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Enhancing patient navigation and referral through tele-referral system with geographical information systems

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ABSTRACT

A tele-referral system with a geographic information system (GIS) integrates telehealth services with spatial data to enhance healthcare delivery. Resource constraints can significantly impact the effectiveness of a tele-referral system with GIS. Addressing delayed or missed referrals is critical to ensuring timely patient care and improving health outcomes. Implementing a tele-referral system with GIS can significantly enhance healthcare delivery by leveraging spatial data and telehealth technologies to improve access, efficiency, and outcomes. One major issue is the lack of access to specialists, particularly in underprivileged communities. Patients face accessing specialized care due to a cumbersome referral process or long wait times, as well as the lack of patient engagement. The results showed that the GIS-enabled tele-referral system significantly reduced patient waiting times and improved the coordination of care. By incorporating these functionalities and strategies, the tele-referral system with GIS can effectively address issues related to delayed or missed referrals, ensuring timely patient care and improving overall health outcomes. By incorporating these strategies and functionalities, the tele-referral system with GIS can effectively address limited access to specialists, ensuring timely patient care and optimal use of available resources.

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1. INTRODUCTION

Patient navigation interventions, which are designed to enable patients excluded from health systems to overcome the barriers they face in accessing care, have multiplied in high-income countries since the 1990s [1]. Patient navigation is the logistical and emotional support necessary to achieve diagnostic and treatment compliance. It can improve the time to diagnosis, initiation of treatment, and patient satisfaction, as well as reduce the cost of treatment [2]. Recent issues related to human health in the world have shown the importance of telemedicine considering the necessity to perform the remote monitoring of patients [3].

The executive branch of the Philippine government, the Department of Health (DOH), is responsible for providing high-quality medical care and supervising all medical services and goods to ensure that all Filipinos have access to basic public health services. It was mandated in the Republic Act No. 11223, also known as the universal health care (UHC) Act establishing through institutionalizing health technology evaluation, establishing policies, programs, laws, and selecting various entitlements for pharmaceuticals, medications, pharmaceutical products, other equipment, procedures, and services fairly and transparently.

Making sure patients are accurately sent to the right care at the right time and health facility is a crucial part of UHC [4], [5]. Recently, the national patient navigation and referral system (NPNRS), which was mandated by Department order (DO) 2022-0210 from the DOH, must replace the OHCS. By connecting medical facilities and organizations across the country, the NPNRS will increase access to healthcare services. A network of partners and interested parties, physical command centers, human resources, information and communication technology capabilities, as well as a collection of monitoring and assessment tools for referral and navigation will all be part of the system [6]. During the pandemic era in 2020, one hospital command system (OHCS) was established to address patients with COVID-19 concerns about healthcare navigation and referral. This system has been in charge of the systematic triaging and referral of patients with COVID-19 suspicions or diagnoses. Many governments and privately owned healthcare facilities participated in offering patients healthcare services [7]. The management of public health institutions in the Philippines, including district and provincial hospitals and rural health units (RHUs), is outlined in the DOH's manual of procedures for health referral system. Depending on the availability of medical staff, supplies, logistics, and services, various medical facilities address issues such as challenges in maternity care and emergency cases (such as accidents or disease complications). Usually, cases are forwarded from the RUH to the district hospital, which is the next higher-level facility. District hospitals send unresolved cases to tertiary facilities like provincial hospitals and medical centers. The medical records must be returned to the RUH for archiving and continued treatment after the indicated patient has been managed. These referrals are intended to deal with situations in which the patient needs in-patient care (i.e., confinement), expert advice, a technical check not offered at the medical facilities or a technical intervention not covered by the medical center [8]. To address the challenges patients, face in accessing specialized care due to a cumbersome referral process or long wait times, as well as the lack of patient engagement, it's important to implement specific features and strategies in the Tele-Referral System with GIS.

It is a global perspective in patient referral and navigation that has begun in some nations like America and Europe to assist patients in navigating through the complexity of care, enable timely access to the health and social care services they require, and contribute to better care integration [9], [10]. Managing patient flow throughout a hospital network to provide fair and qualified access to services is one of the major problems for universal health systems. The use of telehealth approaches to enhance referral management has been shown to increase primary care resolution and promote care coordination [11]. Patient tele-referral systems are becoming increasingly popular as a way to improve patient care coordination and the overall patient experience. Tele-referral systems significantly reduced waiting times for specialist consultations and increased patient satisfaction. These systems have shown potential in reducing unnecessary hospital visits and related costs [12], [13].

