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Integrated Medical Data Record (iMDR) System

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ABSTRACT

This paper presented the Integrated Medical Data Record (iMDR) System with a centralized database over the internet. The iMDR provided a complimentary service for patients' registration, established and checked patients' records.

To gather the needed data, different references were used such as journals, books, and the internet; interviews with some medical personnel who were clinic staff, nurses and physicians, and IT experts. The software methodology used was Rapid Application Development (RAD). The researcher also used Context Diagram and the Wireframe for the menu and interface of the system. For the system evaluation, the research used ISO 25010 software quality model.

As a result, findings showed that the overall rating was 4.82 having met the user requirements for the security of data. It also showed that usability on the system was the highest scored among other categories, got 4.9 and this was great evidence to the respondents that the system exceeded the user's expectation.

Key words :analytics, electronic medical record, healthcare, integrated system

1. INTRODUCTION

Information Technology (IT) is the driving force behind the huge improvement in healthcare. Changes in the healthcare environment produce fundamental shifts in the delivery of healthcare, favoring outpatient care over inpatient care, primary care over specialty care, and guidelines-driven care over autonomous decision making. One of the roles of IT is to support healthcare services in society. The biggest challenge in health informatics is still the creation of an Integrated Medical Data Record (iMDR) System – a patient record that stores pertinent information concerning medical consultations, hospitalization, and treatment.

Integrated Electronic Health Record System (IEHRS) can be considered as powerful healthcare automation with the integration of smart cards used into existing hospital information systems [1].

Integrated system (IS)is a composite entity whose parts can be regarded as systems that are linked to each other to aspecified relations or are joined together to form a single whole in accordance with certain principles. The concept of ISis used in systems engineering, systems analysis, and operations research and plays an important role in the systems approach in various fields of science, technology, and the national economy.

Clinical parameters (eg, vital signs, test results) contained within the electronic health record (EHR) can be used to create alerts that notify the clinician or even trigger predetermined diagnostic and therapeutic bundles, orders or order sets, or a clinical pathways. Smart healthcare is conceived for healthcare transformation through digital health integration based on the main clinical niche [2]. In terms of security, preserving patient information in electronic health records, blockchain technology has provided the storage for the confidential data by the hospitals to tamper it and no one can corrupt it in any form [3].

The decision supports systems (DSS) are widely used to supports healthcare, business and organizational decision-making activities. A decision support system may present information graphically and it may include an expert system or artificial intelligence (AI). Using DSS for identifying the strength and weakness of the organization is to sustain the quality of services [4]. Historical data analysis is used in every facet of business and life, is well-developed and mature. Some information is not always directly actionable, it's an important part of DSS because it reports past performance and highlights areas that need attention. Application of the clustering techniquewill provide integrity and importance on the performance evaluation result in cluster performing and non-performing [5].

In Nueva Vizcaya State University (NVSU), the transaction at the University Clinic is done manually and does not have a centralized repository of records. The Physician as well as the medical staff, encounter difficulties doing the consolidation and retrieval of medical records.

The Nueva Vizcaya State University has two campuses. There were 9,917 populations including students, faculty, and staff during the second semester school year 2018-2019 and there

were 5,685 in Bayombong Campus (NVSU Registrar, 2019). NVSU clinic still uses the traditional way of collecting manually patients' record from paper/pencil, logbooks, and filing cabinet. Patients' records are filed into brown envelopes and displayed at the filing cabinet which would not be secure for the clinic. Cabinets were exposed to the public inside the clinic. Patients' records are repetitive where during checkups, the patients were advised to fill out the medical form even the patients have already filled out the last time they consulted.

The main objective of this research work was to design a computer-based program that would cover the medical aspects of the management and operations of Nueva Vizcaya State University (NVSU) Clinic. It would enable the clinic registration process computerized and this feature would help a lot significantly in keeping records of all patients.

With the advent of computers and its related technology, when everything needs to be done efficiently and effectively, the existence of integrated Medical Data Record (iMDR) System is very evident. The use of iMDR can enhance the services and the workflow of all activities of manpower needed. It also makes clinic management more manageable and easier to control.

