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Data Collection Module for a Centralized Electronic Health Records System

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ABSTRACT

Electronic Health Records (EHRs) play a crucial role in modern healthcare, enhancing quality, safety, efficiency, and research capabilities. However, in Nigeria the full acceptance of such modern ways of managing healthcare delivery is marred with various challenges such as infrastructure, funding, technical expertise, and regulatory issues. This paper presents a proposed conceptual framework of a Data Collection Module for a Centralized EHR System in Nigeria, aimed at addressing data accessibility challenges faced by healthcare facilities for patients registering at their facilities. The module utilizes National Identification Numbers (NINs), barcodes, and biometric identification methods to collect and secure patient demographic data. It incorporates a web application, biometric software, and barcode/QR code software to ensure efficient data collection and verification. Our study demonstrates the feasibility and effectiveness of employing biometric identification techniques in data collection modules, offering enhanced accuracy, reliability, security, and usability of patient data in a developing healthcare system like Nigeria.The proposed module has not been tested in a real-world environment, so more study is required to determine its viability, scalability, and effect on the standard and results of healthcare.

Keywords: Electronic Health Records, Data Collection Module, National Identification Number, Barcode, Biometrics

1. Introduction

Electronic Health Records (EHR) are computerized representations of a patient's medical history, diagnoses, treatments, prescriptions, and other health-related data. These records help to facilitate healthcare services' quality, safety, efficiency, accessibility, research, and innovation (Alshammarie et al., 2022). In the present EHR usage, though still very young in Nigeria, the adoption and implementation of this system of healthcare in Nigeria have been marred by a lack of infrastructure, adequate funding, technical expertise, standards, regulation, and available incentives (Li et al., 2020). Using EHRs in hospitals and other healthcare facilities is one option to enhance the Nigerian healthcare system. In the 2000 ranking by the World Health Organization (WHO), Nigeria was placed in the 187th position as the most effective health system out of 191 nations in the world (Reinhardt & Cheng, 2000). A 2021 Universal Health Coverage (UHC) effective coverage index, which gauges how well people obtain the healthcare they require, was released by the WHO. Nigeria received a score of 42 out of 100 on this indicator, which is lower than the 66 average for the world (World Health Organization, 2021). This implies that there is still much room for development in Nigeria's ability to offer its people affordable, high-quality healthcare, and EHR is a strong booster to achieving this. EHRs can help with data reporting and analysis, as well as with communication, error reduction, accelerating decision-making, and a seamless process (Alshammariet al., 2022).

Primary, secondary, and tertiary health- care are the three divisions of the Nigerian healthcare system (Oleribe et al., 2015). Most people's initial point of contact with healthcare is primary care, which offers fundamental curative and preventive services. Secondary healthcare provides more specialized service delivery and accepts referrals from primary healthcare facilities. An example is the General Hospital. Teaching hospitals and federal medical centers fall into the category of tertiary healthcare providers that offer cutting-edge and specialized services (Oleribe et al., 2015). Most medical facilities within the primary and secondary levels still utilize the traditional paper-based approach to medical records, and a few tertiary medical facilities have converted to the EHR system in Nigeria. Some of the few tertiary institutions make use of the hybrid format of using both paper-based and electronic health records due to some of the challenges previously stated (Attah, 2017). Table 1 is the categorization of the Nigerian healthcare sector, showing primary, secondary, and tertiary healthcare.

The primary goal of this study is to create, utilizing a conceptual and logical paradigm, a data collection module for a centralized EHR system in Nigeria that is in line with best practices around the world and a review of current literature. Further research is required to evaluate the proposed module's viability, scalability, and impact on healthcare quality and outcomes, as it has not been implemented or assessed in a real-world setting.

