a communication link between teleconsultants.
j. **Computing Devices (Terminal):** These are computers used for communication and interaction among the teleconsultants.
k. **Acquisition:** Required information needed for medication

5.1 Implementation of telemedicine in Healthcare delivery

To implement telemedicine in healthcare delivery, medical practitioners need to consider the following points:

- Telemedicine generally depends and reliant on an effective network connection.
- Patients need to be digitally knowledgeable and able to access the telemedicine application using telephone, internet, or videoconference approaches.
- Communication is a vital key for interacting and communicating between practitioners and patients.
- Medical practitioners need to consider patients' consent, capacity, and continuity of care.
- Proper understanding of what telemedicine technology needed to be available to provide safe monitoring in case of follow-up on any emergency of patients on critical medical attention.

6. Research Questions

A medical practitioner wishes to use telemedicine for medical consultation. The following questions were addressed in this study:

- Is telemedicine usage more cost-effective than traditional face-to-face medication?
- Will patient information be more secure on collaborative telemedicine?
- What is the level of privacy when using telemedicine for healthcare services?
- Any adequate mobility level of the telemedicine application when deployed?
- How easy will it be when using collaborative telemedicine technology?
- Is there any need for collaborative telestaff meetings?
- Is telemedicine better than traditional face-to-face (which one to use and when)?
- Can patient's concerns be managed satisfactorily through telemedicine?
- Could information needed to form a diagnosis or inform decision-making be gathered using this method?
- Can a satisfactory relationship with the patient be built?
- Is there any possible continuity for those who need it to be enabled?
- Can two-way dialogue with the patient be established and information is provided in a way the patient can understand?
- What is the patient's preference in terms of diagnosing, taking into consideration the patient's level of confidence with the consultation mode, and ability to communicate using telemedicine technology? What reasonable adjustments can practitioners make to support patients?
- Does the patient require an examination using this telemedicine?
- Are there concerns about the patient's safety, capacity, or safeguarding and confidentiality of information when accessing care remotely?
- Has the patient previously been consulted about the same problem repeatedly remotely? Are the patient's needs being met using telemedicine?
- Is there a step the medical practitioner can arrange remotely before having a traditional face-to-face consultation?
- Are any medical consultants confident in the use of telemedicine technology to deliver a remote consultation? Do medical consultants need any training or technical support?
- Are there any other considerations, for example, medico-legal backing for the practice?
- Is there any measurable difference in the outcomes of care to patients treated remotely through telemedicine compared to those treated on traditional face-to-face?

- Is there any measurable difference in the economic consequences of care delivered remotely via telemedicine compared to traditional face-to-face care?
- Is there any difference in patients' acceptability of care provided remotely compared to those traditionally face-to-face?
- Is there any measurable difference in the professionalism of care through telemedicine compared to care delivered through traditional face-to-face?
- Is there any measurable difference in the transfer of skills among medical consultants in care delivered through the medium of remote consultation compared to traditional face-to-face?
- What are the major barriers to telemedicine care delivery?
- What are the common diseases treated with the aid of telemedicine?
- What are the most common technologies used in telemedicine?
- What is the main telemedicine medical practice applied globally?
- What are the major service delivery types and medical fields to be addressed when using telemedicine technology?

7. Benefits of Telemedicine application for healthcare delivery in Nigeria

The implementation of telemedicine in Nigeria has helped healthcare delivery in the following ways:

