

Development of a Secured Web-based Healthcare Information System (HIS) for Federal Polytechnic, Ile Oluji Community

¹O. O. Olasehinde, ¹O. S. Egwuiche, ¹J. T. Fakoya, ¹M. O Ajinaja
¹Department of Computer Science, Federal Polytechnic, Ile Oluji, Nigeria
Corresponding Authors' Email: olaolasehinde@fedpolel.edu.ng

Abstract

Patient's medical records are needed for accurate diagnoses and treatment of the patients. It ensures comprehensiveness accessibility to patient's records by authorized and authenticated medical personnel whenever it is required. The existing manual system of management of medical records at the Federal Polytechnic (FEDPOLEL), Ile Oluji, is associated with problems such as; delay in retrieval of patient's record, duplication of patient's, lack of security and privacy for the patient's records as well as lack of effective backup of medical records. The project aimed to develop a secured and Web-Based Health Information System (HIS). A secured Web-based HIS will overcome the fragmentation of the healthcare system, enable secured methods of sharing patient information among authorized and authenticated users for the diagnoses and treatment of patients. The proposed HIS implements a Multilayers security techniques such as Firewall, IDS, authentication and access control, and a regular backup of patient's information for the security of patient's records and preservation of the privacy of their confidential information. This work also addresses the protection of patient's medical records against theft, corruption, hostage, and unauthorized disclosure. C# programming language, HTML, CSS, Javascript, and PHP as the Scripting languages and MySQL as the database engine, were used to implement the proposed system. The system grants different access privileges to different users based on their exclusive roles in the clinic. The system's deployment shows efficiency in storing, retrieving, and protecting patient medical records. It also shows great improvement in the Federal Polytechnic, Ile Oluji Clinic's services delivery.

Keywords: Use-Case, Medical Records, Patients, Diagnosis, Treatment, Information Technology

Introduction

Information technology (IT) has revolutionized the way business is being carried out. Many organizations relied on information systems for their operations. Banks, hospitals, supermarkets make use of information for efficient delivery of their services. IT has been utilized to plan, decision-making, monitor, and manage health systems [1].

Quality medical care delivery can only be guaranteed if the patient's records are accurate, comprehensive, and accessible to all parties that required it to treat patients [10]. The existing manual method of recoding, accessing and processing of patients medical record being implemented at Federal Polytechnic, Ile Oluji (FEDEPOEL) raise many challenges such as; omission of patient's information, duplication, and misplacement of patient's records, lack of backup of patients records, non-accessible of patients records by all parties that need them at the same time.

Information systems for clinical decision-making dating back to the 1960s have been found to reduce

medical errors in the healthcare industry [2]. Health Information System (HIS) is an IT system that provides various solutions in health management. It has been used to collect, process, store, and transfer health and patient's medical information among medical expect for the diagnoses and treatment of patients. Patient information is needed for planning, decision making, and the provision of quality health service. HIS is a set of hardware, software, and procedural guidelines for preventive and curative health management [3]. It manages aspects of healthcare, such as clinical, administrative, and finance [4]. A Web-based health Information system is computer programs accessed over the internet using a web browser [5]. It enables detailed patient medical information sharing and management of all activities being carried out on the patients. A secured web-based health Information system is a healthcare application that protects the patient's sensitive information during and after the patient's interaction with various healthcare providers to obtain quick healthcare services. It enables patients' information sharing and coordinates admission, diagnosis, treatment,

and discharge of patients. A health information system is a digital version of a patient's case note that stores data about current and past diagnoses, treatments, test results, diagnoses images, and other patient medical information. HIS enable each patient to have access to information about their health status [2]. The provision of accurate and timely information required by the health policymakers and medical personnel to make an effective evidence-informed decision is one of every HIS goals [7]. Patient's medical records must be checked to ensure their overall quality, correctness, and relevance before storing them in the HIS [6]. Useful information extracted from the patient's medical records is needed for health planning [8].

The design of HIS must be user-friendly and cost-effective. Usability requirement is critical in the design of the HIS. The usability should include; Effectiveness, which measures how well users get their job done accurately and completely. Efficiency measures the HIS productivity in terms of the duration required to perform a given task, and finally, Satisfaction, which is the degree to which users like the HIS. Apart from tracking patient treatment history, access to medical profiles of patients, other benefits of HIS includes [9].;

- a) Improves the accuracy of cares given to the patients
- b) Increase service timeliness
- c) Improves service delivery and capacity
- d) Enforce patients' privacy and security
- e) Reduce the cost of personnel and inventory levels,
- f) Reduce operational cost
- g) Increase the quality of care given to the patient

The manual method is presently being used to manage both staff and students' medical records at the Federal Polytechnic (FEDPOLEL) ile oluji health clinic. The drawbacks of the manual method highlighted in [10] motivated developing a secured and web-based HIS for FEDEPOLEL.

