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Assessment of the adoption of cloud computing system in the Nigeria healthcare sector

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Abstract

The Nigeria healthcare sector has potential for disruptive innovations that will help to raise the country's health outcomes using technologies such as cloud computing. However, lack of digitization hinders the effective delivery of healthcare services, making it difficult to track patient information, monitor treatment progress, and allocate resources effectively. This motivated the study to identify the specific healthcare services that can be improved through the adoption of cloud computing. In this study, a Figma software platform was used to design a prototype of the healthcare software while Java was used for building the healthcare software. The prototype can be found here https://bit.ly/3owXTZk. Findings revealed that cloud computing has the potential to surpass existing systems in terms of telemedicine, scheduling, health status monitoring, laboratory testing, and interactive knowledge sharing. The study therefore recommended that the implementation of healthcare software can reduce administrative costs, improve patient outcomes, and enhance patient satisfaction.

Keywords: Cloud Computing; Healthcare Sector; Figma Software Platform; Telemedicine; e-Pharmacy

JEL Classification: I18, K32

1. Introduction

Over recent years, technologies for self-monitoring and self-tracking have emerged, allowing patients to collect a wide range of health-related data outside the clinic. However, over 90% of healthcare and health related organization in Nigeria still use manual operation in providing services and interacting with their patients (Riggare, et al., 2019; Riggare & Hägglund, 2018).

The healthcare system in Nigeria is a complex mix of public and private healthcare providers and facilities, with significant regional variations in healthcare access and quality. However, the Nigerian healthcare sector is faced with numerous challenges due to inadequate infrastructure, limited healthcare access, and shortage of healthcare professionals (Edmonstone, 2021). One of the significant problems is the lack of digitization in the healthcare sector. The manual recording, usually maintained by a medical record officer or health information management professional, involves keeping patients' information in hospitals involving the use of paper-based systems for documenting and storing patient information. Manual recording and keeping of patients' information can be time-consuming and labor-

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intensive, and it can also be prone to errors such as misplacement, damage, or loss of records (Luepker, 2022). However, it remains a common practice in many hospitals in Nigeria, especially in areas where electronic health record systems may not be available or accessible due to limited resources and infrastructure.

The lack of digitization hinders the effective delivery of healthcare services, making it difficult to track patient information, monitor treatment progress, and allocate resources effectively (Toni & Mattia, 2022). Additionally, it also makes it difficult for people in certain areas to access healthcare services due to unavailability of digital means of connecting with healthcare services. Thus, patients must travel long distances to access healthcare facilities which would have been easy if there is a technological means. The absence of a digital system makes it difficult to manage healthcare facilities and resources effectively, resulting in wastage of resources, inadequate staffing, and poor healthcare outcomes. Hence, this study is embarked upon to investigate the influence of cloud computing on healthcare services in the Nigerian healthcare industry. The study seeks to identify the specific healthcare services that can be improved through the adoption of cloud computing, including data management, telemedicine, electronic health records (EHRs), and medical imaging (Olawale et al. 2022). Finally, the study will provide recommendations for policymakers and healthcare stakeholders on the implementation of cloud computing in the Nigerian healthcare sector, including the potential impact on patient outcomes, cost-effectiveness, and security and privacy concerns. The study will also develop user-friendly software which can be use by all stakeholders (service provider and the patients)

The introduction of ICT into the health sector can significantly impact healthcare delivery, enabling healthcare providers to provide better care, improve patient outcomes, and increase efficiency. Likewise, inherent in cloud computing is the ability to improve patient care, healthcare operations, and research, providing an efficient and secure way to store and access patient data electronically, which is a prime example of how cloud technology enables healthcare professionals to quickly access patient information from anywhere, anytime, and on any device.

Cloud computing is crucial to the delivery of telehealth services as it allows healthcare providers to remotely diagnose and treat patients without physical contact. Telehealth became particularly important during the COVID-19 pandemic, as it reduces the risk of infection and supports social distancing. Prior to the pandemic, digital health was only used to offer clinical and administrative tools to service users and professionals in the healthcare industry. Telemedicine, for instance, has been identified as a viable technology to improve healthcare delivery in Nigeria, particularly in rural areas (Oluwole & Adebowale, 2022).

Nigeria has a significant amount of potential and a great deal of room for disruptive innovations that will help to raise the country's health outcomes using technologies such as cloud computing. According to Olorunsaiye et al. (2021), digitalization has the potential to improve the quality of healthcare services and reduce the burden on healthcare facilities by providing remote access to healthcare services. The availability of cloud computing and digital access, which will have a significant influence on health and well-being results, is essential for the success of digital health in Nigeria. This project tends to provide sustainable solution to healthcare sector in Nigeria.