Table 1: Categorization of the Nigeria Healthcare Sector

Nigeria Healthcare sector categories	Level 1	Primary Healthcare (Pharmacies, health centres, clinics, maternity homes, etc)
	Level 2	Secondary Healthcare (General hospitals, Specialist hospitals) (You can receive diagnostic, therapeutic, surgical, emergency, referral, and inpatient services)
	Level 3	Tertiary Healthcare(they include federal medical centers (FMCs), national hospitals (NHs), and university teaching hospitals) (You can receive teaching, research, training, consulting, referral, and specialized services)

1.1 Electronic Health Records (EHR) System

EHR systems are electronic records of patient health information generated by any care delivery setting (Kauret al., 2023). They include various types of information and functions to support healthcare services (Adler-Milstein & Pfeifer, 2017). EHR systems have been implemented in many nations for a variety of reasons and advantages, including enhancing healthcare quality, safety, efficiency, and accessibility; promoting research and innovation; adhering to rules or receiving incentives; and satisfying patient and provider needs and expectations (Alharthiet al., 2014; Boonstraet al., 2014). However, there are other obstacles and problems related to the technological, organizational, human, and environmental aspects of EHR deployment (Sheikh et al., 2015; Yoon et al., 2016). There is conflicting and inconclusive research regarding how EHR systems affect healthcare outcomes (Banerjee et al., 2023; Campanella et al., 2016; Liu et al., 2023; Kruse et al., 2016).

1.2 Data Collection Modules

Data collection modules are parts of EHR systems that capture patient demographic information from various sources. Clinical decision-making, record-linking, epidemiological research, and resource management all rely on this data for patient identification. The lack of standards, faults, concerns about privacy or security, and resource or time limitations, however, can make data collection challenging (Khojaet al., 2013; Gupta &Dutta, 2021; Liawet al., 2013). The development of data collection modules has taken a variety of forms. Utilizing a central database or server that houses the personal data of all inhabitants or residents of a nation or area is one strategy. Using a special identification number for each person, authorized providers can access this database or server. For instance, the Aadhaar system, a biometric identity system used in India, provides a 12-digit number to each person based on scans of their iris and fingerprints (Tiwari, P.R. et al., 2022). Another strategy is to employ a decentralized or distributed system that enables patients to save their own personal data on portable smart cards or gadgets. In healthcare facilities, these cards or gadgets can be scanned by readers that are compatible. For instance, each citizen's social security number and insurance details are stored on a smart card known as the Carte Vitale in France (Lefebvre &Potvin, 2017; Nøhret al., 2017).

1.3 Biometric Identification Methods

The term "biometric identification methods" refers to procedures that make use of biological or behavioral traits to confirm users' identities. These include recognition of fingerprints, faces, irises, voices, palm veins, etc. Compared to conventional techniques like passwords or tokens, they are more accurate, reliable, secure, convenient, and user-acceptable (Mueller et al., 2023). The use of biometric identification techniques in healthcare has several applications. Using biometric identifiers to link records from different sources or settings is one way to improve the data collection modules of EHR systems. For instance, fingerprint recognition was utilized in Nigeria (Auduet al., 2015) to sign patients up for a centralized EHR system. A cloud-based EHR system in Thailand (Srisa-an & Chomchuay, 2017) was accessed by patients using iris recognition to identify them and access their health records. By employing biometric identifiers to authenticate patients and providers before accessing sensitive or secret information, biometric identifiers can also be used to increase the security and privacy of EHR systems. For instance, facial recognition was utilized in the United States of America (Jain et al., 2020) to authenticate patients and physicians before granting access to an EHR system. Before gaining access to an EHR system in China (Zhang et al., 2012), palm vein recognition was utilized to verify patients' and providers' identities.

2. Materials and methods

The data collection module's conceptual and logical models are used in the research design. This model will employ a data flow diagram and user interface design to describe the theoretical underpinnings of the study. To effectively carry out the research goals, the data gathering module needs the following elements or tools:

i. A web application that establishes a connection with the NIN server and offers an application programming interface (API) to access patient demographic data.
ii. A biometric tool that records a patient's fingerprint and facial image and compares it to information on the NIN server.
iii. A QR code generator that uses the NIN to generate a special medical code for each patient.
iv. A scanner for QR codes that can read medical codes from mobile devices.

2.1 The Proposed Module for Data Collection

Data collection modules are parts of EHR systems in healthcare facilities that capture patient demographic information from various sources. The data collection module will make use of the patient's National Identification Number (NIN) to access their demographic data (such as name, date of birth, gender, address, phone number, email address, photo, fingerprint, and facial image). Figure 1 shows a sample of the various valid National Identification Number (NIN) cards.