The proposed system will incorporate all the HIS benefits highlighted in [9]. The HIS will be accessible from any place that has an internet connection. It will secure patients' medical records against theft, corruption, preserve patient's privacy and improve the clinicians' efficiency in the discharge of their duties.

Related Works

A high percentage of government and private health facilities in Nigeria still use conventional manual filing systems to store their daily activities and manage patients' records. There is a high risk of information loss associated with this style of information management. As technology advances, efficient record keeping is

important in this current digital age. Adopting Information and Communication Technology (ICT) in healthcare management can help healthcare industry stakeholders improve their service delivery drastically. The information age redefines the healthcare system [11] and establishes a robust relationship between patients and medical officers [12]. For instance, the World Wide Web as a platform has made it easy for the public to access health information [13]. The potential to improve patient care through better compliance with standardized guidelines, clinical decision support, and other measures is promising. Even in countries that lack human expertise and financial resources [14], the Health Information System will improve data quality and efficiency management of patients [15]. The rapid growth in the information age is the backbone of the transition from the manual system to the electronic system of medical records management [16].

Health facilities that deploy ICT in their operations have their services easily accessible by the public with a feedback mechanism that captures their patients' opinions [17], [18]. The work in [19] develops a web-based electronic medical record-keeping system in Vietnam. The system interfaces medical equipment for the acquisition of medical data. The medical records are accessible to hospital medical staff and patients to make the healthcare system more efficient. Protection of medical records was not incorporated into the design of this system.

Authors in [20] reported the importance of developing a healthcare system that aids medical practitioners to provide quality service, the security of patient data, supervision, and data management. [21] Highlighted the benefits of Information Technology (IT) initiatives in primary health care in developing countries. HIS reduces cost and improves productivity in the management of patients' information. Detailed, comprehensive, and precise medical records empower healthcare professionals such as doctors and nurses to treat patients to the best of their ability and capability. It guarantees a high level of control and security of the data [22]. Every iota of data is very important to healthcare professionals because all accumulated information can contribute to every patient's proper health management in any health facility.

There has been a massive wave on using IT and its component in transiting any existing health data to a comprehensive community health information system for wider coverage and improved service delivery [23], [24]. The application of information systems and its component into primary health care has unlocked the potentials of providing unified, cohesive, and harmonized health care, which improves the quality of healthcare services and duly increased attention on the

healthcare user [25].

The study in [26] assisted medical practitioners in discharging their duties quickly and accurately, and it provides fast retrieval and processing of the stored patient's records. [27] carried out a study on assessing health management information systems in primary healthcare centers in Edo State, Nigeria, and reported that most health personnel positively impacted by the system. Non-adoption of HIS could lead to misdiagnosis, mix-up of laboratory and medical report as well as mismanagement of patient [28], [29]

Protection of the patient's confidential information against theft, hostage, unauthorized access, use, disclosure, disruption, modification, or destruction is very important in designing and implementing a HIS. Information security aims to keep the privacy of the patient and medical records. Privacy challenges have been a major barrier to the deployment of HIS [30]. Encryption techniques are a widely used method of securing medical information [31]. Encryption techniques use algorithms to convert medical information into a difficult unreadable form to an unauthorized user. Decryption's keys, which are only known to the authorized users, are required to convert the medical information into a readable form.

Design Methodology

System design involves defining the architecture, components, modules, interfaces, and data for a system to satisfy predefined requirements. The purpose of the design phase is to plan a solution for the specifically identified problem. It identifies the modules relevant to the system, the specification of those modules, and how they interact to produce results. The configuration of the web-based application is performed based on the multi-tiered services. The architecture of the model consists of the following:

- a. Web client, i. e., the first tier, facilitates a standard

user interface that allows the user to retrieve information (in the form of HTML/XML pages) or activate applications (HTML/XML page fields).

- b. Web server, i. e., the second tier, processes and redirects user requests, gather results, and sends them to the client in HTML/XML pages. Thus, it provides a middleware platform integrating the desired functionality into the HTML/XML documents.

The design of the proposed HIS involves two stages: Physical design and Database design.

Physical Design

The physical design is a graphical representation of a system showing the system's internal and external entities and the flow of data into and out of these entities. An internal entity is an entity within the system that transforms data. To represent the physical design of the system, we used the use case diagrams. A use case is a methodology used to analyze and identify system requirements. It shows the interactions between the system being design and its users. Use-case diagrams present the visualized observable interactions between the actors and use cases (the system under development). The actors (figure 1) represent the users of the proposed system, and the use cases (figure 2) depicts the various actions that can be performed by the actors.