- **Telehealth, e-health, and telediagnosis**: With technological advancements, healthcare service is received in remote areas without a hitch. ICT devices, such as computers and handheld medical equipment with high-resolution cameras are used to give accurate diagnostic photographs to experts.
- **It facilitates service to disabled patients**: Telemedicine equipment facilitates access to services for patients with disabilities. It also increases accessibility to the elderly, the culturally isolated, and the incarcerated. It also helps patients to spend less time in the hospital, and save money to buy petrol for to and from.
- **Remote treatment and Diagnosing**: Remote treatment and diagnosing can be done virtually to keep patients out of the hospital. Patients who wish to see a medical practitioner with highly specialized experience in a specific illness can do so without outdriving long distances and video visits.
- **Provision of treatments to school-going children**: When children are sick at school, provisions are made for them through telemedicine link with the aid of the school nurse to the doctor partner to perform video tours from the classroom.
- **Disorders not requiring lab examination**: Telemedicine can be effective for cases that do not require laboratory examinations or a physical examination. The technology has helped greatly during the COVID-19 pandemic, a patient who lives long distances away from a primary care center can also achieve better treatment.
- **Allow doctor's appointments virtually**: In this age of social distancing, millions of people look forward to virtual doctor appointments. Telemedicine has improved medication management, patient quality of life, and reduced healthcare costs. Telemedicine application growth is now a key target for healthcare providers who want to deliver healthcare services to patients online and remotely.
- **Overall healthcare system performance is enhanced**: Telemedicine encompasses a greater range of online healthcare facilities. This has facilitated Telehealth to a wide range to provide patient care and enhance the overall performance of the healthcare system.
- **Improvement in patient coordination**: Telemedicine has drastically improved patient coordination and healthcare services. Treatment shortages, overuse of medical care, inadequate drug use, and unnecessary or overlapping care may also result from fragmented care. This helps patient comfortably which improve patient's coordination with the doctor.
- **Minimize traveling of patients**: Healthcare provided through telemedicine potentially decreases the amount of time available for appointments. Patients no longer have to waste hours traveling to or waiting in a hospital. Healthcare can now be more affordable than before. Doctors can view on-demand necessitating the use of an internal database of built-in queries provided by a variety of application programming interfaces and facilities.
- **Teledentistry**: The technology has enhanced dental care, allowing dentists to obtain teeth, dentures, and other dentistry imageries or related evidence to evaluate and transfer it to other practitioners for possible examination.
- **Better service for medical practitioners and patients**: Telemedicine provides speedy growth that offers numerous benefits to both medical practitioners and patients. The vital need for any

healthcare provider is to have better patient services, which telemedicine systems will achieve while still assisting medical practitioners to refine and improve their private practice.

- **Digital health monitoring**: Telemedicine systems with digital health monitoring capabilities, combined with artificial intelligence and machine learning will provide more accurate diagnoses and treatment recommendations. Video conferencing tools and machine learning technologies with the assistance of each patient's case will enable refining the algorithm to provide a better diagnosis for each one. It allows medical practitioners and patients to be safe in a pandemic and expand medical services digitally.
- **Skincare**: Currently patients communicate with a dermatologist through telemedicine by using a Computer, Smartphone, or Tablet. Dermatologists may evaluate patients suffering from psoriasis, bed sores, eczema, and other conditions using high-resolution photographs and film. This is useful for patients who are confined to their homes. Dermatologists can safely and reliably identify and treat skincare disorders using telemedicine technologies.
- **Easy tracking of patients for medication**: Telemedicine technology allows providers and other healthcare personnel to track patients for proper medication over long distances using high-tech medical equipment.
- **Secure patients from infectious disease**: During the pandemic, telemedicine has helped everyone live in a safe society. For example, patients suffering from COVID-19, flu, or a cold should consult with a medical doctor without taking germs into the workplace.
- **Cost-effective**: When comparing conventional ways of healthcare administration, telemedicine is a more cost-effective approach. This is valid since physicians and patients do not need to travel each time; they need to see a doctor or patient. In addition, video consultations are typically less expensive than in-person consultations, saving money on travel and hospital setup costs. Telemedicine expands the medical industry's frontiers in the field of science, especially in videoconferencing streamlines during the medical examination of patients.
- **Reduce traditional face-to-face meetings**: Telemedicine has several efficient applications in situations where face-to-face meetings are unavoidable. The technology is an alternative that reduces overall health risks during the treatment of patients who need supervision.