2. Literature Review

2.1. Cloud Computing

Cloud computing refers to the delivery of computing services, such as servers, storage, databases, networking, software, and analytics, over the internet ("the cloud"). These services are provided by cloud service providers who own and maintain the infrastructure, while customers can access and use them on-demand via the internet, without having to build or maintain their own IT infrastructure (Mell & Grance, 2011).Cloud computing is a model that enables on-demand network access to a shared pool of computing resources, such as servers, storage, applications, and services, that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell &Grance, 2011).

Cloud computing offers several benefits, including scalability, flexibility, cost-efficiency, and increased collaboration and productivity (Armbrust et al. 2010). Thus, transforming the way businesses and organizations operate and has become a key enabler of digital transformation. According to Chandra et al. (2015), there are several models of cloud computing, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). In IaaS, customers rent computing resources, such as servers, storage, and networking, from cloud service providers, in PaaS, customers have access to a platform on which they can develop, test, and deploy applications without having to manage the underlying infrastructure, and in SaaS, customers can access and use software applications that are hosted by cloud service providers.

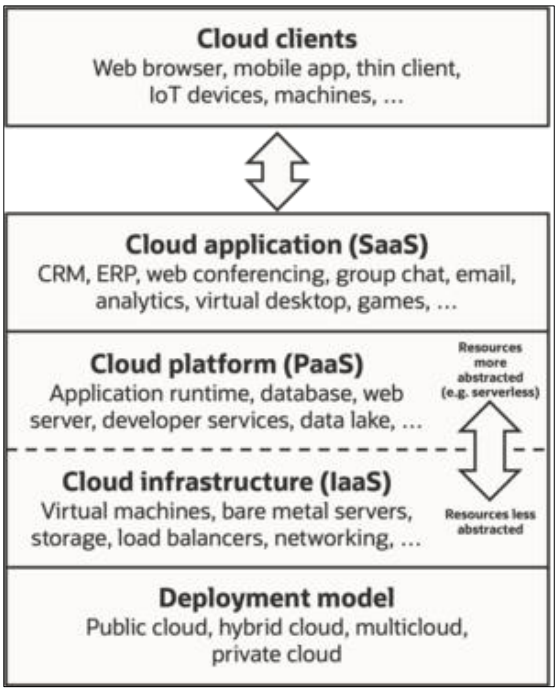

Figure 1 Cloud Computing Service Models (Source: VCE Guide 2023)

Cloud computing also presents some challenges and risks, including data security and privacy concerns, vendor lock-in, and service availability issues (Rittinghouse & Ransome 2016). Organizations must carefully consider these risks and implement appropriate measures to mitigate them.

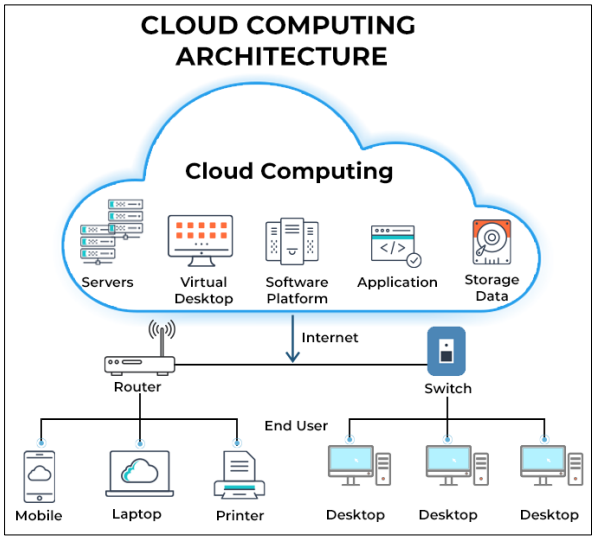

Figure 2 Cloud computing sample architecture (Source: Semantic Scholar)

The healthcare industry is rapidly adopting cloud computing technology to improve the quality of care, increase efficiency, and reduce costs. This literature review explores the use of cloud computing in healthcare, its benefits and challenges, and future trends.