1.1 Objective of the Study

This study aimed to improve the quality of health services through the creation of iMDR and the centralization of patient information. It also sought to create integrated access to information dispersed among several systems with the use of a single patient identifier.

This study also aimed to determine the different problems of the present system and intended to minimize those problems by reengineering the current system to a more connected and centralized system.

More specifically, this study was directed to:

1. Develop the iMDR system interface to cater the following;
   a) Repetitive collection of patient data such as history and personal information
   b) Patients' information reliability and availability issues and
   c) Uncollaborated patient care
2. Provide features to iMDR system to improve the existing system of the university exclusively oriented to:
   a) Patient registration;
   b) Establishing patients' record; and
   c) Checking patients' record;
3. Evaluate the system external and internal quality using the ISO 25010 software quality model in terms of:
   a) Usability;
   b) Reliability;
   c) Security and
   d) Portability.

2. METHODOLOGY

The researcher used the descriptive-normative method, where it involves the description, recording, analysis, and interpretation of the prevailing condition of the present system. It also used to compare test results with the present system by its usability, reliability security, and portability.

The conceptual framework of the study in Figure 1 categorizes into three phases satisfying the objectives of the project. The first phase composed of software methodology, problems encountered and hardware and software development tools; the second phase is the inserting data sets into different modules of the systems such as the patient's registration, patient's medical record, and patient's medical history and; the third phase shows how the system will be evaluated using the ISO 25010 software quality in terms of usability, reliability, security, and portability. The main output of this study is the Integrated Medical Data Record (iMDR) which will be used to produce the patient's medical record and history and used to produce an analytical report like a summary of diseases for the current month and year.

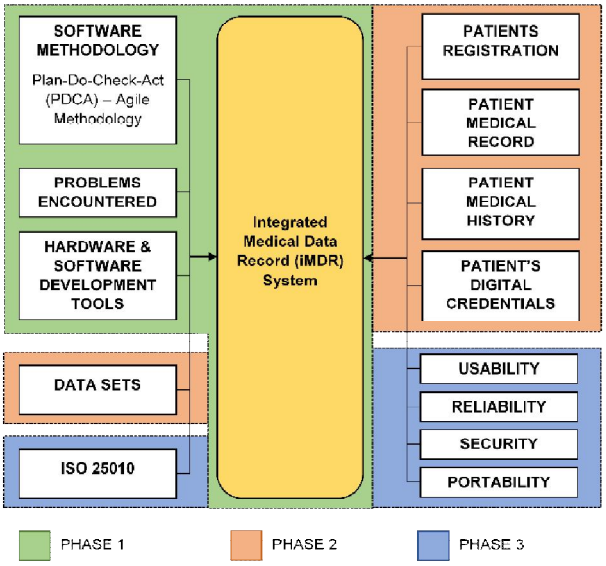

Figure 1: Conceptual Framework of the iMDR

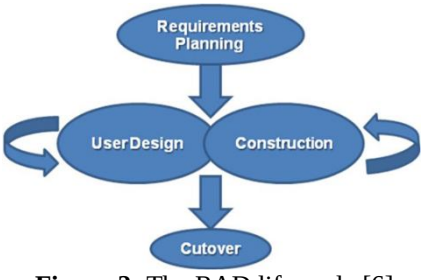

Figure 2: The RAD life cycle [6]

According to the project objective, the author proposed and analyzed each methodology. The author decided to use the Rapid Application Development (RAD) Methodology as shown in Figure 2, because RAD is a highly interactive

system development approach. RAD attempts to reduce development times and the difficulty in understanding a system from a paper-based description. During development, it also specifies testing at multiple points.