8. Factors that Could Affect Telemedicine Implementation of Healthcare Delivery in Nigeria

Though there is advancement in technology, the implementation of telemedicine in healthcare delivery in Nigeria could be faced with a lot of challenges that will end the idea and its implementation in failure. There are common barriers that need to be addressed in the process of applying telehealth-related practices for healthcare delivery. Among those things to be considered the taken off includes privacy loss, confidentiality revealing, fraud and abuse, inaccurate solutions, medical liability, misdiagnosis, complexity, and so on that could discourage someone telemedicine in Nigeria. Some other critical factors or barriers could affect telemedicine implementation. These include:

i. **National ICT Policies:** This involves policymakers who have technological awareness and an interest in ICT for national development. These policymakers mirror general ICT policies towards healthcare delivery and remote consultation.
ii. **ICT Infrastructure:** There is no way an effective telemedicine will survive without effective ICT infrastructures. The infrastructures such as Electrical power, Internet and telecommunication, Computers, Telephones, and Wireless networks will facilitate communications, data collection, and storage.
iii. **Implementation Factors:** In Nigeria, most medical practitioners see telemedicine as a practice that could cause them to lose their jobs which is not true. It only helps in treating patients at a distance with the aid of ICT infrastructures. Medical practitioners who are interested in telemedicine should consider the Training of staff, Health policies for the take-off, The choice of telemedicine applications based on accessible technologies and needs, e-awareness, e-acceptance, e-readiness, and e-management support.
iv. **Culture-Specific Beliefs, Values, and Technological Culturation:** Medical practitioners need to consider patients' attitudes toward telemedicine implementation, while technological acculturation has to do with the influence of cultures and religion on an individual's attitude toward modern technology. For example, religious leaders preach against the usage of technology for the diagnosis and treatment of patients for fear of hacking their private information.

9. Participants involved in the study

There are different participants involved during the fieldwork to whom the questionnaire was administered. Those involved gave their perceptions about remote telemedicine and traditional face-to-face medical consultations, viz:

- Qualified healthcare practitioners from any discipline.
- Patients at consultation centers.
- Governments and Policymakers that enact policies officials.
- ICT Providers that aided the internet connectivity.

9.1 The Studied Area and Sample Size

The study was conducted across the six geographical regions of Nigeria where the university teaching hospitals were sited. These comprise Medical consultants, Patients, Policymakers, and ICT provider agencies in the regions. This technique was used to determine those who were given a questionnaire to get the sample size needed from the population. The selection was done based on the identification made by the stakeholders. 100 copies of the administered questionnaire were distributed among the population and 95 copies were returned. It represents the population response rate of 95% as follows:

i. Medical consultants and Nurse = 20
ii. Patients (outpatient) = 32
iii. Policy Makers (Govt. officials) = 32
iv. ICT Provider agencies = 31

The selected populations were asked to indicate freely how strongly each feels about the application of telemedicine for healthcare delivery compared to traditional face-to-face consultation.

9.2 Data Collection Instrument

A well-setup questionnaire was formulated and used in this study with the attempt to compare traditional face-to-face to telemedicine consultation as a proper channel to know the perspective of the selected population to know their views. This questionnaire was conducted to gather the necessary primary data for the study [24].

9.3 Data Analysis

The data analysis was carried out using Microsoft Excel to get the frequency distribution of the data captured. The descriptive survey was adopted to get the view of the selected population to infer the perception of the entire population. Table 1 shows the demographic of the participants.

10. Results

The population distribution of the selected population on the view of telemedicine implementation regarding the population's perceptions of the convenience, easy, inexpensiveness, satisfaction, the large network connectivity of users, ability of simultaneous communication, instantaneous/real-time and small delay of telemedicine over traditional face-to-face medication is shown in Table 2. However, Figure 9 shows how the questionnaire was distributed among the medical consultants, patients, Policymakers, and ICT providers in the studied area.