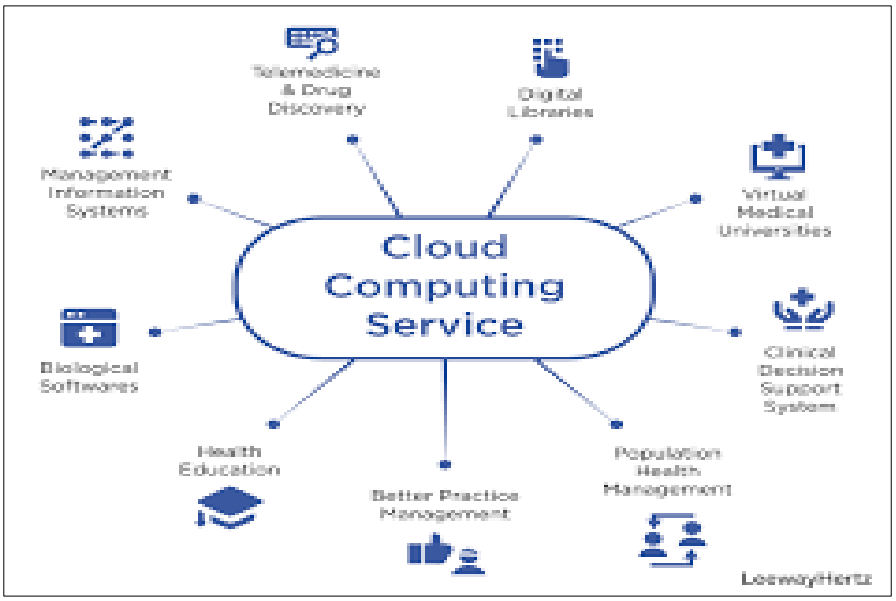

Figure 3 Integration of cloud computer in the health sector (Source: Scholar)

Therefore, cloud computing is becoming increasingly important in healthcare due to its ability to store and process large amounts of data. It enables healthcare providers to access patient information remotely, collaborate with other healthcare professionals, and analyze data for better patient outcomes (Shah &Mehta, 2019). One of the significant use cases of cloud computing in healthcare is data storage and management. Cloud storage enables healthcare providers to store and manage large amounts of patient data securely and efficiently. Cloud-based storage solutions can reduce the cost of data storage and eliminate the need for on-site storage infrastructure (Zhang et al., 2019). Moreover, cloud storage solutions can enable healthcare providers to access patient data from anywhere, thereby improving the quality and efficiency of healthcare service delivery.

Furthermore, cloud computing in healthcare can be used for telemedicine. Telemedicine enables healthcare professionals to provide medical services remotely through the use of technology, such as video conferencing and remote monitoring. Cloud-based telemedicine solutions can provide healthcare professionals with secure and reliable access to patient data, which can improve clinical decision-making and patient outcomes. Moreover, cloud-based telemedicine solutions can enable healthcare providers to reach patients in remote and underserved areas, improving healthcare access in these areas (Rho et al., 2018).Cloud computing can also be used for medical imaging. Medical imaging generates large amounts of data that require extensive storage and processing resources. Cloud-based medical imaging solutions can enable healthcare providers to store, share, and analyze medical images securely and efficiently. Cloud-based medical imaging solutions can also provide healthcare professionals with access to advanced image processing and analysis tools, improving the accuracy and speed of diagnosis (Luo et al., 2019).

3. Research Methodology

3.1. Designing the Healthcare Software

For the purpose of this study, a Figma software platform was used to design a prototype of the healthcare software while Java, a popular programming language will be used for building the healthcare software. The healthcare software is an application that will facilitate the management of patient information, clinical data, medical records and interactions. The prototype will be made responsive, showing all the navigation of the healthcare software and how it will be used by the end users.

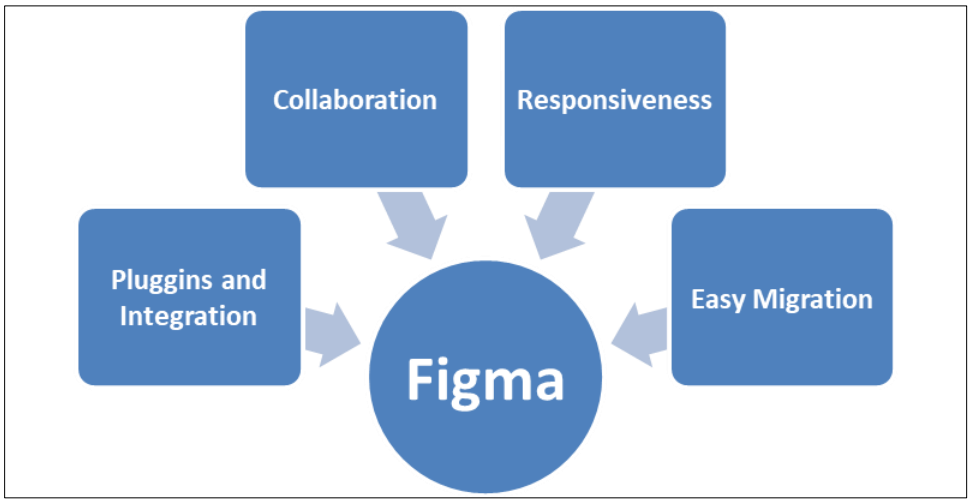

Figure 4 Using Figma for designing Healthcare software prototype (Source: Author 2023)