A. Requirements Planning

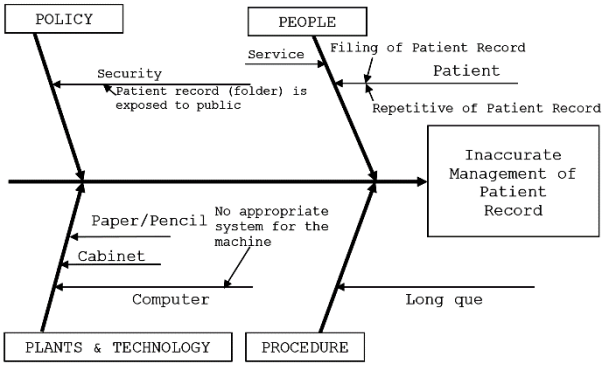

Figure 3: The Fishbone Diagram of the Project

During this phase, the researcher observed, interviewed some medical personnel and patients from the NVSU clinic to gather data needed to evaluate the problem and proposed a simple solution to the client. The researcher used the Ishikawa diagram or often called the "fishbone" diagram to breakdown or identify the problem and to sort ideas into useful categories. Ishikawa diagram is a visual way to look at cause and effect analysis. Using the diagram shown in Figure 3, it isclearly evident that there us a number of causes that may be contributing to the admission of patients.

B. User Design

After gathering, the researcher projected the problems and formulated the objective of the study. This phase involved converting the description of the alternative solution into logical and then physical system specification. The researcher made and presented action diagrams defining the interactions between process and data. System procedures are designed and preliminary layouts of screens are developed. Below are the processes made and used by the researcher during this phase.

- Context Diagram- Shows the system under consideration as a single high-level process and then shows the relationship that the system has with other external entities (systems, organizational groups, external data stores, etc.).
- Wireframes - The researcher used wireframes for the menu and interface of the proposed system. This process focuses on how the respondents want the user to process the information on the system.

C. Construction

The researcher started to develop the proposed system based on the gathered data (planning and design phase). The hardware specifications used to develop the system's interface are Intel Core i5-7200 @ 2.50GHz processor, 12GB DDR4 Memory, 500GB SSD, NVIDIA GeForce 940MX 2GB for the GPU, 1920 x 1080 resolution and Windows 10 operating system. Software development tools used are as follows:

- Visual Studio (VS) Code - The proponent used this in coding and creating interface (UI and UX) of the system, the connection between the database to the system, and the server.
- Hypertext Preprocessor (PHP 7) - The proponent used this programming language to develop the system especially its major functionalities.
- Hypertext Markup Language (HTML5) – The proponent used HTML5 as the building blocks in creating the interface of the system. It is used to define and describe the content of the system.
- Cascading Style Sheets (CSS3) – The proponents used this to add design flexibility and interactivity to the system and also have greater control over the layout to make precise section-wise changes.
- Bootstrap 4 – A CSS framework used to design and enhance the front-end of the system.
- CodeIgniter (CI) 3.1 – The proponent used this PHP framework to develop the project faster than writing it from scratch. CI is a powerful PHP framework with a very small footprint, built for developers who need a simple and elegant toolkit to create a full-featured web application.
- Cross-Platform Apache MySQL PHP Perl (XAMPP 3.2.2) – The proponent used XAMPP to interpret scripts written in the PHP file and managed database.
- MariaDB 5.5 – The proponent used MariaDB for creating and managing databases and connects them to the system because of its quick processing, proven reliability, ease, and flexibility of use.
- Adobe Photoshop CS6 – The proponent used Adobe Photoshop to create and modify images used in graphics and interface design of the system.
- JQuery 3.7 – The proponent used this JS Library to the system and to simplified JavaScript code.
- DataTable 3.7 – The proponent used this plugin for tabulating the table element of the system.
- ECharts– The proponent used this JS Library to display the blood pressure and TPR data and to simplify the report of entries.

D. Cutover

The system features were presented to the IT experts and medical personnel before and after the implementation of the business process involvement, measuring effectiveness, and deciding whether the objective was achieved or not. This also includes checking of data to ensure that it has worked.

Seven (7) or 58% were IT Experts and five (5) or 42% were system users are the respondents of the developed system.