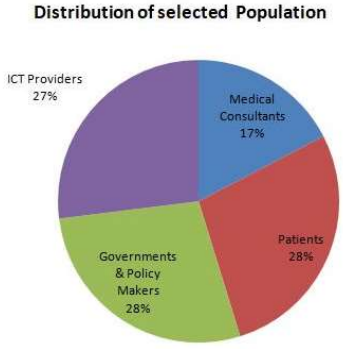

Fig. 9. *Distribution of population's View*

The population distribution of the questionnaire as shown in the Figure comprises Medical consultants 17%, Patients 28%, Policy makers (Government officials) 28%, and ICT providers 27%. Therefore, the result obtained from population distributions shows in terms of satisfaction stakeholders on ease of use, equipment setup expenses, technical reliability, time duration, trust among a large number of professionals, and diagnostic accuracy and convenience of patients. On satisfaction, the majority prefer traditional face-to-face 53% to telemedicine 46%; ease of use 55% preferred face-to-face due to the inability to use telemedicine equipment while 35% preferred telemedicine means of healthcare delivery; In terms of a large number of professionals, 22% prefer face-to-face while 78% prefer telemedicine application; equipment setup expenses, 58.8% prefer face-to-face while 41.2% prefer telemedicine; time duration(delay) 38% prefer face-to-face while 62% prefer telemedicine and diagnostic accuracy and convenience to patients 42.5% prefer face-to-face while 58.5% prefer telemedicine medium of healthcare delivery shown in Figure 10. In the overall result, 87.37 % of respondents preferred the application of telemedicine, and 12.63% preferred face-to-face healthcare delivery in terms of patient health management and satisfaction improvement. Therefore, the application of telemedicine enhances patient information sharing and the safety of both medical consultants and patients in case of any pandemic. Traditional face-to-face medication is only needed when the patient needs urgent medical attention that requires physical examination. Figure 11 show the six teaching hospitals (UCH Ibadan, Maiduguri, Jos, Zaria, Port-Harcourt, and Enugu) where medical practitioners diagnose patient remotely with the aid of telemedicine application with the corresponding 20, 12, 9, 22, 11, and 21medical consultants (practitioners) respectively.

Table 1: *Demographic of Participants*

Characteristics of Participants		**Frequency**
Main Category	**Subcategory**	
Gender	Male	84
.	Female	11
Ages (in Years)	36 - 45 years.	37
	46 - 55 years.	40
	≥ 56 years	18
Qualifications	Post Graduate	52
	Graduate/HND	43
	NCE/OND	31
Teaching Hospitals	UCH Ibadan	20
	Maiduguri	12
	Jos	9
	Zaria	22
	Port-Harcourt	11
	Enugu	21
Experiences	0 – 5 years	18
	6 – 10 years	15
	11 – 15 years	20
	16 – 20 years	17
	≥ 20 years	25
No. of consultants	0 – 5 Staffs	23
	5 – 10 Staffs	20
	10 – 15 Staffs	23
	15 – 20 Staffs	12
	> 20 Staffs	17
Preferred Diagnosis	Face-to-Face	12
	Internet/Web	24
	Telephone	12
	Videoconferencing	47

Table 2: *Medical Consultants and Patients agreeable medium of treatments*

Strengths	**Face-to-face**		**Telemedicine Applications**					
			Internet/Web		**Telephone**		**Videoconference**	
	Y	N	Y	N	Y	N	Y	N
Convenient	20	15	30	25	20	26	30	34
Easy	10	22	25	20	25	10	40	48
Inexpensive	60	50	10	20	20	15	10	15

Satisfactory	19	30	31	10	10	35	40	25
Large Users	10	35	25	30	30	15	25	20
Simultaneous Communication	25	35	10	20	25	24	40	26
Real-time base	10	30	15	35	15	25	60	10
Small delay	15	30	25	20	15	25	35	25

Table 3: *Medical Practitioner Metrics Assessment Evaluation*

Performance Parameters	Response Target	Number of Responses	Response Mean
System Reliability Index (SRI)	>3	95	3.33
System Ease of Usage (SEU)	<3	95	2.65
System Degree of Relevance (SDR)	>=3	95	3.02

Table 4:*The reliability and validity results of the stakeholders' view*

Items	Hypothesis	Cronbach's ∝
X1	Perceived ease of use telemedicine	0.80
X2	Perceived usefulness of telemedicine	0.74
X3	Usage view of telemedicine by medical consultants	0.75
X4	Self-efficacy and capability of telemedicine	0.75
X5	The social trust of telemedicine among medical consultants	0.70
X6	Institutional individual's trust	0.76
X7	Social active person participation	0.71
X8	Medical Consultant'sattitude to the Participation of Telemedicine	0.76
X9	Technological complexity perceptions of telemedicine	0.72
X10	Compatibility with the existing face-to-face values	0.75
X11	Expected user satisfaction acceptance of telemedicine	0.73
X12	Risk perspective regarding consultants & patient's satisfaction	0.72