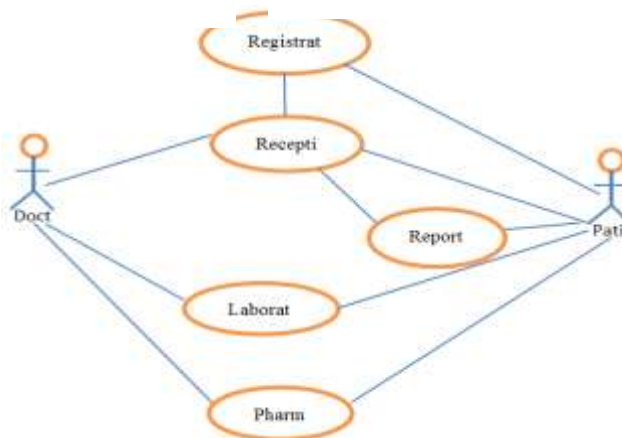
A Use-case diagram is useful for getting an overall view of the proposed system. Figure 3 shows the use case diagram of HIS. The Use cases in figures 4 to 9 show the roles performed by the various actors of the proposed HIS.

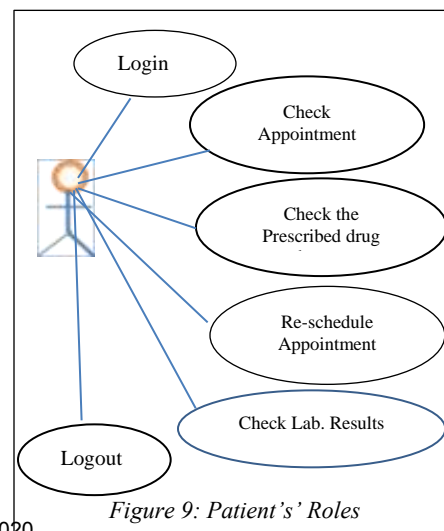
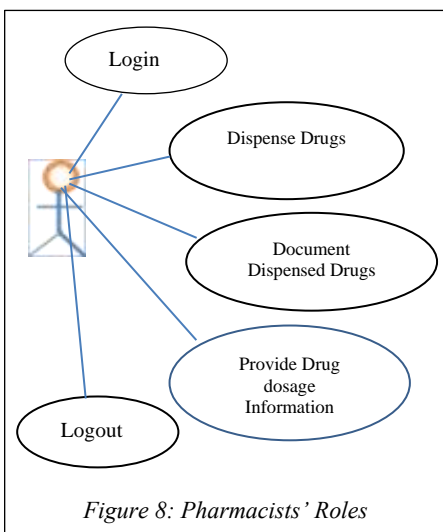
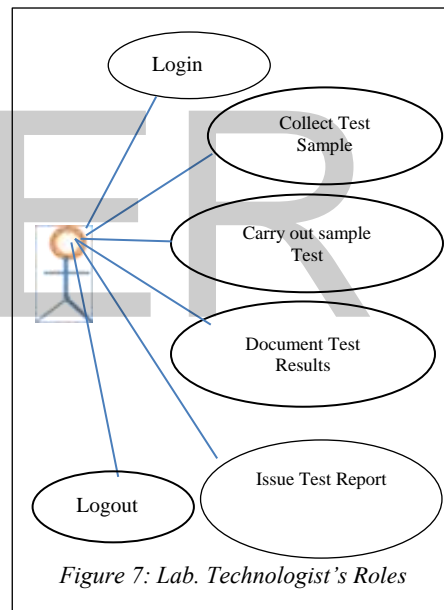
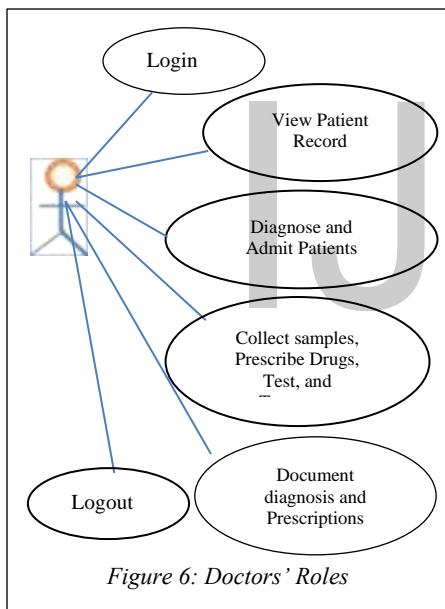
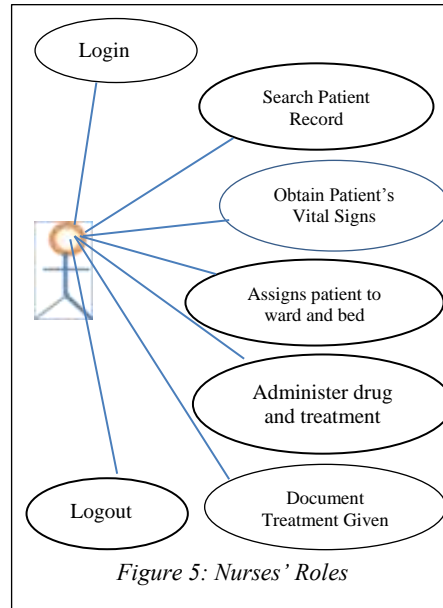
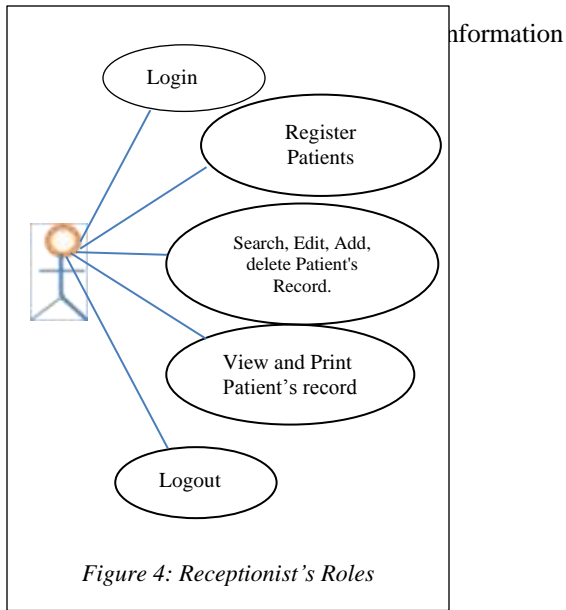