The conceptual framework phase 3 (figure 1) would satisfy objective 3 where the researcher used a Likert scale to evaluate user's acceptance using the ISO 25010 standard such as usability, reliability, security, and portability.

2.1 Statistical Treatment

The evaluation used was formative and summative evaluations. A formative evaluation was used in every phase. Summative evaluation consists of test design for criterion-related references-items and provides opportunities for feedback from the users. Revisions were made necessary.

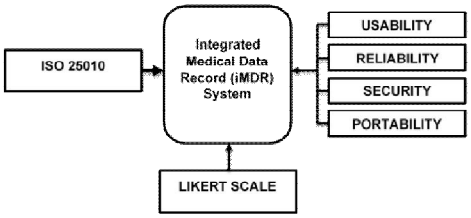

Figure 4: Evaluation Tool

The researcher used ISO 25010 standard shown in Figure 4 as stated in objective 3 which would reveal criteria on the system's usability, reliability, security, and portability. To interpret the data effectively, the Likert Scale has been used. It used a five-point scale: each point corresponding to a Likert itemas shown in Table 1.

Table 1: The five-point Likert Scale

Point	Scale	Verbal Interpretation
5	4.2 – 5	Strongly Agree
4	3.4 – 4.19	Agree
3	2.6 – 3.49	Neither agree or disagree
2	1.8 – 2.59	Disagree
1	1.0 – 1.79	Strongly Disagree

3. RESULTS AND DISCUSSION

The developed system was designed and developed using the PHP scripting language using the Codeigniter framework as shown in Figure 3.

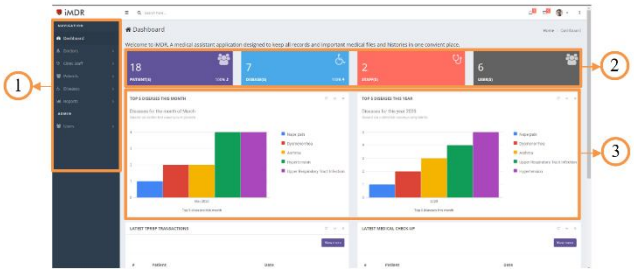

Figure 5: Screenshot of iMDR System main page

Figure 5 shows the dashboard of the system interface. (1) Main Menu provides the link for the different module of the system, such as management of Doctor, Clinic Staff, Patient, Diseases and Reports; (2) Overview gives the number of patients, diseases, staff and a total number of users; (3) Analytical system shown in a form of bar chart categorizes the most common diseases or diagnosed patient within the month and top five diseases annually; and (4) Latest Transactions (Figure 6) provided in the dashboard so the user will have access as a shortcut to views the last ten patients who conducted medical checkup.

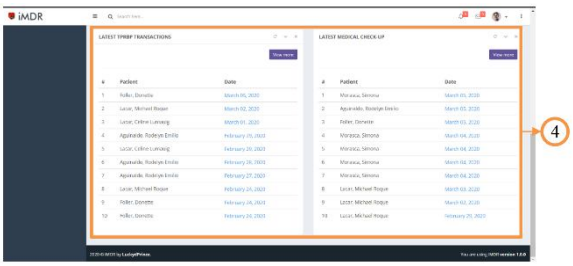

Figure 6: Screenshot of iMDR System main page (bottom part)

3.1 Modules

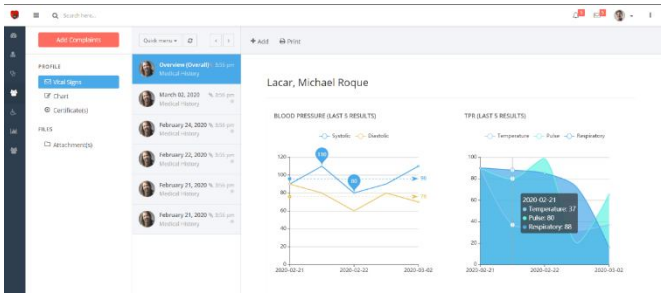

Figure 7: Screenshot of Patient Vitals Signs for TPRBP (Temperature, Pulse, Respiratory, and Blood Pressure)