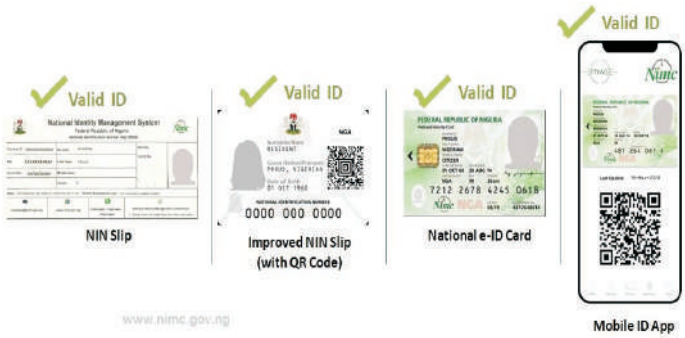

Figure 1: Valid National Identification Number (NIN) cards(NIMC, 2023)

The patient provides his National Identification Number (NIN), and this data from the National Identity Management Commission (NIMC) server is confirmed using biometric fingerprint and facial recognition technologies. The NIN of each patient is converted into a special medical code to build an electronic medical case file that clinicians can access from different healthcare facilities in order to make medical decisions. A QR code that can be scanned by smartphones serves as the medical code's storage format. The data collection module connects to the NIN server via a web service to confirm the patient's identity. Before accessing the patient's personal information, the patient's permission is also sought. A flowchart process diagram to show how a patient's NIN can be used in opening electronic medical case files is shown in Figure 2.