Structurally, HSC will have 3 component parts on development, including:

- The users: Sign-up, register their details, book appointment with health practitioners, schedule date for laboratory tests, order for drugs, read about health tips etc.
- The Administrative: Approve scheduling request, confirm the KYC of the users, process the users' request.
- The Technology Maintenance: Fix bugs at any time, access and control, data processing and insight generation.

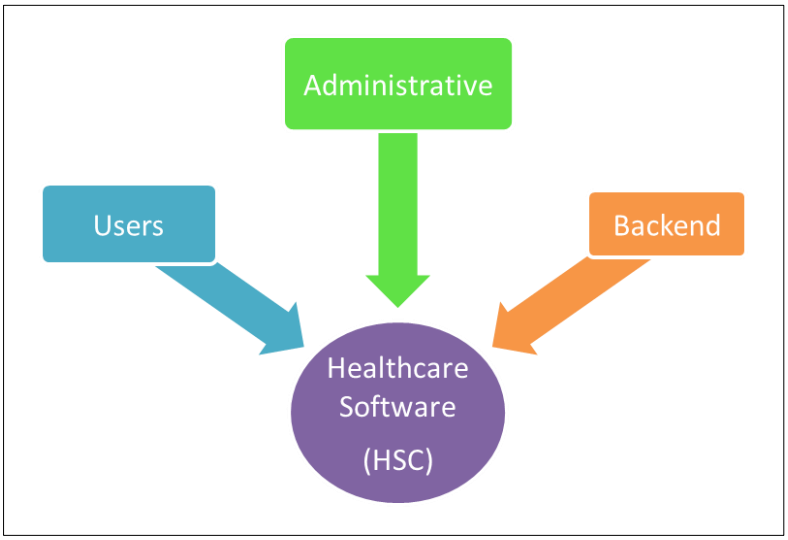

Figure 5 Structural Design of HCS Application

3.2. The Functional Design for Healthcare Software

Functional design involves breaking down the system or application into its functional components and specifying how they interact with each other to achieve the desired behavior. The goal of functional design is to ensure that the HCS software meets the requirements of its users and stakeholders.

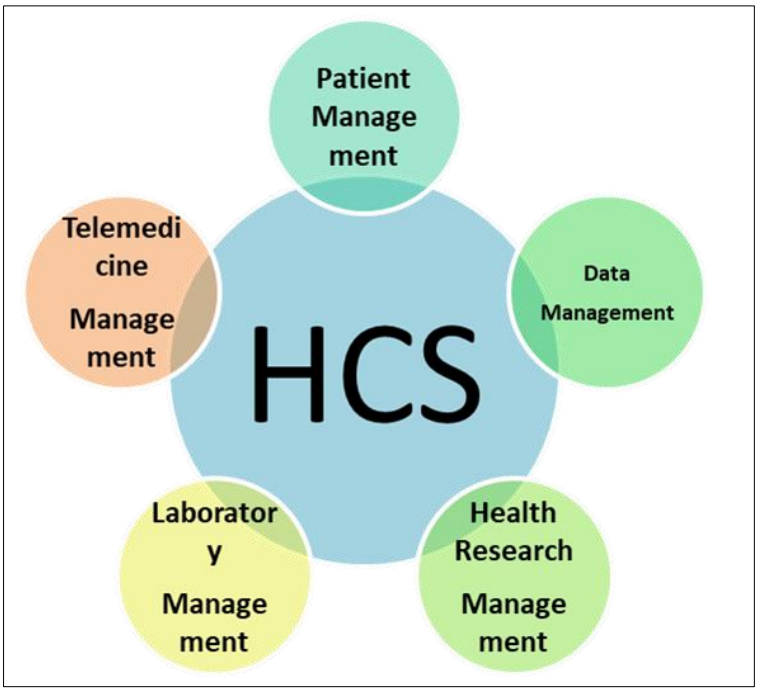

Figure 6 Functional Design of proposed HCS Software(Author 2023)

3.3. HCS Prototype Software Workflow

- The user/patient registers with their details on the HCS platform e.g name, phone number, email.
- The user selects the desired hospital and location to use.
- The user writes the purpose of contact, upload any further details and schedule appointment on the available date on the platform.
- The administrator approves or process the request of the patient/user
- User can also fund their account with ATM, USSD code or makes payment manually and upload the receipt for immediate approval.
- Customer records are stored and can be access or transfer to another hospital as requested by the user.
- Users get an automated mail before and after their appointment or usage of the HCS application
- Track overall effectiveness and improve processes where necessary.