Figure 1: Actor



Figure 2: Use Case





Database Design

Database design involves modeling all the tables or entities and their relationship for the HIS's successful design and implementation. The Entity-Relationship

(ERD) graphical representation that shows the relationship between the entities and attributes for the proposed database design is shown in figure 10

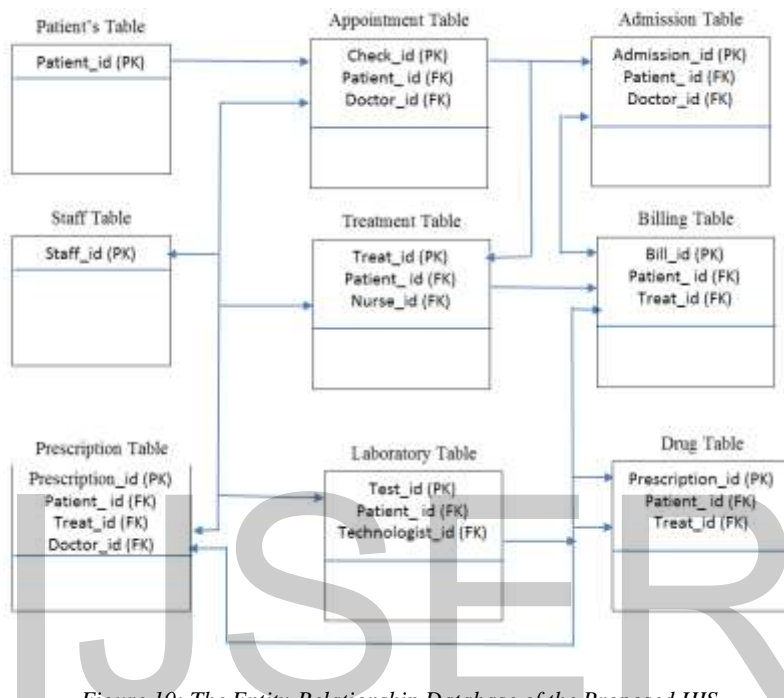


Figure 10: The Entity-Relationship Database of the Proposed HIS

HIS Proposed Security Design

The security design of the proposed HIS is shown in figure 11. All traffic access to the HIS passes through the firewall. The firewall module is configured to prevent illegitimate traffic (packets) from passing through the internet into the HIS. Legitimate traffics requests are allowed to pass through the firewall into the Intrusion Detection System (IDS). The IDS checks the traffics for intrusive packets. Intrusive packets are prevented from accessing the HIS. The IDS will track down a legitimate masqueraded packet that maneuvers itself through the firewall. The IDS enforces the availability, integrity, and confidentiality of the HIS. Every access into the network server is subjected to the authentication and access control policy of the HIS. Access control protects the HIS from unauthorized users and gives authenticated and authorized users access based on their user types; six categories of user types are implemented in this design; doctor type, nurse type, receptionist type, pharmacist type, lab technologist type, and patient type, the possible allowable roles carried out

by each of these user types are described in figures 4 to 9.