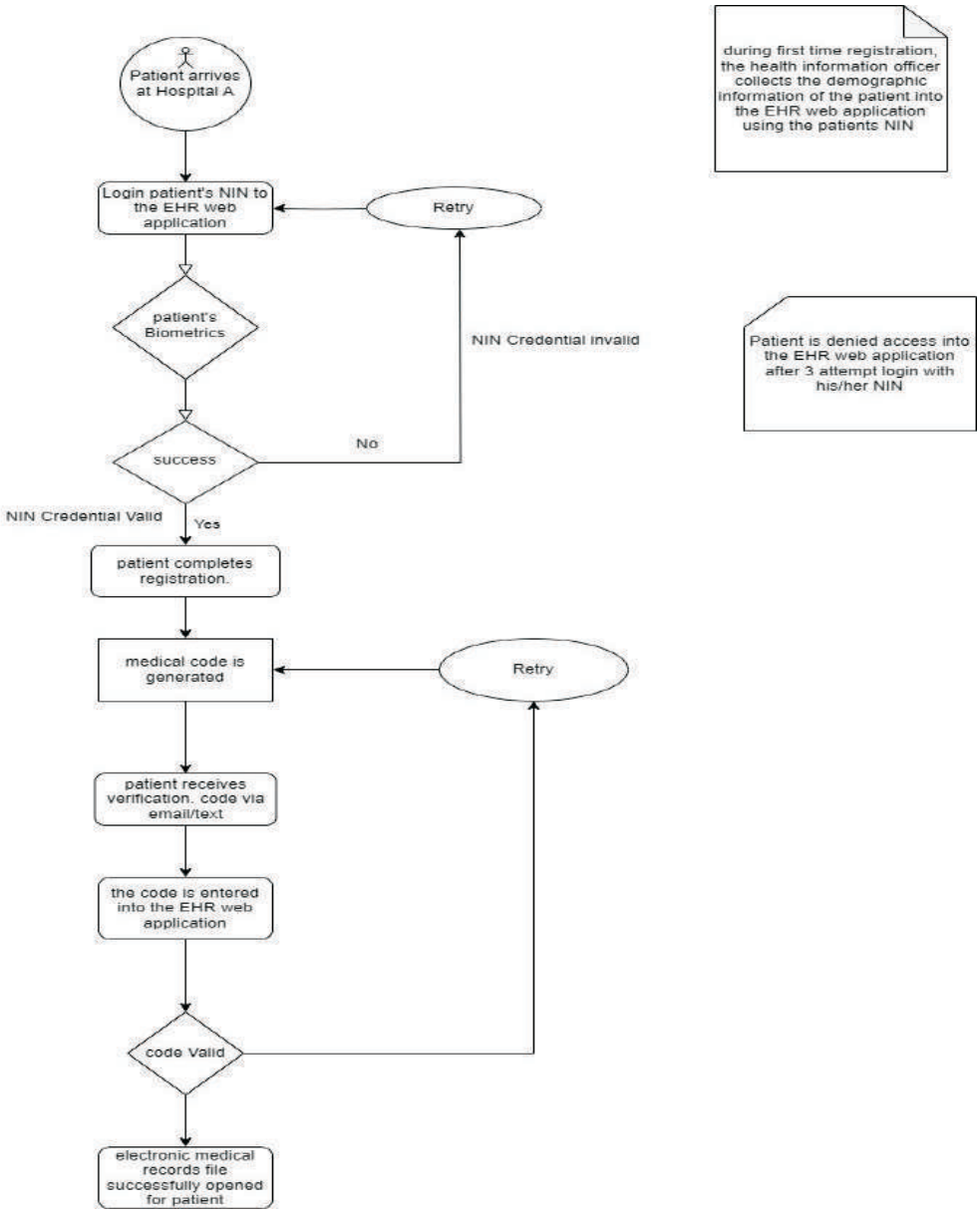

Figure 2: Flowchart of the process of opening an electronic medical case files using patient's NIN

2.2 Web Service

In order to provide an API for obtaining patient demographic data, the web service must connect to the NIN server. To send and receive XML messages from the NIN server, the web service employs the SOAP protocol and also uses SSL encryption to safeguard the security and privacy of the data.

The two main functions of the web service connecting to the NIN server are "getPatientInfo" and "verifyPatientInfo." The "getPatientInfo" function accepts the NIN as an input parameter and outputs an XML message with the relevant patient demographic data. A NIN and a biometric feature (a fingerprint or facial image) are inputs for the "verifyPatientInfo" function, which outputs an XML message with the match score and confidence level.

2.3 Biometric Software

The patient's fingerprint and facial image are taken by the biometric software and compared. The patient's biometric traits are extracted and compared by the biometric software using a proprietary algorithm. In order to calculate the match score and the degree of confidence in the identification, the biometric program also uses a threshold value. The two features that make up the biometric program are "Capture Biometric" and "MatchBiometric". The "captureBiometric" function accepts a biometric feature (such as a fingerprint or face image) as an input argument and outputs an image that has been base64 encoded. Two base64-encoded photos are passed as input inputs to the "matchBiometric" function, which outputs a match score and a confidence level.

2.4 QR (Quick Response) Code Software

The medical code for each patient is generated and verified by the QR (Quick Response) barcode software. The medical code is encoded and decoded by the QR code software using a specified format. A checksum value is also used by the QR code program to confirm the accuracy of the data. The "generateCode" and "scanCode" buttons on the QR code program are its two basic operations. The "generateCode" function accepts a NIN as an input parameter and outputs a QR code picture. A QR code picture is passed as an input parameter to the "scanCode" function, which outputs a NIN.

2.5 Luhn algorithm

The Luhn algorithm is a straightforward checksum technique used to confirm a number of identifications, including IMEI and credit card numbers. The following is an expression for the Luhn algorithm:

$$L(x) = \sum_{i=0}^{n-1} f(x_i) \bmod 10 \quad (1)$$

Where
x = string of digits,
n = length,
xi = i-th digit.

The function f doubles every second digit from right to left and subtracts 9 if the result is larger than 9
If x is valid, the Luhn algorithm returns zero;
if x is invalid, the Luhn algorithm returns a non-zero.

2.6 barcode or QR code format

Using the barcode or QR code formats, data can be encoded in a visual pattern that a machine can read. A barcode, or QR code, is formatted as follows:

$$B(x) = (P,D,E,C) \quad (2)$$

Where x is a string of alphanumeric characters, P indicates the kind and version of the format, D is the data that corresponds to x, E is an error correction code that permits recovery of incomplete data, and C is a checksum value that confirms the data's integrity. For example, a QR code version 1 with error correction level L and alphanumeric mode can have a prefix where the first part indicates the type (QR code), the second part indicates the version (1), and the third part indicates the mode (alphanumeric).

