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Decision Support System for Rural Health Units with Mapping

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ABSTRACT

The amount of data and technology available in this demanding and difficult world is overwhelming. However, certain organizations—like the Rural Health Unit of the Municipality of Solano, Nueva Vizcaya—continue to conduct their business manually as of right now. The unit's problems, issues, and obstacles in providing medical services were highlighted, along with the degree of conformity with ISO/IEC 25010 Software Quality Standards. Additionally, illnesses can be managed and treated utilizing data mining techniques to forecast the occurrence of diseases due to the unpredictable availability of data. The present investigation employed clustering and classification data mining techniques to forecast the incidence of disease in each barangay within the municipality within a specific timeframe. To address the unit's issues, a decision support system and an effective record management system were created. Its primary feature is the disease-occurrence mapping, which helps the unit's doctors and other medical professionals make decisions about diagnosis, treatment, and recommendations. According to the ISO/IEC 25010 Software Quality Standards, the system received a qualitative rating of "very great extent."

Keywords: Rural Health, Clinical, Techniques, Mapping, EMR, Equipment, Record Management

I. INTRODUCTION

In our highly demanding world, where information and innovation are abundant, data of all kinds originating from many sources is taken into account and analyzed. All of this merely takes place to make life easier in every way, including learning, traveling, communicating, and much more. In a modern, technologically advanced society, the healthcare sector is not immune to this kind of situation. It is one of the numerous industries where technology and data are applied in a variety of ways. With the global expansion in computer use that started in the early 1950s, computer technology became widely used in medicine. Health informatics, also known as health information systems, is a field that sits at the nexus of computer science, information science, and health care. This technical advancement made it possible. It focuses on the tools, resources, and techniques needed to optimize information gathering, archiving, retrieval, and application in biomedicine and health.

The healthcare industry has greatly benefited from information technology, not only in terms of new medicine discovery and equipment development but also in terms of bettering and organizing electronic medical records (EMR). Summaries of a patient's diagnosis, test results, and prescriptions found in medical records would provide a general picture of the patient's health; enabling enhanced patient care and a more precise diagnosis. Additionally, by digitizing medical records, labs and specialists would be able to collaborate more easily and share information without having to spend time or resources on physical transmission. Jones went on to say that EMR protocols can aid in lowering malpractice and increasing accountability when they are properly adopted and maintained. It would be simpler, and it would take less time to produce and maintain electronic records. Additionally, they lessen the possibility of errors being committed and make life easier for medical accountants.

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Source: https://www.aamc.org/news/electronic-health-records-what-will-it-take-make-them-work

Healthcare professionals can more quickly detect areas of risk by tracking clinical difficulties with the integration of electronic health records (EHR). It is possible to implement procedures precisely and swiftly to enhance patient care. It would be possible to closely examine and compare a clinician's prescription drug usage trends, including doctor referrals for the worst-case situations, to established benchmarks. It has been demonstrated that using computer-based clinical support in an EMR enhances both patient outcomes and physician performance. Patient outcomes, safety, and quality of care are all improved by electronic medical records (EMR). EMRs improve patient care by reducing medication errors, reducing needless investigations, and improving communication and interactions between patients, primary care physicians, and other healthcare providers. Additionally, even though there are some arbitrary worries about the time and expense of implementation, EMRs make family physicians' jobs easier. EMRs have been shown to increase work flow efficiency by cutting down on the time needed to retrieve records, enhancing access to thorough patient data, assisting with prescription management, enhancing patient appointment scheduling, and offering remote access to patients' charts. In addition to the EMRs, the staff, equipment, and facilities make it possible to provide healthcare. Since these structural elements form the basis for the provision of high-quality healthcare services, it is predicted that they will have an impact on the quality of such services. Clinicians can see how a patient's health has evolved over time in addition to the illnesses they are now dealing with by integrating an EMR with comprehensive patient profiles and analytics features.

They can create more specialized recommendations and more focused long-term sickness management strategies with access to these insights.

Over the past two decades, the Philippine healthcare system has experienced significant transformations as a result of numerous reforms and regulations implemented by the government to ensure that every Filipino has simple access to health benefits.