The increase of geographic information systems (GIS) integration nowadays, has proven invaluable in various fields, including healthcare. GIS offers geospatial data analysis, visualization, and mapping capabilities that aid in identifying geographical patterns related to healthcare services and accessibility. GIS can optimize healthcare resource allocation and improve patient outcomes in underserved regions [14]. A study in the integration of GIS technology into patient tele-referral systems allows primary care physicians to identify the most suitable specialist for each patient based on geographical proximity and specialty availability. The results showed that the GIS-enabled tele-referral system significantly reduced patient waiting times and improved the coordination of care. By incorporating these functionalities and strategies, the tele-referral system with GIS can effectively address issues related to delayed or missed referrals, ensuring timely patient care and improving overall health outcomes.

Hence, the current study entitled enhancing patient navigation and referral through tele-referral system with GIS for Southern Isabela Medical Center aims to computerize the patient navigation and referral process in the hospital, most especially, it seeks to investigate the implementation, impact, and effectiveness of patient tele-referral with GIS in the healthcare domain. The integration of GIS technology in tele-referral systems provides valuable insights into geographical healthcare disparities and aids in optimizing resource allocation. Addressing delayed or missed referrals is critical to ensuring timely patient care and improving health outcomes. One major issue is the lack of access to specialists, particularly in underprivileged communities. By streamlining the referral procedure, boosting patient access to specialized care, and maximizing resource allocation, a tele-referral system with GIS can assist lessen this problem. However, challenges such as data privacy, interoperability, and initial implementation costs need to be addressed to ensure the widespread adoption of this approach. Data privacy and security are paramount in a tele-referral system with GIS, as the system handles sensitive patient information. Ensuring compliance with legal requirements and implementing robust security measures are essential to protect patient data.

2. METHOD

2.1. Research design

This study used the tele-referral system with a GIS that was built through research and development (R&D). This study is created using the methods and procedures of system analysis and design. Furthermore, this research used the principles and methodologies of the prototyping model called agile development method which is shown in Figure 1 [15].

Descriptive survey study was used as a research design for the evaluation of the developed computerized system. This aimed to seek the respondents' perspectives or experiences in using the system in a predetermined structured manner.

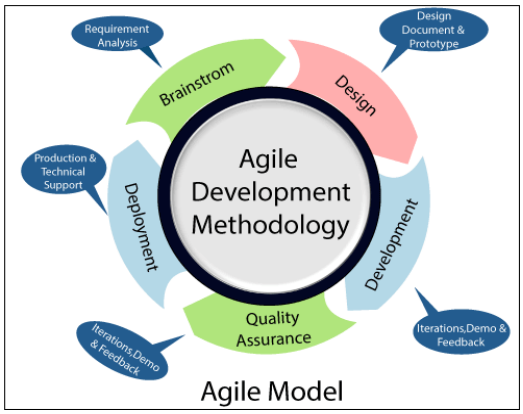


Figure 1. Agile prototyping model of software development

The following steps detailed and described how the computerized system was created: Brainstorm: in this stage, system requirements were specified. The functional and non-functional requirements were included to describe all the interactions that the end-users had with the computerized system; Design: in this stage, the developed system specifies its features, its entire structure, and the inter-relationship among the components of the system. The programming language and the platform in which the computerized system was compatible were also defined; Development: in this phase, the design of the system prototype was converted into a computer-understandable language and program. The developer combined all the product requirements and customer feedback, turning the design into code; Quality assurance: after the development of the tele-referral system, a test run was done to remove all the bugs. After codifying the whole program of the developed system, a test run was conducted on a given set of test data. In this phase, initial user evaluation is also initiated to test if the output of the test run matches the expected results. However, when errors still exist, phase 1 – brainstorming shall have to be performed again to specify the lacking requirements of the prototype identified in the testing and go through the following processes until the prototype has been refined; Deployment: after the user accepts the developed system, parallel testing was employed in the operation. During this phase, all the programs of the system were installed onto the user's computer, practicing the computerized operation while conducting manual operation in patient navigation and referral. This is done to demonstrate how much more effective automated processes are than manual ones. After the created system was installed, user training also started; Feedback: after the developed system has been initially evaluated, the developer collects input from the end users and works through it.