The first module of the system focuses on the patients' electronic medical record (EMR). The client still using paper records to store all this information has been identified as one of the sources of problems. Therefore, this module was built as an integrated or centralized document repository for the clinic, leading to their goal of paperless transactions. Digitizing the patient records for faster and efficient retrieval of data which was previously performed by a nurse or medical staff through finding the documents needed of the entire transactions. This module is the important part of the system as the data collected were also being utilized in other modules. With this iMDR system, tru EMRmodule, the clients are now able to collect and track medical data of a patient as shown in Figure 7 for the patients Vitals Signs and Chart of a patient.

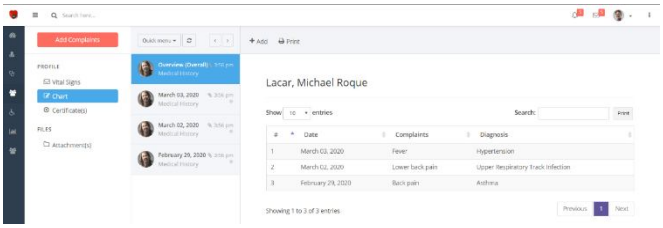

Figure 8: Screenshot of Patient Medical Chart

Figure 8shows the list or history of a patient every time the patients visit the clinic. It answers objective 1 that the medical staff can verify and show the summary of the results of the patients before adding a new medical record to avoid the repetition of collections. It provides reliable data and availability as long as connected to the database server to view all the patient records and collaborate with the physician.

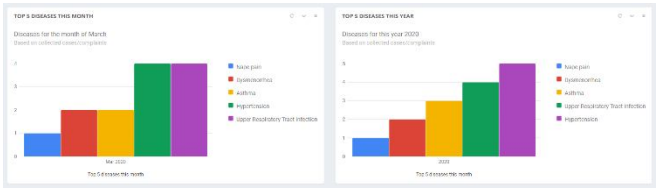

Figure 9: Screenshot of Top five Diseases for the current month and year

The second module, reports module, allows the clinic to generate and print mandated reports requested by the NVSU Administration office such as Auxilliary Office and Human Resource Management Office. This module addressed the difficulty and time-consuming in processing and generating reports such as getting the top five diseases in most cases every month (Figure 9), all diagnosis and transactions (Figure 10) which cause delays in reporting and submitting the clinic to the respective offices in the University. With the reports module, the clients were able to have more time in providing health services to constituents rather than having spent time creating reports.

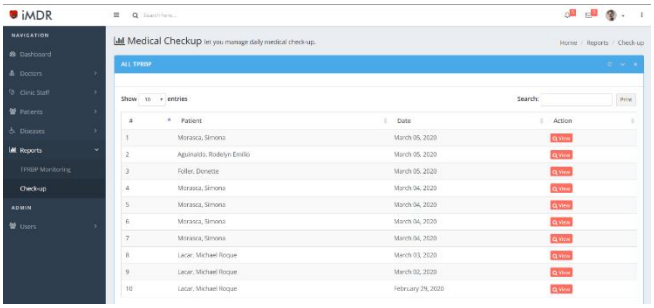

Figure 10: Screenshot of Daily Medical check-up

This module is capable of handling simple analytical and manipulating medical records. This function presents data in a way that can assist in program proposals and decision making by helping prioritize programs and medicines to deliver for the derived output of the system and the clients can prepare some outbreaks or by purchasing medicines, etc.

3.2 Evaluation

The developed system has undergone a system unit and integration testing. The researcher conducted functional prototyping with the target users to perform various testing and collect recommendations in every module. Recommendations received from the respondents every session were addressed and incorporated to the system revisions. After integrating different modules and conducting final integration testing, the researcher conducted the user's acceptance testing (UAT).

The researcher presented and conducted the UAT Form to I.T. experts and to the target users, this includes physicians, Nurses, Medical Staffs, and I.T. encoders. Experts and Users were asked to fill out the UAT Form to quantify the users' acceptability of the different modules of the system.