3. Results

The screen shot outputs below show the possible results that can be gotten from the interface from the web service, the captured biometrics, and the QR code software. Figure 3 shows the web application screen for the officer in charge of registering the new patient. The Health Information Officer at the registration desk inputs his hospital staff login details to access the portal.
When the Health Information Officer has logged into the EHR portal, it then directs him/her to the next page, which is the patient's registration dashboard section, which commences the registration of the new patient at the health facility. All that is required of the patient is his or her national identification number and a default password for the health facility. Figure 4 shows the web application screen for the commencement of creating a new account for a patient.

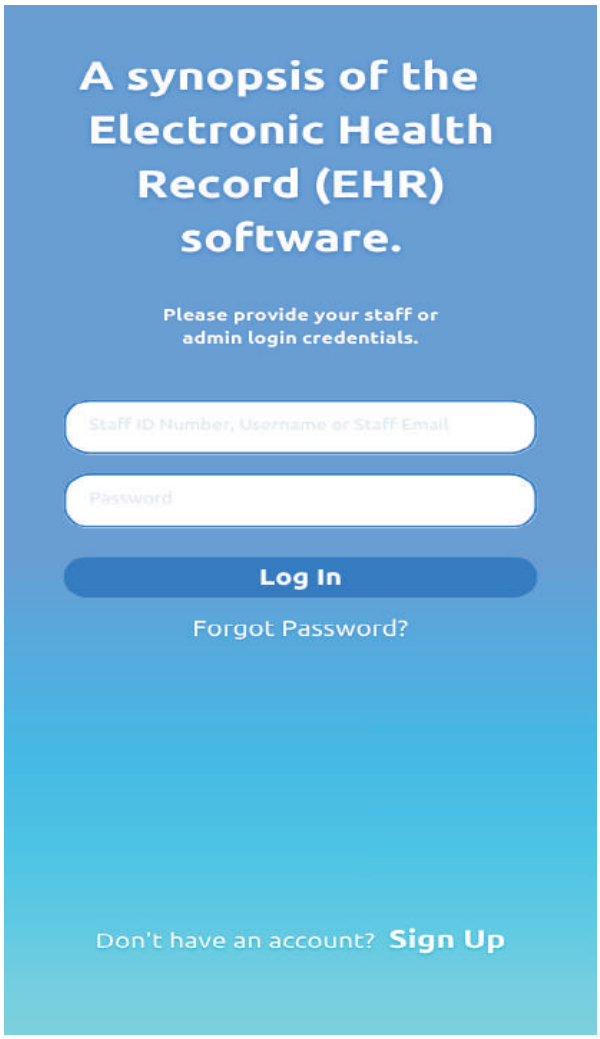

Figure 3: Health Information Officer Login into the EHR web application

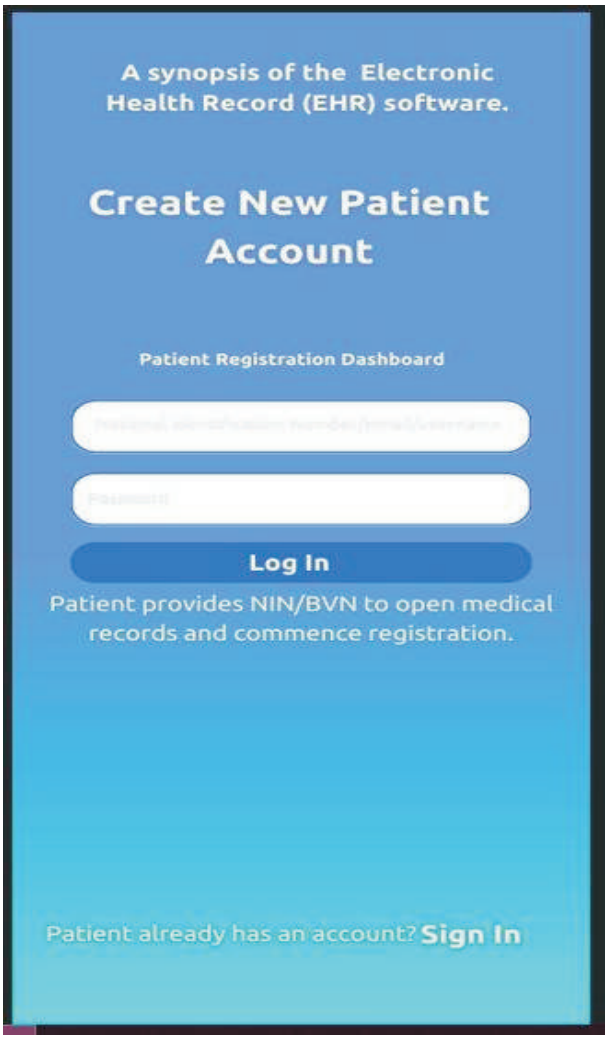

Figure 4: Patient Registration Dashboard for EHR Web App taken.