2.2. System architecture

Figure 2 shows a conceptual diagram of system deployment of the developed system. Participating health facilities and rescue groups can access the system by connecting to the internet. Tele-referral system with GIS was uploaded to the cloud where all data entries are also recorded. Patient records recorded in a computerized system are processed on the web server and verified with the database of the hospital information system of SIMC, which health workers and patient navigators use. A visualization technique called modeling of system architecture enables several parties to work together on system design, discover its inefficiencies, and suggest improvements [16].

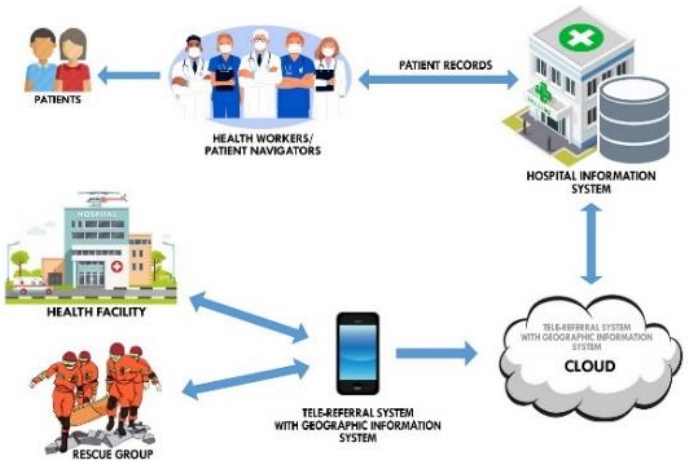


Figure 2. System architecture of the developed system

2.3. Process flow

Figure 3 describes the process flow of patient navigation and referral where health facilities and rescue refer patients online. When a patient referral is accepted, it will proceed to tele-triage to prepare patient transport to SIMC; however, referrals not accepted will be referred to other health facilities. Patients transported to SIMC will proceed to OPD/ER for treatment. If the case is admissible, the patient will be treated in-patient; otherwise, the patient will be discharged and reported to the referring facility for back referral. A framework with a process flow diagram that tackles these three circumstances. derived from a conceptual model that uses data flow diagrams, a common information system design tool [17].

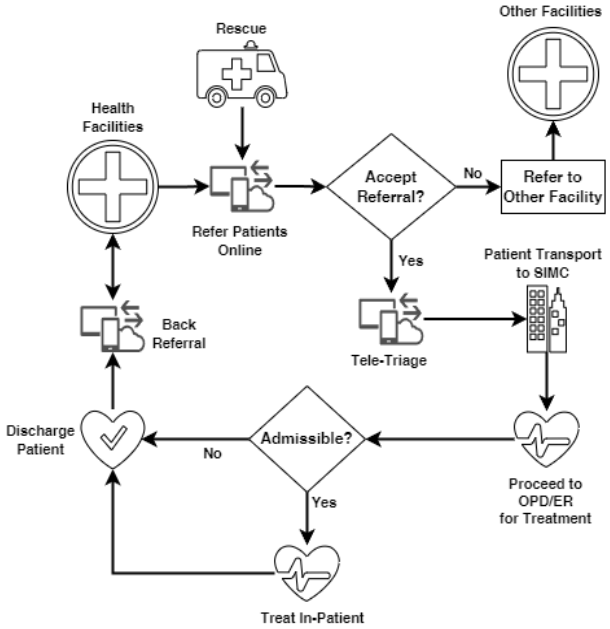


Figure 3. Process flow diagram of patient navigation and referral system

2.4. Use-case diagram

Figure 4 displays the tele-referral system with GIS use case diagram. It illustrates how system end users interact and how their positions as the system's created end users are limited. Drawing a use case diagram for a GIS-based tele-referral system requires figuring out who the important players are and how they interact with the system.