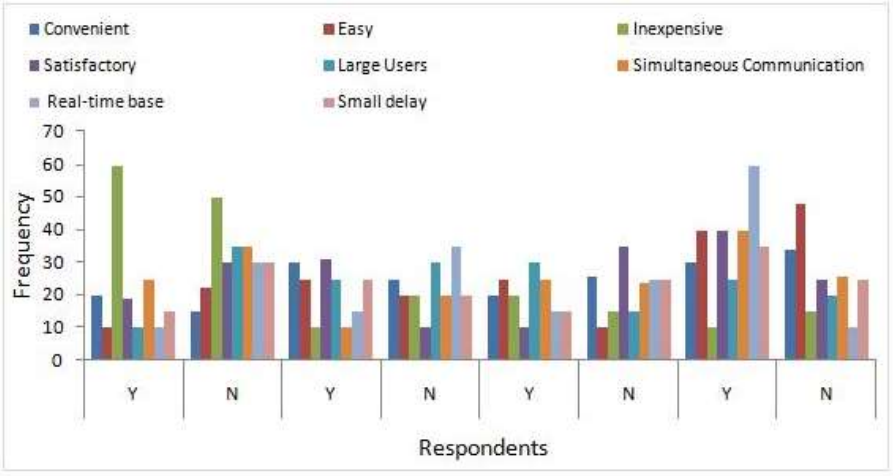

Fig. 10. *Bar Chart of Medical Consultants and Patients Agreeable preferred means of treatments*

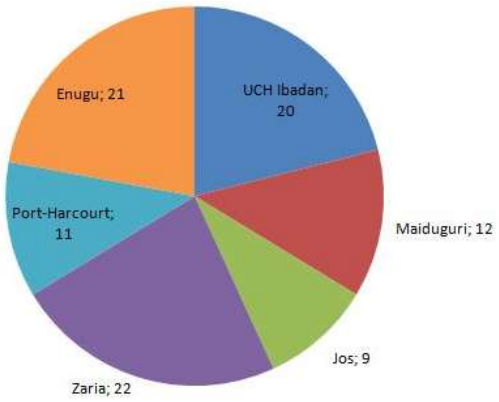

Fig. 11. *Distribution of Medical Consultants among the Six Teaching Hospitals*

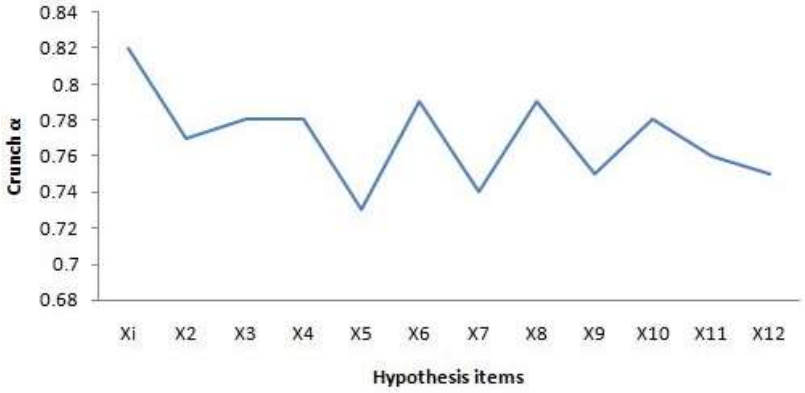

Fig. 12. *Graph showing reliability and validity analysis results of hypothesis (Table 4).*

11. Discussion

From the statistical analysis in Table 2, the telemedicine relevance to healthcare delivery in Nigeria was commendable compared to traditional face-to-face healthcare delivery. The result was capable of assisting the medical consultant in getting an accurate, decisive decision and reduction in wrong medications. The SRI, SDR, and SEU indicate medical practitioners' evaluation metrics assessment ratings shown in Table 3. SEU was low due to a lack of computer literacy, hardware requirements, and the cost of putting the system into use, and SDR and SRI are higher as a result of the integrity and relevance of telemedicine applications to healthcare delivery. However, the medical practitioners found the application of telemedicine relatively easy to use regarding the technical know-how requirement. The results of reliability and validity analysis of the hypothesis obtained from the Cronbach's $\propto$ ranges between 0.71 and 0.80 as shown in Figure 12 as deduced from Table 4.