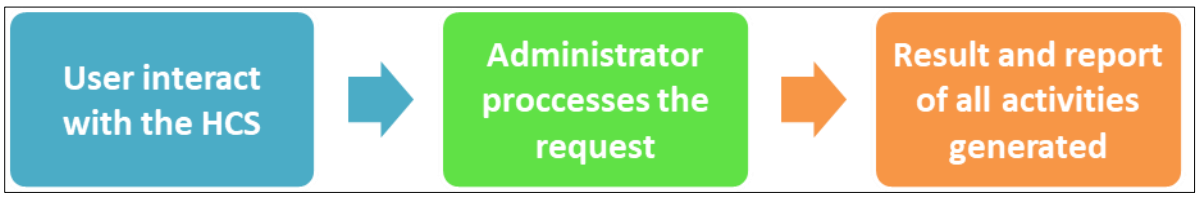

Figure 7 HCS Workflow for Improvement over Manual Processes (Author 2023)

To ensure the software can handle large user loads and function correctly, it is crucial to conduct unit testing before deploying it to the cloud for public use. This practice will help to evaluate compliance and readiness for user traffic and identify any potential bugs or issues that may arise. By addressing these challenges before release, it will assist to increase user satisfaction and reduce the likelihood of disruptions or downtime.

3.4. The 12-Factor App Development Model

The 12-Factor principle is a methodology for building software-as-a-service (SaaS) applications that are scalable, maintainable, and portable. These principles were originally introduced by Heroku co-founder Adam Wiggins in 2011 and have since become a widely adopted framework for cloud-native application development.

Figure 8 The 12 Factor App Principle (Singal, 2020)

The 12 factors are as follows:

- **Codebase:** One codebase tracked in revision control, many deploys.
- **Dependencies:** Explicitly declare and isolate dependencies.
- **Configuration:** Store configuration in the environment.
- **Backing services:** Treat backing services as attached resources.
- **Build, release, run:** Strictly separate build and run stages.
- **Processes:** Execute the app as one or more stateless processes.
- **Port binding:** Export services via port binding.
- **Concurrency:** Scale out via the process model.
- **Disposability:** Maximize robustness with fast startup and graceful shutdown.
- **Dev/prod parity:** Keep development, staging, and production as similar as possible.
- **Logs:** Treat logs as event streams.
- **Admin processes:** Run admin/management tasks as one-off processes.

When it comes to developing healthcare software, there are several programming languages to choose from. However, the most important programming language to power a healthcare software development which will assist to achieve scalability, performance, and security. Figma is a design tool that is commonly used for creating prototypes and mockups of digital products such as websites, mobile apps, and software interfaces. While it is not a software development platform, it can be a helpful tool in the design process of healthcare software and all the needed functionalities.

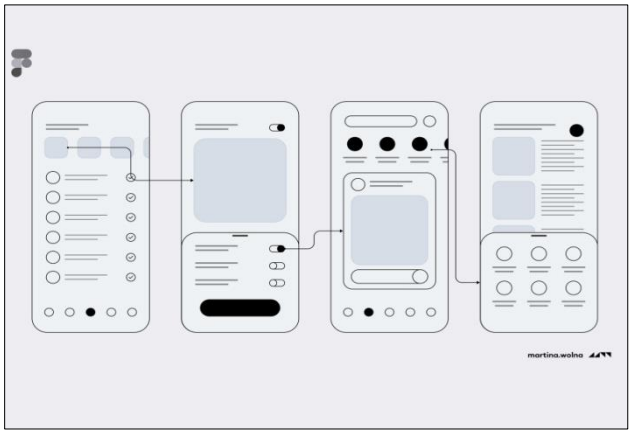

Figure 9 Request-Response Lifecycle in Figma

3.5. User Interaction for Data Input, View and Retrieval

This approach will ensure that the user interface is designed with the user's needs and preferences in mind, making the software more user-friendly and efficient using a server that can translate data into a readable format via the webpage. The user (patient) signs up and logs into the application to request for the health report (over a specific period of time) and history, schedule meeting with health practitioners, check drugs prescription and make order for it. After this, the service gives a response through a request-response cycle (Hou et al, 2016).