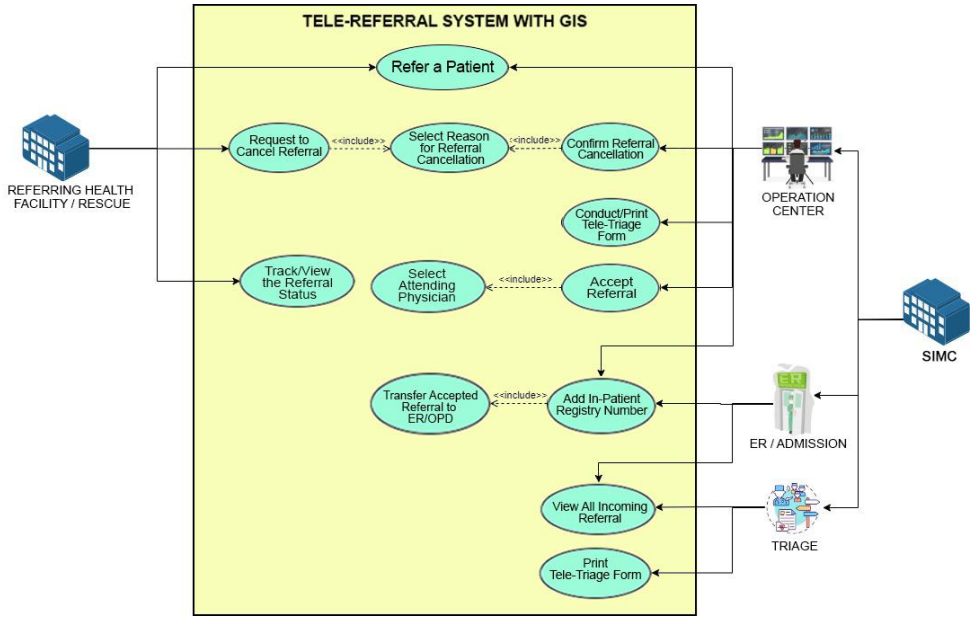


Figure 4. Tele-referral system with GIS use case diagram

3. RESULTS AND DISCUSSION

3.1. Identified problems and issues in the process of patient navigation and referral

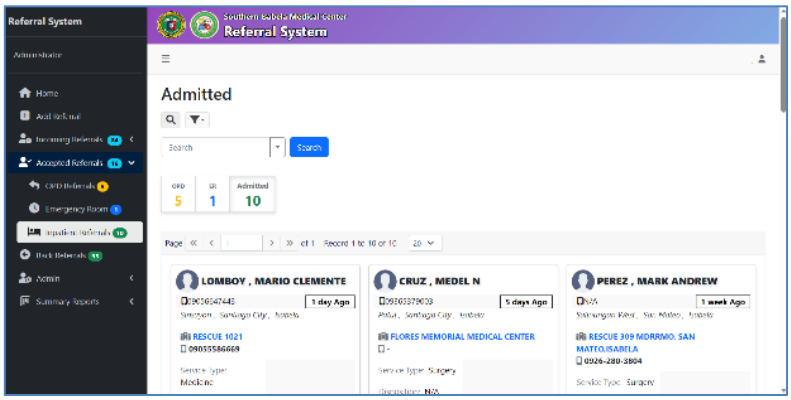
A common and persistent problem in patient navigation and referral systems is ineffective or insufficient coordination and communication between healthcare professionals and patients [18]. This can lead to various challenges and issues, such as: delayed or missed referrals: when there is a lack of effective communication between healthcare providers, referrals may not be sent or received in a timely manner. This can lead to delays in patients receiving the necessary care and may worsen their health conditions; Lost patient information: inefficient information management can result in patient data getting lost or misplaced during the referral process. This can lead to confusion and potential errors in patient care; Poor follow-up: Inadequate follow-up after a referral is made can result in patients not receiving the necessary care or services they were referred to. This lack of follow-up can impact patient outcomes negatively; Fragmented care: the treatment plan may not be continuous or coherent if multiple healthcare practitioners involved in the patient's care are not properly coordinated. This may result in inconsistent patient care and fragmented care; Limited access to specialists: patients may face challenges in accessing specialized care if the referral process is cumbersome or if there are long wait times for appointments with specialists; Lack of patient engagement: patients may not be actively engaged in the referral process, leading to non-compliance or disinterest in following through with the recommended referrals; Communication barriers: language barriers, technical issues, or miscommunication between providers and patients can hinder the referral process and create misunderstandings; Resource constraints: in some healthcare systems, there may be limited resources available for patient navigation and referral management, leading to overwhelmed staff and inefficient processes; and Data privacy and security concerns: patient data sharing between different healthcare providers can raise privacy and security concerns if not handled appropriately. To address these persistent problems, healthcare organizations and systems need to implement strategies that improve communication, streamline referral processes, and enhance patient engagement. This may involve adopting health information technology solutions, utilizing secure electronic health records, and establishing clear communication channels between providers. Additionally, educating both healthcare providers and patients about the importance of referrals and follow-up care can contribute to better outcomes.