The Department of Health (DoH) has a list of 721 public hospitals and 1,071 licensed private hospitals. The Department of Health (DOH) oversees about 10% of the country's hospitals, and local government units (LGUs) and other federal government agencies run the remaining 40%. All of the hospitals employ highly qualified medical professionals. However, overall, the Philippines' healthcare system is of a very high caliber. Although the medical personnel in the Philippines are highly skilled, the facilities might not be as good as those in upscale US or European hospitals. Although generally effective, the government of the Philippines generously supports the public healthcare system in both rural and urban areas. In the Philippines, private healthcare facilities are typically better equipped and offer far more consistent care than public ones. The majority of hospitals offer effective and reasonably priced medical care. The facilities, however, are nothing like those found in upscale medical facilities elsewhere. Positively, compared to public hospitals, private hospitals in the nation have better technological infrastructure. Thus, patients can be certain of receiving better care from private hospitals than from state ones.

From electronic medical records to medical analytics, technology has quickly advanced in the realm of medical sciences. The existing state of health can be improved with the use of ICT. Furthermore, the ultimate goal of health information technology (HIT) is to support

medical professionals in giving their patients exceptional care. In order to achieve this, HIT enhances point-of-care locations across the patient-provider flow, from the moment the patient enters the hospital until they leave and head home.

The RHU of Solano, Nueva Vizcaya, is open Monday through Friday from 8:00 a.m. to 5:00 p.m. for medical services to an average of 80–100 Solano residents as well as some residents of neighboring communities. The manual recording causes delayed processing and decision-making for the health professionals, especially the Municipal Health Officer, given the volume of data entering the unit. Accessing patient records might be challenging for management as well because they are kept in logbooks and forms. The unit's method of storing patient data jeopardizes its privacy and security. Furthermore, the lack of central storage could lead to errors in patient records. Because doctors must manually review past medical information, diagnosing illnesses is typically a laborious task for them. Even though the unit has a variety of computers, their primary functions are communication and report generation, which adds to the delays in the delivery of useful programs and data. A decision support system featuring mapping for the RHU of Solano, Nueva Vizcaya, has been developed. This is primarily intended to support the unit's doctors and other medical experts in making decisions. The two components of the system will be the diagnosis and the treatment or recommendations.

The system will provide the diagnostics to support the doctor's decisions so that treatments are more effective. The data mining frameworks for clustering and classification will be applied to the patient's concerns. The information acquired during diagnosis will be collated and maybe shown as if-then rules. Furthermore, the classification data mining technique is applied to anticipate group memberships for data instances such as age, gender, disease occurrence location, and similar ones. Reports presented in this way would be simpler to read and comprehend.

Conversely, the system's treatment/recommendation section would now propose the course of action that medical practitioners should take with their patients. This covers prescription medication, counseling, and doctor referrals. Careful strategic planning also takes into account recommendations, warnings, and reminders for the administration and the leader of the unit.

To calculate data patterns and extract hidden patterns, respectively, standard statistical methods and data mining techniques will be applied. The system will use these techniques to map, track, and report on the prevalence of diseases in each barangay within the municipality of Solano at any given time. This will help the leader of the unit plan and organize various programs for the events.

The current state of the healthcare industry leads the researcher to assume that this system is both relevant and timely. By combining clinical and patient data, this decision support system will help with patient care administration. Additionally, timely reports and actions will be delivered thanks to the system's data generation, which will improve the unit's decision-making and lead to more efficient procedures.

II. AN EXPLANATION OF THE ISSUE

2.1 Description of the Problem

The goal of this project was to develop a decision support system and an effective record management system that would be applicable to the healthcare services and programs offered to Solanoans. In particular, this study looked for solutions to the following queries:

1. What difficulties, concerns, and obstacles does the Rural Health Unit face in providing healthcare services?
2. Which data mining methods will be applied to identify the disease cases?
3. Which algorithms for grouping and classification will be applied when creating the system?
4. What kind of mechanism could be created to make the Rural Health Unit's medical service delivery easier?
5. How closely does the created system adhere to ISO/IEC 25010 Software Quality Standards in terms of:

a) Functional appropriateness,
b) Performance effectiveness,
c) Compatibility,
d) Usability, and
e) Dependability is the first five factors.
f) mobility;
g) Durability; and
h) security

6. Based on this analysis, what improvements to the system can be suggested?

2.2 Overview of the Research

The reasoning behind the study's proposed goals and the steps used to get there are summed up in the conceptual framework. It starts with the specifics that need to be looked at and the Decision Support System (DSS) modules, especially the Clinical Decision Support System (CDSS) that can help with the problem that has been identified.