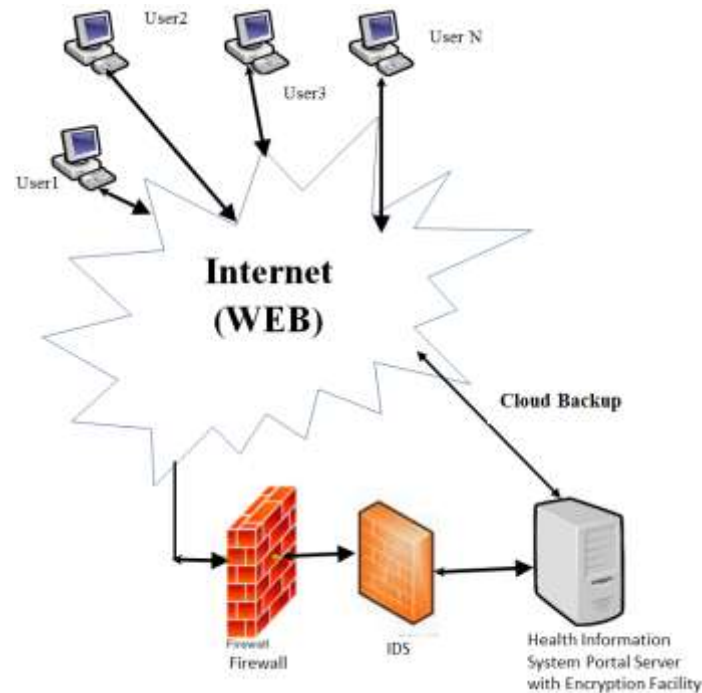


Figure 11. The architecture of the Secure Web Base Health Information System.

HIS Implementation

The web application was developed using the following tools:

1. HyperText Markup Language 5 (HTML5). It is the latest version of HTML. It was combined with other tools to design the frontend, otherwise called the user interface.
2. Cascading StyleSheet (CSS). It is used to style and format the structure and design of the frontend.
3. Bootstrap. It enhances the system's responsiveness.
4. Javascript. It enhances and increases the speed of the system.
5. C# is the programming language of development.
6. SQL Server is a database management system used to store and retrieve data on every request triggered by the system's users.
7. Net Core is used as the framework of deployment in this project.

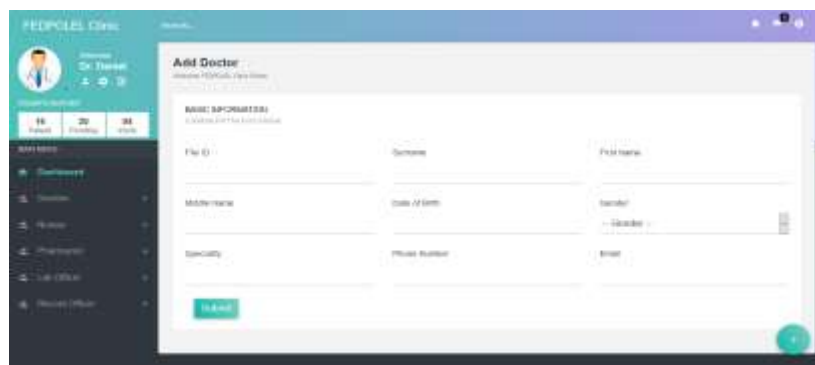


Figure 12. Add New Doctor.

Figure 12 is a page that allows the chief Doctor or the global admin to add new doctors.

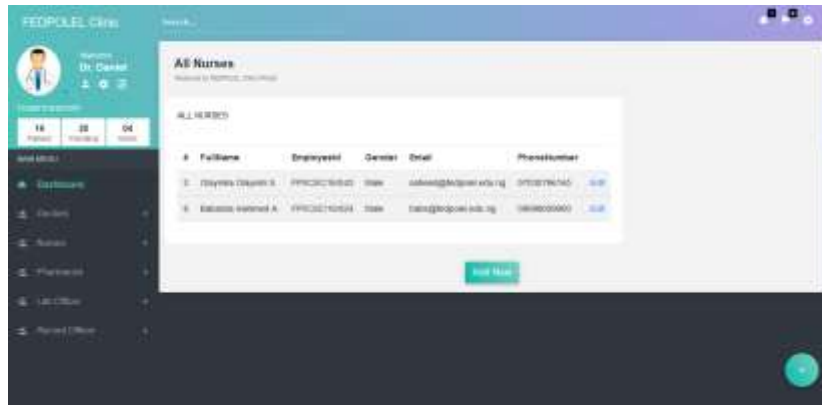


Figure 13. View list/add new Nurse (by Doctor).

Figure 13: This is a page that displays all nurses registered on the website. It is only accessible by the global admin and

the chief Doctor. The Doctor can see all nurses and add new Ones to existing ones or create new ones if no nurses exist.