3.2. Developed tele-referral system with GIS to address the identified problems and issues

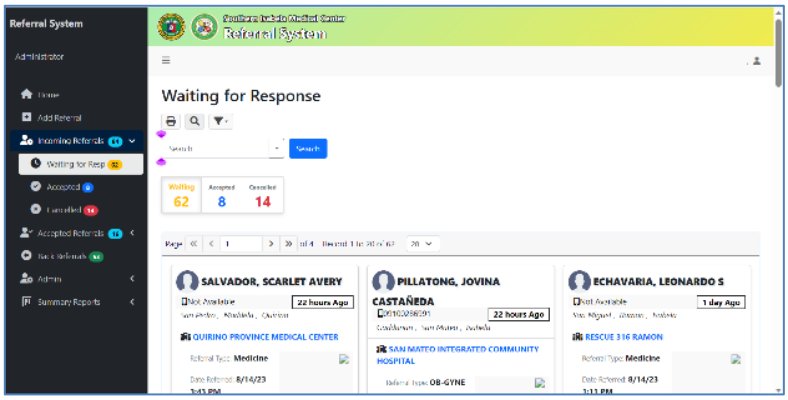
The tele-referral system with GIS is activated through an internal website while it is in the first installation phase. Mobile devices such as cell-phones and laptops can access this. The system's database was created using MSSQL and was designed utilizing a variety of web development tools, including HTML5, Bootstrap, PHP, JQuery, and JavaScript. Through a mobile application, the GIS can be used on a smartphone.

The developed system would help the healthcare facility in managing patient referral and navigation, most especially it strengthens the following features presented in Figure 5. Patient navigations, tracking and monitoring. Figure 5(a) navigation of referred patients. Patients can be referred to SIMC by participating

medical centers and rescue organizations, particularly when the patient (a) requires expert opinion, (b) needs a technical examination that is not available at the referring medical centers, (c) requires a technical solution outside the purview of the health center, and (d) needs in-patient care (i.e., confinement). Data collection and record of patient information. Through the use of the tele-referral system, data gathering and recording of patient information became easy as it automatically saved to the system's database upon data entry. Effective data collection and information management can increase patient participation, result in better treatments, and help the healthcare sector save money. When collecting patient data, data security, data quality, and data correctness are taken into account [19]. Figure 5(b) monitoring and tracking of referred patients. The patient navigators can easily track or monitor the status of the referred patient, if what action and status has been prescribed to the patient such as priority, emergent, urgent, inter-facility transfer, isolation, OPD request, medical repatriation, teleconsultation, or inquiries. Because it offers the mechanism and facilitates the consumption of healthcare services offered in service delivery centers, a healthcare navigation system is a crucial component of a strong service delivery network. Assigning of attending physician to referred patient. The attending healthcare facility can assign an attending physician to the referred patient upon his confirmation. From this, the patient and the referring healthcare facility can be informed quickly that there is an available physician who will be attending the case of the patient. The utilization of ICT has transformed how healthcare delivers care to patients. With the help of digital health, individuals in general and patients in particular can access healthcare services locally or from a distance [20].