Source: https://healthitanalytics.com/features/understanding-the-basics-of-clinical-decision-support-systems

The DSS/CDSS has been implemented, and this has set the users' level of access. The use of a system to support a doctor's decision-making regarding the diagnosis and treatment of a disease or complaint is the study's ultimate outcome, or notion. There are three primary stages in the proposed system. The first is the patient consultation, where the patient's medical history, concerns, and information are evaluated. To ensure its security and secrecy, these pertinent data and information are being captured, kept, and updated in a central database. The system's several intervention modules are the subject of the second section. It is found that electronic medical records (EMR) are present through central storage. The patient profile, complaints, and consultation data are specifically contained in this electronic medical record (EMR), which will be accessed via the system. Moreover, it makes it feasible to manage records in the simplest possible way by searching, saving, printing, etc. Most significantly, an electronic medical record (EMR) is created using consolidated data, and this EMR will act as the primary source of historical and current data for the best intervention, assisting the doctor in making suggestions to improve patient outcomes and diagnosis. Also, compared to the typical patient record handling of the rural health unit, the physician would be more efficient because of the simple access to the EMR. Finally, the DSS creates personalized reports to showcase findings and help with the creation of program proposals, decision-making, and—most importantly—actionable insights and suggestions. Users will be assigned varying levels of access permissions based on the duties they are responsible for, which will include data encoding, report generation, and system maintenance. Furthermore, the produced system's quality will be evaluated and measured in relation to user needs using the ISO/IEC 25010 Software Quality Standards as the foundation. The ISO/IEC 25010 Software Quality Standards provide the most widely used models for evaluating software products. Makes a significant contribution to determining the software processes' delivery performance and suggesting enhancements.

The study's conceptual paradigm can be broadly divided into three sections. The first section begins with an overview of the unit's difficulties, issues, and challenges. Name, gender, age, address, complaints, and medical history are all factors that the unit considers when constructing a patient profile. These data sets include crucial elements for research and visualization. The input also includes the top ten diseases in terms of treatment and morbidity. Various procedures, such as data mining and analysis, were carried out in order to collect pertinent and helpful data for this investigation. The Scrum phases will be used during system development in order to get user feedback and proceed with the work as necessary. Ultimately, the RHU can now quickly and effectively offer the Solanoans pertinent healthcare services, from prevention to treatment, thanks to the system. Furthermore, it will enable the administration and doctors to get notifications and reminders about impending events before they happen, enabling them to make better-informed decisions about how to go forward. When needed, reports are also easily accessible.

III. METHODOLOGIES

3.1 Design of Research

A decision support system for the RHU of Solano, Nueva Vizcaya, was conceived and built in this study. It employs a descriptive research methodology, mainly questionnaires and interviews, to collect information pertinent to the study's conduct and developmental research to advance the system's development. The system development process also made use of the Agile Scrum methodology. It is based on incremental development, in which every sprint (objective) is integrated into a shippable product and is modified in response to input from stakeholders and customers. The

scrum team can quickly and simply modify the product goals in subsequent sprints to deliver more value iterations in the event of any issues or modifications. Stakeholders are happier in this way because they have been involved at every stage and have received exactly what they desire.

The researcher was then inspired to apply the Agile Scrum Methodology, which consists of the following steps: initiate, plan and estimate, implement, review and reflect, and release.