After inputting the patient's NIN number into the system by the health information officer, details of the patient that were captured immediately come out of the system, saving the time the health information officer would have taken to input these details. Figure 5 shows a sample of the details that can be gotten from the National Identity Management Commission's (NIMC) server using the patient's National Identification Number.

To further authenticate the patient's records that have been generated from the NIMC server, the patient's fingerprint and facial image are taken by the biometric software and compared. This helps to double check that the details are directly from the NIMC server and match the patient presently at the hospital. Figure 6 shows a sample of the the patient's biometrics being taken.

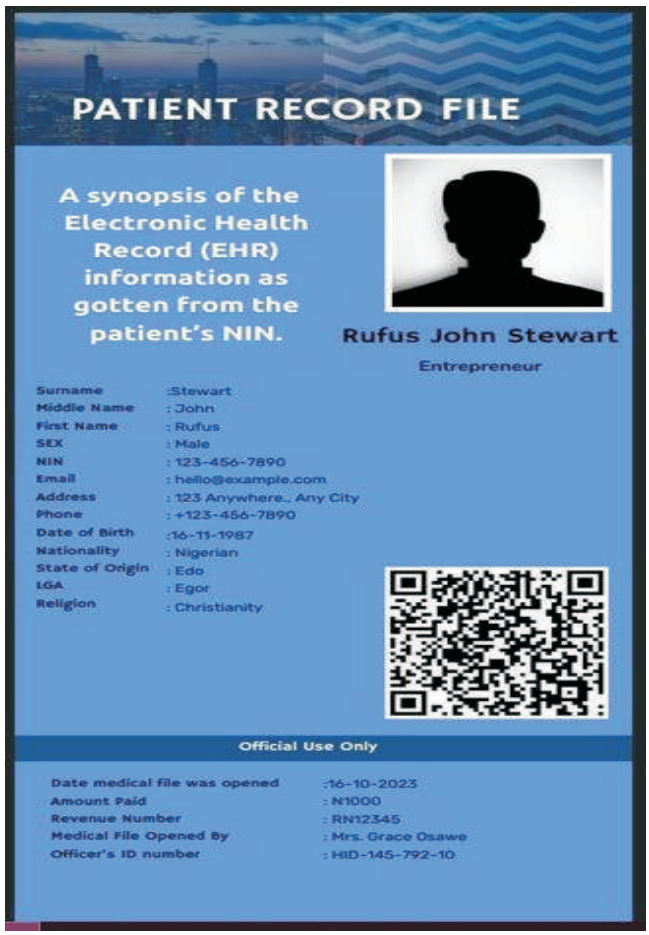

Figure 5: Sample of data to be captured from NIMC Server via Patient's NIN

Figure 6: Obtained Sample of Patient's Biometrics. (Altexsoft, 2023)

6. CONCLUSION

According to our research, the accuracy, reliability, validity, security, and usability of patient demographic data can all be improved by adopting biometric identification techniques for data collection modules. The work has also shown that adopting biometric identification techniques for data collection modules in a developing nation such as Nigeria is feasible, acceptable, and effective.

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