(a)

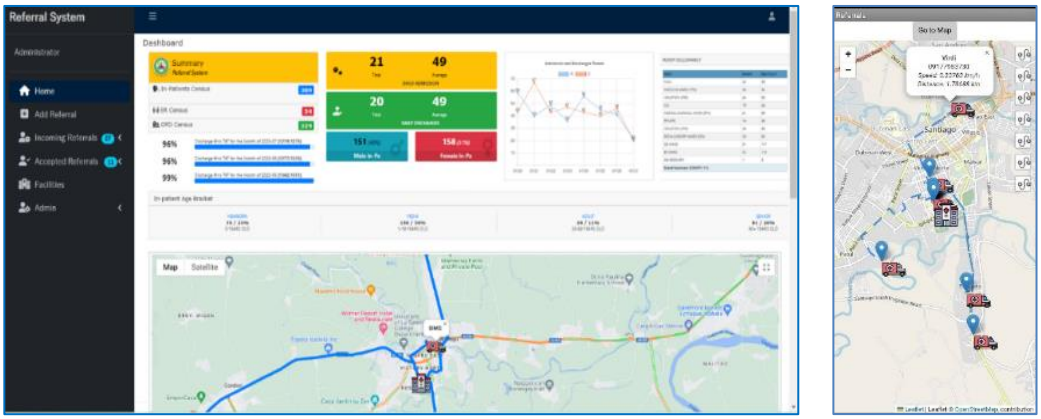


(b)

Figure 5. Patient navigations, tracking and monitoring (a) navigation of referred patients and (b) monitoring and tracking of referred patients

Figure 6 is dashboard, Figure 6(a) real-time dashboard on tele-referral system tracking of ambulance location and movement. A GIS application installed on the mobile device of ambulance drivers is used to locate ambulances and where they are heading. This enables the monitoring of the census of in-patient, ER, and OPD; daily admission and daily discharges including admission and discharge trends, in-patient age bracket, and room occupancy, presented in the form of charts. Figure 6(b) the GIS-support mobile application

for ambulance tracking. With this, the movement of the ambulance is monitored in delivering healthcare services. Given that geography has a significant impact in both population and individual health, a study in GeoAI- A growing role in health and healthcare is played by a mix of GIS and artificial intelligence (AI) [21]. A real-time dashboard simplifies how the institution operates through the displayed data which is also considered by management in the decision-making process [22], and effective interventions for possible future developments [23].



(a) (b)

Figure 6. Dashboard (a) real-time dashboard on tele-referral system and (b) GIS-support mobile application for ambulance tracking

Figure 7 heat map census. This shows the graphical representations of data that visualize the locations/areas with a high volume of patients admitted to the hospital. The darker the shade, the greater the quantity. Colors are easier to distinguish and make sense of than raw numbers, especially in dealing with large volumes of data [24]. As discussed in digital health network, the process of referring patients to specialists may be time-consuming, stressful, and sometimes frightening for primary care providers and their patients. The most frequent issues in the operation are low-quality referrals from primary care doctors, the lack of a global platform for patient referral management, and the lack of compatibility with the EHR system. Hence, the utilization of electronic referral management software must streamline and facilitate patient referral management information exchange by taking advantage of emerging cloud-based technologies. Some of its benefits mentioned are (a) identifying, pre-qualifying, and scheduling patient referrals; (b) tracking to ensure referral success; (c) preventing referral leakage; (d) securing patient information exchange; (e) ease of access to consultation reports and test results; (f) ensuring continuity of care; (g) online networking and marketing opportunity; (h) facilitating co-management of patients and optimizing meaningful use of network resources; (i) referral analytic reports; and (j) less cost and ease of implementation [25].

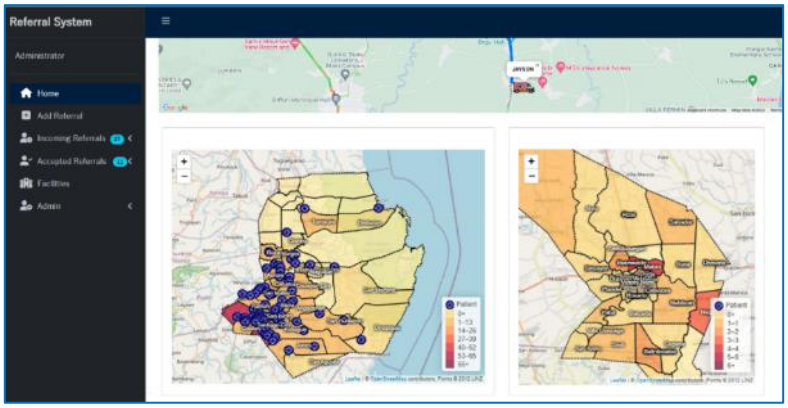


Figure 7. Heat map census presentation

3.2.1. Level of compliance of the developed computerized system to ISO 25010 software quality standards as assessed by the IT experts