Most of the respondents are optimistic that the benefits derived from telemedicine for healthcare delivery are more than that of traditional face-to-face medications. Most stakeholders(respondents) felt that the telemedicine application could be useful in enhancing medical care practices, patient management, and patient satisfaction while some were wary of the consequences of telemedicine in terms of cost, time, security, and diagnostic accuracy. However, ICT equipment usage in this case will help in the saving cost of purchasing telemedicine equipment and consultation expenditures. Therefore, policymakers should enact laws that will regulate the use of telemedicine in healthcare delivery practice.

The study is limited to Nigeria's healthcare delivery with small sample sizes of administered questionnaires due to insurgency of Boko Haram, bandits, kidnapping, and militancy of which the security of the researcher is not guaranteed. Probably this reduces the individual's views, thereby limiting the understanding of the stakeholders' contributing factors to discrepant views that could be biased to medical consultants to create equality concerning the strengths and weaknesses.

12. Conclusion

Telemedicine is a technology that connects medical practitioners or consultants with patients at a distance to ensure that there is adequate and proper medication. Therefore, it is helpful to medical office staff in eliminating the burden of patient check-in and concentrating on too much workload. Many medical practitioners and patients cherish the introduction of this technology in giving healthcare delivery to the people of Nigeria based on the ease, cost reduction of traveling to hospitals, and security of patients and healthcare workers against bandits, Boko-haram, and other evil-doers. However, medical practitioners are concerned with the cost, time, security, and diagnostic accuracy of medication along with teleconsultation setting, practice expenses, and diagnosis time. With the high increase in Nigeria's population, there is a need for telemedicine applications to give proper and efficient healthcare delivery. Telemedicine will enhance proper monitoring, diagnosing, and patient information sharing amongst healthcare providers at a distance through electronic means. Using Telemedicine in healthcare delivery in Nigeria in healthcare services is cost-saving for patients. However, the use of telemedicine cannot replace a traditional face-to-face meeting but can be used as an alternative. With online visit capability, medical consultants can take care of patients while still potentially assisting other patients within hospital premises. This reduces distance limitations by exchanging information about a diagnosis, care, and disease prevention between the doctor and the patient through electronic means. The most extensive telemedicine application can get healthcare services coverage closer to people who live in rural areas where quality treatment is otherwise impossible to access. Telemedicine has tremendously increased the quality of healthcare facilities by allowing the exchange of information across many distant areas. It expands accessibility to underserved areas, making it easier for them to schedule and hold appointments. Then people with reduced mobility get doctors' medications and prescriptions which they need more quickly. Telemedicine minimizes the doctors' and patients' traveling around the globe and changes each risk patient's life, ensuring that each sick person receives the appropriate healthcare treatment. Virtually, most medical consultants (practitioners) expressed positive views regarding telemedicine equipment and solutions that can bring beneficial values to medical practice in Nigeria. However, the study identified some challenges in the application of telemedicine in medical practice in terms of expenses, cost of equipment setup, time, technical incompatibility, and security issues. Based on the results obtained, the medical consultants (practitioners) are highly satisfied with its implementation.

Based on the findings from the results, the following recommendations:

- Computer Literacy programs should be made available to the unlettered segment of the populace to enable them to use telemedicine and digital health-associated technologies
- Low-cost hardware and software should be made available for low-income earners to use to access telemedicine.
- Outreach programs should be conducted to foster the use of telemedicine across various stakeholders.
- Training for healthcare workers should be provided to enable them to fully utilize the benefits of telemedicine.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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