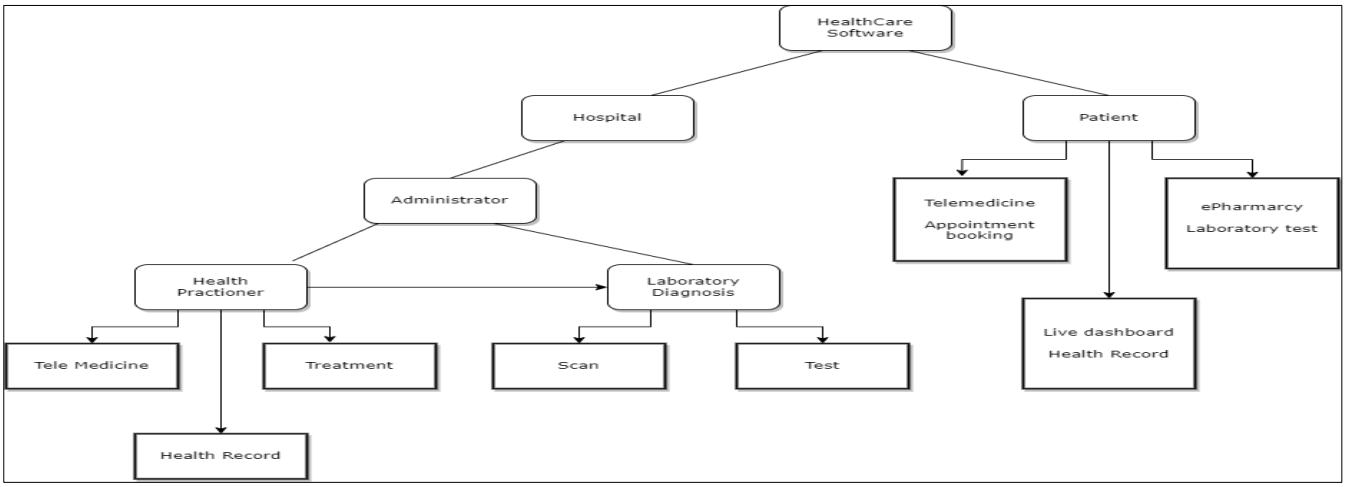

Figure 10 Use case of the HCS Application (Author 2023)

3.6. Access to Healthcare Software Prototype

The prototype of this study can be fund here. Kindly visit https://bit.ly/3owXTZk

The healthcare software is design to allow two different users to access it, the patient and health practitioners. This is to ensure that each of the end users have peculiar access to the platform and they can use it for different purposes.

Figure 11 The registration page for patient and doctors using HCS application

Here, the end users (patients) have access to their Personal profile; Medical report; Add fund to the account; Withdrawal funds from the account; Telemedicine; and Transfer their file to other medical centres.

Figure 12 The patient interface page for all activities

This healthcare software provided this platform for;

- Health practitioner: To prescribe drugs digitally and monitor the usage by the patient.
- Patient: To have access to the details of the drugs, the usage method and the expected outcome of it.