Table 1 shows that the developed tele-referral system with GIS as assessed by the IT experts is highly compliant based on the ISO 25010 software quality standards, with an overall mean rating of 3.90. Among the eight software quality characteristics, the system was highly compliant in terms of performance efficiency, compatibility, usability, security, maintainability, and portability. Functional stability and reliability were rated compliant.

Comparable studies have been done before, but this one intends to evaluate the technical quality and functional performance of the nursing process' electronic documentation system at the University of So Paulo Teaching Hospital. Both the quality model and the evaluation process are established in the International Organization for Standardization/International Electrotechnical Commission regulation standard 25040. Functional appropriateness, reliability, usability, performance efficiency, compatibility, security, maintainability, and portability were the quality attributes that were assessed. Results from the extra instrument, however, indicate that only the feature of usability received a rate of favorable answers of less than 70% in the evaluation of the information technology specialists. Additionally, rates for performance effectiveness, dependability, and compatibility were all lower than the specified parameter [26].

In contrast to this study, which concentrated on the eight quality criteria, the software achieved rates of positive replies of over 70% for the majority of the quality attributes tested. These positive responses ranged from 3.47 to 3.70.

Table 1. Level of compliance of the developed computerized system to ISO 25010 software quality standards as assessed by the IT experts

ISO 25010 software quality standards		Mean	SD	Descriptive equivalent
A.	Functional stability	3.47	.298	Compliant
B.	Performance efficiency	3.51	.417	Highly compliant
C.	Compatibility	3.65	.351	Highly compliant
D.	Usability	3.70	.285	Highly compliant
E.	Reliability	3.48	.399	Compliant
F.	Security	3.70	.286	Highly compliant
G.	Maintainability	3.61	.270	Highly compliant
H.	Portability	3.64	.437	Highly compliant
	Overall mean	3.60	.192	Highly compliant

3.3. The level of acceptance of the developed computerized system as assessed by the end-users using the ISO 25010 software quality standards

Table 2 shows that the developed tele-referral system with GIS as assessed by the end-users is highly accepted based on the ISO 25010 software quality standards, with an overall mean rating of 3.53. Among the eight software quality characteristics, the system was highly accepted in terms of compatibility, usability, reliability, maintainability, and portability. Functional stability and performance efficiency received ratings described as 'accepted'. Utilizing ISO/IEC 25010 quality standards, this study's objective was to evaluate the software quality of portable pregnancy health record devices. A questionnaire addressing the four exterior quality elements of functional appropriateness, operatability, performance efficiency, and reliability, as well as several activities, were required for the evaluation [27].

However, the study at hand on the developed tele-referral system with GIS showed a different result path having obtained high ratings across all software quality characteristics mentioned. Their research revealed that dependability and functional suitability-rather than operability and performance efficiency were the 17 apps' most sought quality characteristics.

Table 2. The level of acceptance of the developed computerized system as assessed by the end-users using the ISO 25010 software quality standards

ISO 25010 software quality standards		Mean	SD	Descriptive equivalent
A.	Functional stability	3.47	.183	Accepted
B.	Performance efficiency	3.40	.435	Accepted
C.	Compatibility	3.90	.224	Highly accepted
D.	Usability	3.53	.506	Highly accepted
E.	Reliability	3.55	.447	Highly accepted
F.	Security	3.36	.329	Accepted
G.	Maintainability	3.52	.179	Highly accepted
H.	Portability	3.53	.506	Highly accepted
	Grand mean	3.53	.195	Highly accepted

3.4. Mann-Whitney test results comparing the level of compliance as assessed by IT experts and level of acceptance as assessed by end users on the developed computerized system

The results shown in Table 3 indicated that there was no significant difference in the level of compliance as assessed by 5 IT experts, and the level of acceptance as assessed by 30 end users on the developed computerized system, z = -.849, p = .396. Thus, we failed to reject our null hypothesis. This implies that the extent to which the IT experts assessed the compliance of the developed computerized system does not differ from how the end users assessed its acceptance. Moreover, both measures received highly favorable ratings.