3.2 Research Approaches

The researcher began by requesting permission in writing from the Office of the Mayor to interview the relevant Municipal Health Officer (MHO) in order to get relevant papers and data for the study. After the letter was approved, the researcher went to the MHO and gave her an overview of the study's methodology, emphasizing the assurance that the data would be handled with the utmost confidentiality, as specified in the mayor's letter. The MHO then instructed the front-line healthcare professionals to offer additional services in order to help the researcher gather the data needed for the study. In order to corroborate the information shared throughout the health workers' series of interviews, direct observations were also recorded. The researcher saw firsthand how transactions moved through the RHU. The researcher saw how each patient's Individual Treatment Record (ITR) was completed to obtain their profile, how these are stored, and how they are accessed when patients return for a follow-up examination. Additionally, the researcher saw that several other forms, logbooks, and cabinets were used at the RHU to store a number of other unit reports. Furthermore, the researcher employed document scanning to review each patient's Individual Treatment Record, which contains written information on the patient's name, gender, age, address, complaints, and medical history. The researcher assumes that all of the information listed on the patients' ITR was provided voluntarily and directly by them, as they gave permission to be interviewed by the on-duty health worker. To ascertain the overall performance of the system, a questionnaire based on the characteristics and sub-characteristics of ISO/IEC 25010 Software Quality Standards was taken into consideration. Because they were informed about the technical aspects of the study, the participants in the questionnaire were IT specialists. The participant's participation in the study is optional, and the researcher promised them that all information and data collected would be handled with the highest level of confidentiality.

3.3 Analysis of Data

The interview was conducted using a qualitative strategy that employed contextualization and theme techniques to examine the respondents' responses. These answers were used to compile data on the challenges, issues, and problems facing the rural health unit, which served as the foundation for building a successful decision support system. The medical histories of the patients were utilized to gather and categorize the symptoms of prevalent diseases using document scanning and observation checklists. This allowed for the additional analysis of these symptoms using clustering determining a precise diagnosis. The data from the ISO/IEC 25010 Product Quality Questionnaire was calculated, compiled, looked over, and judged using descriptive statistics. The mean result was obtained with ease by utilizing the Likert scale. A mean is calculated by multiplying each item being averaged by a weight determined by the item's relative relevance. After adding up the results, divide the total by the sum of the weights. The weighted mean and frequency counting will be employed in the data analysis. The way that the aforementioned Likert scale will be applied to the data is shown in the table below. Additionally, several graphical and pictorial models will be employed to display various outcomes.

Table 1: Likert-Scale for the Compliance with ISO/IEC 25010 Product Standard

Weight	Weighted Mean	Descriptive Rating
1	1.00 - 1.79	Very Little Extent
2	1.80 - 2.59	Little Extent
3	2.60 - 3.39	Moderate Extent
4	3.40 - 4.19	Great Extent
5	4.20 - 5.00	Very Great Extent

IV. RESULTS

The following conclusions were drawn from the IT experts' observations, interviews, and responses utilizing ISO/IEC 25010:

1. The RHU's Issues, Problems, and Challenges

Through methodical and comprehensive observations, interviews, and document scanning, the researcher determined the following issues, problems, and difficulties that the RHU faced:

- A delay in decision-making and processing as a result of manual transaction recording

- the inaccessibility of patient records due to their storage in logbooks and forms, which jeopardizes the privacy and security of patient data;
- Lack of a central repository;
- Manually going backward in medical records can be a laborious task; and
- The challenge and lag in producing reports

The Rural Health Unit of Solano, Nueva Vizcaya, currently handles patient characterization, record-keeping, and retrieval by hand. Patient records are kept in multiple locations, jeopardizing their security and privacy. It is difficult and time-consuming for doctors to evaluate patients' conditions.

The patient records for diagnosis are kept in multiple locations, which frees up medical staff time to review earlier medical records. Computers are visible, but solely in relation to reports and communication.

2. Information Mining Methods

A method used in many fields to give the available data context is data mining. In this work, data mining techniques for classification and clustering were used to ascertain the frequency of sickness in a certain barangay at a given time. The healthcare sector has made extensive use of clustering algorithms to facilitate disease prediction and diagnosis [13]. Patients benefit from quick, sufficient, dependable, and less expensive healthcare delivery because of this. Specifically, clustering is a method of organizing data in a database according to specific standards; well-organized clusters have a high degree of inequality with other cluster objects and a high degree of similarity among the objects in the cluster. The end user receives the clustering result, which provides insight into the database's future state. However, classification is a type of data mining where a set of data is given classifications. It makes use of rules to help improve analysis and forecast accuracy.