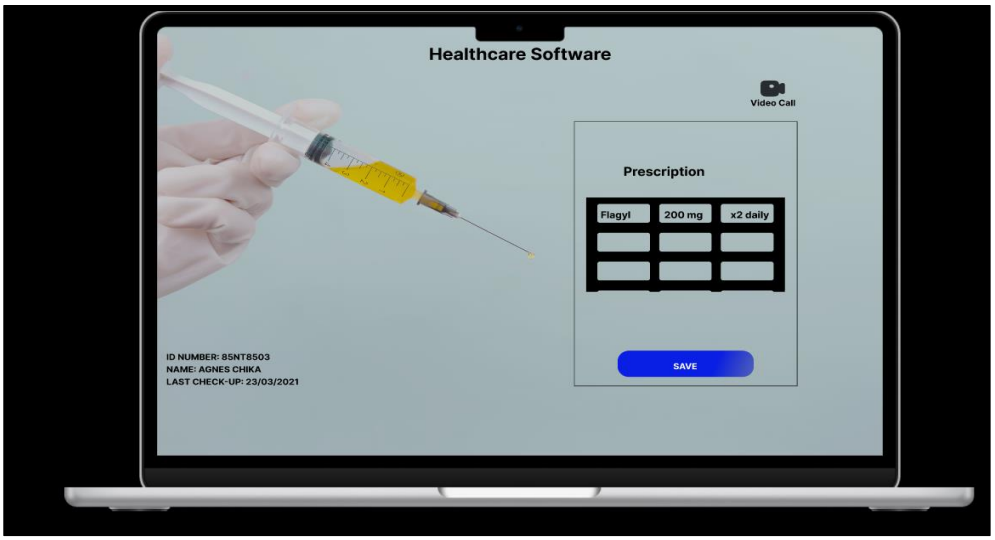

Figure 13 Patient Page for e-Pharmarcy

Telemedicine involves the use of video conferencing, phone calls, messaging, and other digital communication methods to provide medical consultations, diagnoses, and treatment plans.

Figure 14 Patient-Practioner Tele-medicine portal

Figure 15 shows the health practitioners' dashboard which is a digital tool that provides a comprehensive and centralized view of a patient's health information and allows them to track patient progress, view medical histories, and monitor vital signs, among other things.

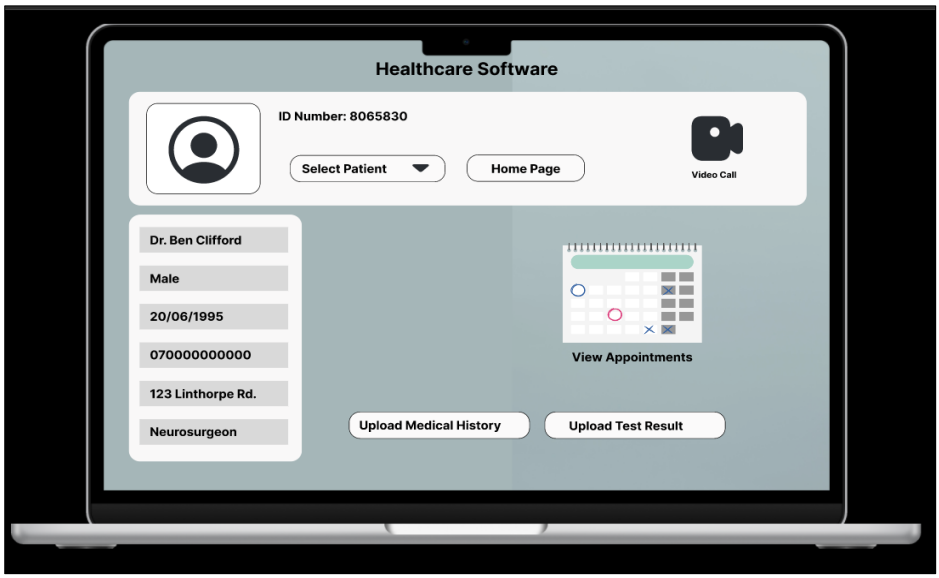

Figure 15 Health practitioners' Dashboard

The dashboard provides a centralized information to the administrators to view real-time data, allowing them to quickly identify areas that require attention and make informed decisions to improve patient care and operational efficiency as shown in Figure 16.