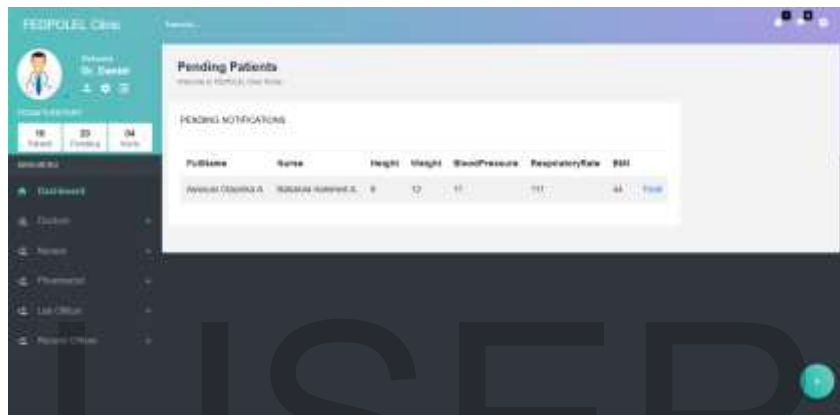


Figure 14. Patients awaiting the Doctor's appointment/treatment.

Figure 14 is a page that displays all patients awaiting treatment or appointment. Before a patient can be displayed or added to this list, a nurse must have an active account after carrying out some preliminary checkups. The page displays the patients based on First-In-First-Out (FIFO). From this page, the Doctor can then attend to a patient, schedule an appointment, prescribe drugs, or instantly give treatment.

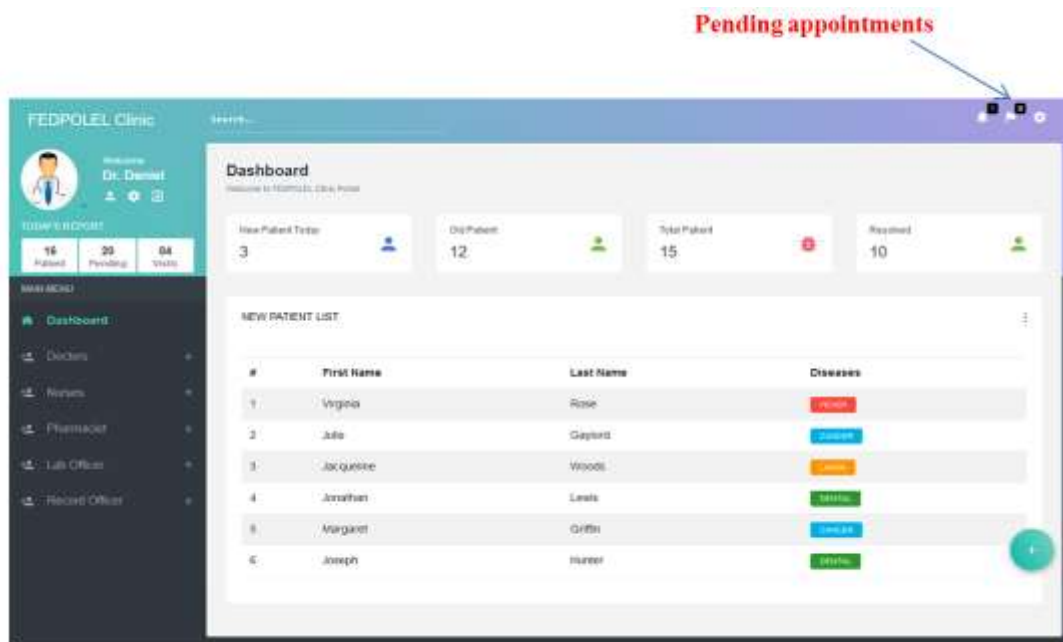


Figure 15. Doctors' Dashboard.

Figure 15: shows the Doctor's dashboard. On this page, the Doctor can summarize the whole system, including the number

of new patients, number of all patients, number of patients attended to daily, the last ten patients added to the system.