The UAT Form questionnaire designed in such a way that the target respondents can rate the functionality and usability of the developed system. Questions were divided into four major categories which were derived from ISO/IEC 25010 namely: 1) Usability, 2) Reliability, 3) Security and 4) Portability of the system. It is answerable with a rating from 1 to 5 with 1 being *strongly disagree* to 5 with *very strongly agree*.

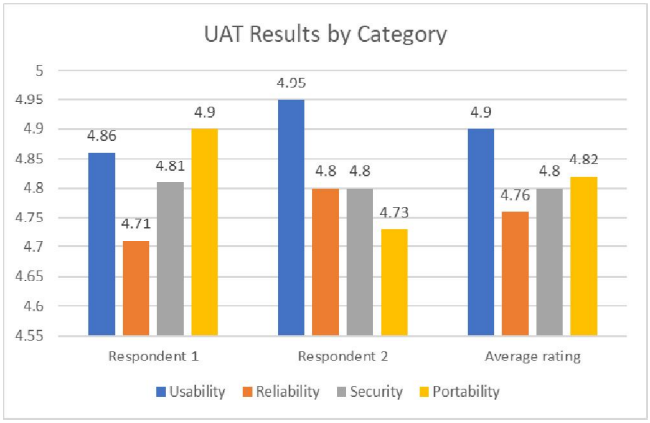

Figure 11: Tabulation Results per Category

Figure 11 showed the average rating of the total population per respondents, Respondent 1 (IT Experts), and Respondent 2 (System Users). Usability scored 4.9 which was the highest score among other categories for both experts and system users. Reliability got the lowest score and only got an average of 4.76 which generally accepted for both respondents.

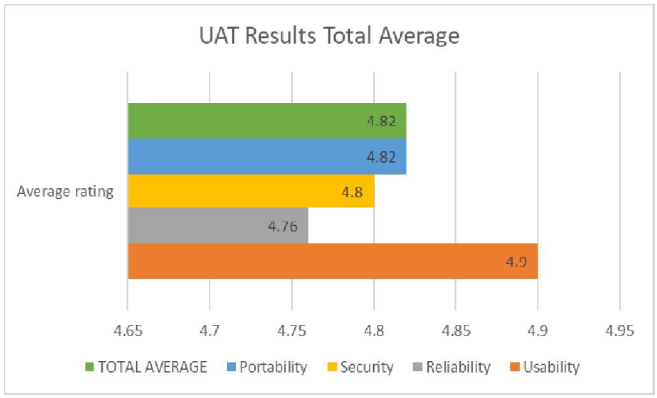

Figure 12: Tabulation Results Total Average

Figure 12 revealed the results of the UAT and got an overall average of 4.82 out of 5, having met the user requirements and with users being generally satisfied with the developed system. This means that the respondents were satisfied with the developed system. There were comments and feedback gathered during the UAT but most of them were under system User Interface (UI) – where colors and icons, and add more charts to give instant overview or results to the report needed. As a solution, the researcher made the components appealing to the user and charts not only right from the dashboard but also to the patients' history and reports.

4. CONCLUSION

Based on the methodology used and findings derived from this study, the following conclusions were drawn.

1. The developed system acted as a platform to create, store, and consolidate important medical data, which served as a backbone and great prospects for future clinical purposes.
2. TheiMDR system featured automate numerous daily operations and enabled smooth interaction of the respondents/users. The developed system was a great opportunity to create distinct, efficient, and fast delivery of healthcare models.
3. The overall feature was presented and findings showed that the overall rating was 4.82 having met the user requirements. It also showed that usability on the developed system was the highest scored among other categories and got 4.9 and this was great evidence to the respondents that the developed system exceeded the user's expectation.

5. RECOMMENDATION

The following recommendations were offered based on the findings and conclusion of the study.

1. The system users should store all patient medical data into digital form through the use of the developed system for a more secure way and better filing of records.
2. Future researchers are encouraged to conduct similar studies by utilizing the Decision Support System (DSS).

ACKNOWLEDGEMENT

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