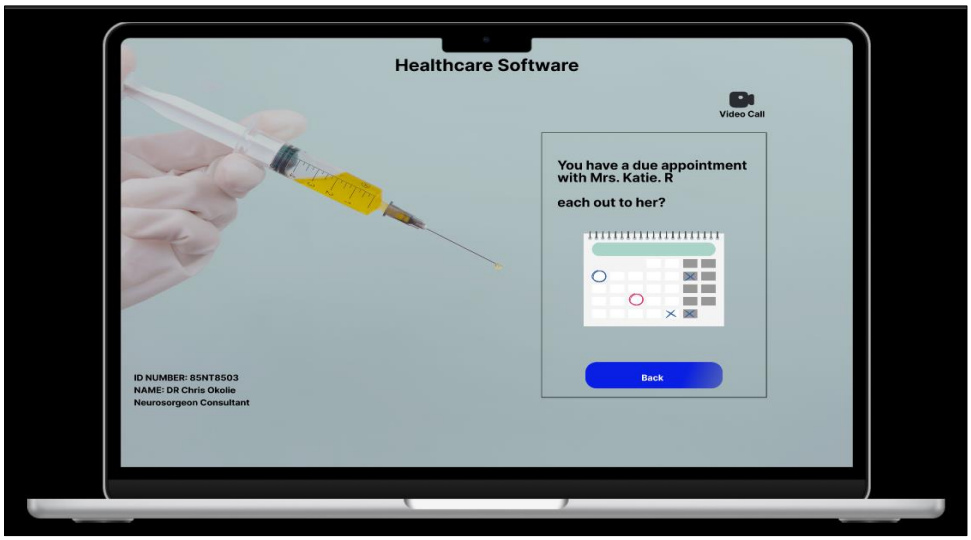

Figure 16 HCS Administrative Dashboard

3.7. Evaluation of Implemented Design

System evaluation is a process of assessing the performance, effectiveness, efficiency, and overall quality of a system, involving gathering and analyzing data to determine how well a system is meeting its intended goals and objectives, and identifying any areas for improvement. The evaluation process typically involves collecting data on various aspects of the system, such as its functionality, reliability, usability, maintainability, and security. This data can be collected through a variety of methods, such as user surveys, performance testing, and system logs. Once the data has been collected, it is analyzed to identify any issues or areas for improvement. The evaluation team may then recommend changes to the system, such as software upgrades, changes to user interfaces, or improved security measures.

3.8. Ethical Considerations for the New System

The design and implementation of healthcare software needs important ethical considerations and this include;

- Patient privacy and data protection: Toensure that patient data is kept secure and confidential.
- Bias and discrimination: To prevent bias or discrimination against certain patient groups, there is testing of the software on diverse populations, using unbiased data sets, and involving ethicists in the development process.
- Patient safety: Healthcare software is designed to prioritize patient safety, with built-in safeguards to prevent errors or adverse events.
- Accessibility: The healthcare software is designed to be accessible to all patients, regardless of their abilities or disabilities.

3.9. Healthcare Software Implementation Status and Testing

Table 1 Healthcare Software Implementation Status and Testing

Requirement	Status
Patient Status Tracking System	Passes
Administrative management	Passes
Telemedicine	Passes
ePharmacy	Passes
Information management testing	Partially passed
Performance	Passed
Reliability	Passed
Collaboration	Satisfactory
Security of data and system in cloud	Fair

3.10. Security and PII Protection

Healthcare software is one of the most important and sensitive areas where strong security and protection of personally identifiable information (PII) is essential. The software is used to store and manage sensitive patient information, including medical records, treatment plans, prescriptions, and insurance information, among others, with implementation of strong security measures to protect against unauthorized access, data breaches, and other security threats, including strong passwords, multi-factor authentication, encryption of data at rest and in transit, and regular security updates and patches. Also, regular security audits and risk assessments to identify and address potential vulnerabilities must be done.

4. Conclusion

Cloud computing will make the healthcare sector in Nigeria more technologically innovative, reducing high loss of life of patient, stressful operational procedures, replace traditionally method of accessing healthcare through the telemedicine, e-Pharmacy, live chat, appointment scheduling and other added features. Tests of the system requirements and evaluations of the effectiveness of the online deployment produced commendable outcomes. To fulfill the criteria, ethical considerations were properly accessed. Healthcare software has the potential to surpass existing systems in terms of telemedicine, scheduling, health status monitoring, laboratory testing, and interactive knowledge sharing.

Recommendation

The prototype system not only showcases how gaps in healthcare information systems can be filled, but also reveals potential opportunities for innovation in this field.

- The adoption of cloud computing will allow patients to communicate with their healthcare providers via telemedicine, which saves time and money. With the use of healthcare software, patients will be able to monitor their health conditions, access educational resources, and receive alerts and reminders about their medications and appointments. Thus, cloud computing helps to improve patient safety by reducing medication errors and providing accurate medical information.
- Using healthcare software can greatly impact healthcare professionals, providing them with tools to enhance patient care, streamline workflows, reduce administrative burdens, and providing real-time access to patient information, lab results, and treatment plans. Additionally, the healthcare software is built to provide decision support systems that can assist healthcare professionals in making informed decisions about patient care, including diagnosis, treatment, and medication management. Also, healthcare professionals can also communicate with other healthcare providers, track patient progress, and manage patient data more efficiently.
- More importantly, the healthcare software will benefit all stakeholders in the Nigerian health sector including healthcare organizations, government agencies, and insurance providers. This can help organizations reduce administrative costs, improve patient outcomes, and enhance patient satisfaction.

- The healthcare regulator should oversee the use of the software in order to maintain the confidentiality and privacy of users data. The information of the users must be made confidential, thus avoiding third party from accessing the platform.

Compliance with ethical standards

Disclosure of conflict of interest

Authors declare that there are no conflicts of interest regarding the publication of this paper.

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