One technique meant to improve the efficiency of analyzing very large datasets is classification. More specifically, it classifies the data into several groups using mathematical techniques such as statistics.

3. Algorithms for Clustering and Classification

Methods of classification and clustering are typically applied to the available data in order to forecast specific results. These database-stored data are full of hidden information that can be mined for useful information while making decisions.

According to one definition, clustering is the process of organizing database records according to specific standards. The end user receives the clustering result, which provides insight into the database's future state. Data are grouped using clustering without reference to a specific data class.

This study maximizes the use of if-then phrases, which produced a partitioning method. One of the most commonly used partitioning clustering algorithms, K-means clustering, was used in the creation of this work. Furthermore, it was discovered that data is classified into one or more clusters using the K-Means clustering algorithm. It can receive data inputs without class labels and group the data. By using this strategy, the data is divided into groups or clusters, with similar features being grouped together in one group and dissimilar attributes being put together in other groups. Because of this, it was pointed out that cluster analysis is a structured, methodical way to look at data and find medical groups with clinical similarities.

However, classification is a data-mining method that gives a set of data categories in order to help with more precise analysis and forecasting. It is one technique among many designed to improve the efficiency of the analysis of very massive datasets, such as medical data.

In particular, the decision tree method was applied in this investigation. The most commonly utilized method of data analysis is the decision tree. Moreover, the medical industry frequently uses classification techniques like decision tree algorithms to categorize medical data in order to make diagnoses. Decision trees create a set of prediction rules, typically in the form of an if-then statement, by specifying the order of attributes. A series of rules that can be used to categorize the data according to its attributes are produced throughout the decision tree development process. Using the provided data set, this technique builds a tree structure, with each node representing a test condition or attribute and the final leaf node representing the test results or classes. All samples are initially located on the single root node, and the attribute partitioning condition is used to build the subsequent nodes. The decision tree is well suited for medical databases since it is easy to comprehend and display, requires little data preparation, and can handle both numerical and categorical data.

4. Mapping-based Decision Support System for Rural Health Units

This technology that has been built is decision-support systems that will help the Solanoans receive medical care. Additionally, it helps with patient profiling, record retrieval, and record keeping for the unit. Additionally, the technology produces information in visually appealing formats to help doctors make better decisions regarding patient outcomes.

5. RHUDSS Level of Compliance with ISO/IEC 25010 Standards

Table 2: An overview of the software assessment conducted in accordance with ISO/IEC 25010 standards

Characteristics Criteria	Mean	Description
A. Functional Suitability	4.73	Very Great Extent
B. Performance Efficiency	4.76	Very Great Extent
C. Compatibility	4.64	Very Great Extent
D. Usability	4.80	Very Great Extent
E. Reliability	4.77	Very Great Extent
F. Security	4.85	Very Great Extent
G. Maintainability	4.58	Very Great Extent
H. Portability	4.72	Very Great Extent
Overall Mean	**4.73**	**Very Great Extent**

In terms of the ISO/IEC 25010 Characteristics criteria for extent of compliance, the software application was rated as having a "Very Great Extent" with an overall mean of 4.73 using the Likert scale. Out of the eight ISO/IEC 25010 qualities, the chart showed that security, usability, and dependability were rated as the most important three and were called "Very Great Extent." The system's performance, portability and adaptability, interoperability, and maintainability are then judged using a descriptive rating of "Very Great Extent," with mean scores of 4.76, 4.73, 4.72, 4.64, and 4.58, in that order.

V. CONCLUSION

For the RHU of the Municipality of Solano, Nueva Vizcaya, the created Rural Health Unit Decision Support System (RHUDSS) with Mapping worked as an effective record management system. The central storage makes it possible to access data quickly for patient profiling, record-keeping, and record retrieval. Furthermore, the RHU's decision-making procedures and the administration's overall decision-making will greatly benefit from the implementation of a decision support system. In order to provide pertinent programs and services for the Solanoans, tailored reports on disease occurrence mapping are generated. This system, which met the requirements of the ISO/IEC 25010 Software Quality Standards, meets them to a "Very Great Extent" degree in terms of functionality, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. It is advised to have a web-based application for convenient data access in order to further improve the application. This will assist the health unit with regard to the current state of medicine and the availability of other medical supplies.

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