This is in line with the electronic documentation system, where the identical software quality traits were assessed by assessors composed of IT experts, nurse lecturers, and staff nurses. The findings show that only the usability characteristic had a positive response rate from the IT specialists' rating that was under 70%. Over 70% of respondents agreed that each of the nursing instructors' quality attributes was present. The system received great grades for usability, security, and functional adequacy from staff nurses from the medical and surgical clinics who have used it previously as well as from staff nurses from other hospital departments and other medical facilities who have not [28]. E-health is an efficient way of accessing and information and communication technologies (ICT) across different fields of application that affect the health sector, from the experienced specialist doctors to the hospital manager, via nurses, data processing specialists, social security administrators, and patients [29]. The technical quality of a mobile application to support the nurse's decision was evaluated in the study of the assessment of a quality software application for the prevention of skin lesions in infants using the product quality model. It used IT specialists and healthcare professionals as the evaluators, just like the study 20 assessors, divided into two groups of ten nurses and ten IT specialists, used the program, carried out tests based on two case studies, and evaluated six quality factors and 23 sub features. The items having a concordance percentage of more than 70% were declared sufficient after the data were analyzed using a specific methodology. The qualities with the highest concordance percentages among the groups of nurses and IT professionals were functional adequacy (100%-98.9%), reliability (90%-100%), usability (93.2-85%), performance efficiency (100%-100%), compatibility (97.5-90%), and safety (94%-91%). In the evaluation of the sub-features, only accessibility displayed a percentage value that was less than the necessary one (70%-60%) [30]. Healthcare telemonitoring has emerged as a promising approach to remotely monitor patients remotely, enabling timely intervention and personalized care [31].

Compared to how end users rated the system's level of acceptability, the IT specialists provided a higher rating for the system's level of compliance than did the study. Nevertheless, both pieces of software are of an equally high technological caliber to satisfy the requirements of healthcare professionals, add to the working process, advance knowledge, and encourage the development of clinical reasoning in professionals.

Table 3. Comparing the level of compliance as assessed by IT experts and level of acceptance as assessed by end users on the developed computerized system

	N	Mean rank	Sum of ranks	z	Sig.	Decision
IT experts	30	18.60	558.00	-.849^{ns}	.396	Failed to reject Ho
End users	5	14.40	72.00			

4. CONCLUSION

The tele-referral system with GIS shows tremendous promise for enhancing patient satisfaction, efficiency, and access to healthcare. The integration of GIS technology into tele-referral systems can optimize care coordination and resource allocation, ultimately leading to improved patient outcomes. The created computerized system conformed with the rules and regulations imposed by the DOH, which is extremely advantageous for Southern Isabela Medical Center, its patients, the medical staff, and patient navigators. The integration of telehealth services with geographic data through a tele-referral system and GIS improves the delivery of healthcare. Through the use of telehealth technology and spatial data, a tele-referral system with GIS can greatly improve access, efficiency, and outcomes in the delivery of healthcare. Hence, expanded implementation of tele-referral systems in other healthcare facilities is recommended to optimize the meaningful goal of digitalization in the healthcare system. The developed software was of an equally high technological caliber to satisfy the requirements of healthcare professionals, add to the working process, advance knowledge, and encourage the development of clinical reasoning in professional further research, development, and collaboration between healthcare institutions, policymakers, and technology developers, as well as the provision of government support, is essential to realizing the full potential of this innovative approach in healthcare. By incorporating these strategies and functionalities, the tele-referral system with GIS can effectively address limited access to specialists, ensuring timely patient care and optimal use of

available resources. The tele-referral system with GIS can effectively address data privacy and security concerns, ensuring the protection of sensitive patient information while providing efficient healthcare services.

5. ACKNOWLEDGEMENTS

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