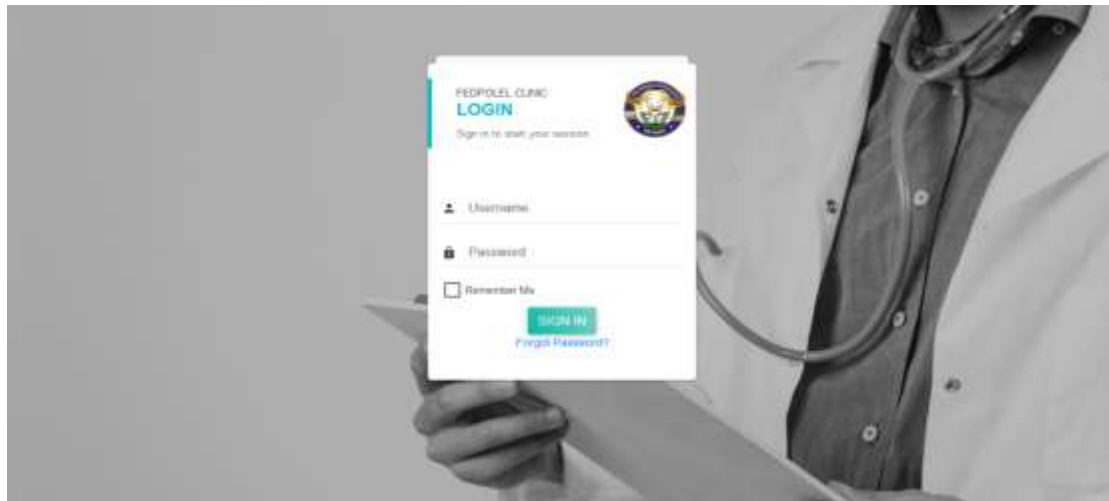


Figure 16. Central Log in Page.

Figure 16: is the main login page for every user on the system. Once valid login credentials are supplied, the system detects the user's role (assigned while added to the system) and redirects the user's dashboard based on the role. Returns "Invalid username/password" if otherwise.

Conclusion

We present the design and development of a secured and Web-based Health Information System for the Federal Polytechnic, (FEDPOLEL) Ile Oluji Nigeria. The drawbacks of manually searching for patients' files and their processing for medical treatment have been addressed in this work. Security and privacy enforcement of patients' confidential information against theft, corruption, hostage, and unauthorized disclosure are also addressed in this work. Multilayers security techniques such as Firewall, IDS, authentication, access control, and the regular backup of patient's information were implemented in this work. Encryption techniques' were employed to enforce confidentiality and preservation of the privacy of the patient's records. C# programming language, e and SQL database, was used to implement the proposed system. The HIS implementation shows efficiency in the storage and retrieval of patient records and great improvement in the service delivery of the FEDPOLEL clinic.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgments

The authors acknowledge the following Agency and individuals for their support and contributions towards the successful design, planning, and implementation of this

Institutional Based Research;

- a) The Nigerian Government, through the intervention of the Tertiary Education Trust Fund (TETFund), provided funding for this institutional Based Research (IBR) for the Federal Polytechnic, Ile-Oluji Community.
- b) Medical Director, FEDPOLEL Clinic, Nigeria, and his team provided all the necessary information to execute this research.

References

- [1] G. Omole. Health Management Information System for Decision-Making in Nigeria: Challenges and Resolutions. (IJSER) 4(5), 2015. ISSN (Online): 2319-7064 <https://pdfs.semanticscholar.org/ba98/a2aae975f9014109c76815a44973f00ed72f.pdf>
- [2] D. Demirel. Effectiveness of Health Information System Applications: Clinical Information and Diagnosis Treatment Systems in Turkey. European Journal of Multidisciplinary Studies, 2(5), 2017. http://journals.euser.org/files/articles/ejms_may_aug_17/Demokaan.pdf
- [3] S. K. Stansfield, J. Walsh, N. Prata, and T. Evans. Information to Improve Decision Making for Health. In: D. T. Jamison, J. G. Breman, A. R. Measham. Disease Control Priorities in Developing Countries. 2nd edition. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2006. Chapter 54. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK11731/> Co-published by Oxford University Press, New York.
- [4] A. Vafaei, M. Vahedian, H. Esmaeily, K. Kimiafar K. Views of Users towards the Quality of Hospital Information System in Training Hospitals. J Res Health Sci. 2010; 10(1):47-53.
- [5] Coiera, E. (2004). Four rules for the reinvention of health care. British Medical Journal; 328:1197-9.
- [6] WHO. Health Metrics Network Framework, and Standards for Country Health Information Systems, World Health Organization, 2008.
- [7] Clarke MA, Belden JL, Koopman RJ, Steege LM, Moore JL, Canfield SM, et al. Information needs and information-seeking behavior analysis of primary care physicians and

- nurses: A literature review. *Health Info Libr J.* 2013; 30:178–190
- [8] T. Lippeveld, R. Sauerborn, C. G. Bodart. World Health Organization; Design and implementation of health information systems; 2000; pp. 15–32.
- [9] J. P. Glaser, E. L. Drazen, L. A. Cohen. Maximizing the benefits of health care information systems. *Journal of Med Syst.* 10(1):51-56. 1996, doi: 10.1007/BF00992950
- [10] Danso, J. A Study of Records Management Practice at Health Facilities in Upper Denkyira West District of Ghana. *Advances in Life Science and Technology.* 2015. 30: 64-72.
- [11] Haux, R., E. Ammenwerth, W. Herzog, P. Knaup, 2002, Health care in the information society. A prognosis for the year 2013, *Int. J. Med. Inform.* 66 (1–3) 3–21.
- [12] Ball, MJ, and Lillis, J. E-health: transforming the physician/patient relationship, *Int. J. Med. Inform.* 2001. 61 (1) 1–10.
- [13] Powell, J.A., M. Darvell, J.A. Gray, 2003. The Doctor, the patient, and the world-wide Web: how the internet is changing health care, *J. R. Soc. Med.* 96 (2) 74–76.
- [14] Kawamoto K, Del Fiore G, Lobach DF, Jenders RA. Standards for scalable clinical decision support: need, current and emerging standards, gaps, and proposal for progress. *Open Med Inform J.* 2010; 4:235-244. doi:10.2174/1874431101004010235.
- [15] Kunitawa, Andrew, et al. "Factors Affecting the Utilisation of Electronic Medical Records System in Malawian Central Hospitals." *Malawi Medical Journal.* 2017.
- [16] Gillingham P. Computer-based Information Systems and Human Service Organisations: Emerging Problems and Future Possibilities. *Australian Social Work* 2011; 64: 299-312.
- [17] Kanchi S, Sabela MI, Mdluli PS, Inamuddin, Bisetty K. Smartphone-based bioanalytical and diagnosis applications: A review. *Biosensors & Bioelectronics* 2018; 102: 136-149.
- [18] Riano D, Ortega W. Computer technologies to integrate medical treatments to manage multi-morbidity. *Journal of Biomedical Informatics* 2017; 75: 1-13.
- [19] Nguyen, Thuan D., Hai D. Vu, John G. Webster, & Amit J. Nimunkar. "A Web-Based Electronic Medical Records and Hospital Information System for Developing Countries." *Journal of Health Informatics in Developing Countries.* 2011.
- [20] Krishnan A., Nongkynrih B., Yadav K., Singh S. and Gupta V. "Evaluation of computerized health management information system for primary health care in rural India." *BMC Health Services Research*, 2010, pp. 1 – 13.
- [21] Tomasi E., Facchini L.A., and Maia M.F. "Health information technology in primary health care in developing countries: a literature review." *Bulletin of the World Health Organization*, 2004 pp. 867 – 875.
- [22] Kasereka G. and Mosoti D. "Towards Integrated Patient Health Information Analytics collected in Health Information Systems (HIS)." 7th ICT Conference 21st – 22nd March 2019, Nairobi, Kenya
- [23] Byrne E., and Sahay S. "Health information systems for primary Health care: Thinking About Participation" 2015, pp. 237 – 250
- [24] Marful W.A. and Winter A. "Hospital Information Systems in the Ghanaian Psychiatric Hospitals: Post Act 846 of 2012 Review Analysis". *Journal of Health Information Africa.* 2018; 5(2):27-31. DOI: 10.12856/JHIA-2018-v5-i2-203
- [25] Katic M., Soldo D., Ozvac Z., Blazekovic S.M., Keglevic M.V., Markovic B.B., Tiljak H., Lazic D., Nekić V.C., and Petricek G. "Information systems and the electronic health record in primary health care." *Informatics in Primary Care - British Computer Society*, 2007, pp 187 – 192
- [26] Opeyemi, A.A., Blessing, O. A., and Blessing, E. O. 2016. An Online Outpatient Database System: A Case Study of General Hospital, Minna. *Intelligent Information Management.* 2016: 103-114
- [27] Esene, H.A. Assessment of health management information system in primary health care centers in Edo state, Nigeria (Fellowship of the College in Public Health dissertation). 2015. Retrieved from <http://dissertation.npmcn.edu.ng/index.php/FMCPH/article/view/2560>.
- [28] Keenan, C. R., Nguyen, H. H. and Srinivasan, M. Electronic medical records and their impact on residents and medical student education. *Academic Psychiatry.* 2006. 30 (6), 522-527. doi:10.1176/appi.ap.30.6.522
- [29] Okeke, J. O. Shortage of health professionals: A study of recruitment and retention factors that impact rural hospitals in Lagos State, Nigeria. 2008. (Doctoral dissertation).
- [30] Y. Fang, J. Sun, X. Zhu and C. Zhang, "HCPP: Cryptography Based Secure EHR System for Patient Privacy and Emergency Healthcare," in *2013 IEEE 33rd International Conference on Distributed Computing Systems*, Minneapolis, Minnesota USA, 2011 pp. 373-382. doi: 10.1109/ICDCS.2011.83
- [31] Cheng-Kun, W. Security and privacy of personal health record, electronic medical record and health information: Problems and Perspectives in Management. 2015:13(4)

IJSER