ELECTRONIC HEALTHCARE REFERRAL SYSTEM (EHRS)
A CASE STUDY OF LIRA REGIONAL REFERRAL HOSPITAL (LRRH)

By

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AUG, **2026**

DECLARATION

I **OWINO HARON** Registration No. **BU/UP/2023/1837** do hereby declare that this project report is a result of my effort and has not been submitted to any institution of higher learning before for an academic award and should not be reproduced without my consent

Sign.....Date.....24th-08-2026.....

OWINO HARON

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May God bless you all abundantly.

DEDICATION

I dedicate this work to my family for their endless love, support, and encouragement throughout my academic journey. Their sacrifices and belief in me have been a constant source of strength and motivation.

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SUPERVISOR'S APPROVAL

This study project, Electronic Healthcare Referral System is done under my supervision as the university supervisor and submitted with my approval

Sign.....Date.....27th April 2026

MR. OBOTH ANDREW OKOTH

SUPERVISOR

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LISTS OF ACRONYMS

EHRS: Electronic Healthcare Referral System

LRRH: Lira Regional Referral Hospital

e-Referral: Electronic Referral System

HMIS: Hospital Management Information System

MIS: Management Information System

FHIR: Fast Healthcare Interoperability Resources

HL7: Health Level Seven Standards

RAD: Rapid Application Development

ERD: Entity-Relationship Diagram

MVP: Model-View-Presenter Architecture

SDG 3: Sustainable Development Goal 3

REST APIs: Representational State Transfer APIs

SUS: System Usability Scale

ISO 25010: Software Quality Standards

GDPR: General Data Protection Regulation

UML: Unified Modelling Language

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Abstract

The Electronic Healthcare Referral System (EHRS) was developed to enable health workers and in-charges at referring facilities to create, submit, and track patient referrals to Lira Regional Referral Hospital in a fast, organised, and paperless manner. The system was developed in response to the challenges observed across health facilities in the Lango sub-region of Uganda, where the referral process relies heavily on handwritten referral forms and manual communication between facilities. These paper-based procedures delay the transfer of critical patient information to receiving doctors, often forcing clinicians at Lira Regional Referral Hospital to repeat diagnostic tests that had already been conducted at the referring facility. This results in longer patient waiting times, increased congestion, inefficient use of departmental resources, and potential risks to patient safety, particularly in emergency cases.

To understand these challenges, data was collected through interviews with hospital in-charges, administrators, and clinical staff, and further supported by observations of the existing referral workflow at Lira Regional Referral Hospital and selected health facilities within the Lango sub-region. The collected data was analysed to identify key system requirements and inform the design of the solution.

The system was designed using Entity Relationship Diagrams (ERDs) for the data model and Use Case Diagrams to represent system interactions. It was implemented using React and Tailwind CSS for the front-end interface, Node.js and Express.js for the server-side logic and API management, and SQLite for structured data storage. The system supports referral creation with patient details and attached lab documents, real-time status tracking, emergency notifications for administrators, department-level referral assignment, and an analytics dashboard displaying referral statistics by diagnosis, referring facility, and department.

In conclusion, the system met all the objectives set out at the beginning of the study and provides a practical, lightweight, and affordable solution to the referral management challenges at Lira Regional Referral Hospital. It is recommended for adoption by regional and district hospitals across Uganda facing similar challenges with paper-based referral processes.

CHAPTER ONE

1.1 Introduction

Referral systems play a major role in managing the patient health record flow from primary to secondary health units with resources beyond those available where health care was initially sought. This is crucial in any healthcare system since it plays a vital role in the management of diseases and promotes health outcomes (Gupta, Talati, Bhattacharya, & Singh, 2017). Efficient referral systems provide access to treatment and skills by coordinating different levels of healthcare through appropriate referral levels that promote health and well-being of lives (Singh, Doyle, Campbell, Mathew, & Murthy, 2016). A referral is defined as a process in which a health worker at a health system level that has insufficient resources (medications, equipment, skills) to manage a clinical condition seeks assistance from a better facility or with different resources in the same or higher level to help or take over the management of the client's case (Alaro, 2016). Patient referral involves certain criteria followed (Griffin, Nate, Rivard, Christianson, & Dusek, 2016), and beyond this, other factors influence a referral system to ensure its effectiveness hence patient referral systems are critical for effective healthcare delivery, particularly in regional hospitals like Lira Regional Referral Hospital (LRRH) in Uganda's Lango sub-region. This study investigated the inefficiencies of the current manual referral process and proposed an Electronic Hospital Referral System (EHRS) to streamline coordination between health facilities. The chapter provided the background, problem statement, objectives, research questions, significance, and scope of the study.

1.2 Background of the Study

Globally, effective healthcare referral systems are recognized as a critical component of well-functioning health systems, ensuring that patients receive appropriate, timely, and specialized care across different levels of service delivery. The World Health Organization emphasizes that integrated, people-centered health services are essential for improving health outcomes and optimizing resource utilization. In its global strategy (2015), WHO advocates for coordinated referral pathways that link primary, secondary, and tertiary care to enhance efficiency and equity in healthcare access. Furthermore, the principle that access to quality healthcare is a fundamental human right, as highlighted by WHO (2006), underpins global health policies. This is reinforced by United Nations Sustainable Development Goal 3 (SDG 3), which aims to ensure healthy lives and promote well-being for all by improving service delivery systems, including referral mechanisms.

In Sub-Saharan Africa, however, healthcare referral systems remain weak and fragmented due to systemic challenges such as inadequate infrastructure, shortage of skilled health personnel, limited medical equipment, and poor coordination between levels of care. Studies across the region indicate that inefficient referral pathways often result in delays in treatment, duplication of services, and increased patient burden. Many patients bypass lower-level facilities due to perceived or actual inadequacies, directly seeking care at higher-level hospitals, which leads to overcrowding and resource strain. According to research by Pittalis, Brugha, and Gajewski (2019), these inefficiencies significantly compromise the quality and continuity of care, particularly in low- and middle-income countries where health systems are already under pressure.

In Uganda, the healthcare system is structured into hierarchical levels, ranging from Health Centre I (community level) to national referral hospitals, with regional referral hospitals acting as key intermediaries providing specialized services. Despite this structured system, referral practices are often inconsistent and poorly coordinated. Challenges such as lack of standardized referral guidelines, insufficient diagnostic capacity at lower-level facilities, stock-outs of essential medicines, and financial constraints among patients contribute to inappropriate or delayed referrals. As noted by Daniels and Abuosi (2020), an effective referral system is essential for ensuring continuity of care and improving overall health system performance. However, increasing demand for specialized services, coupled with systemic inefficiencies, continues to strain Uganda's regional referral hospitals.

At the local level, Lira Regional Referral Hospital plays a vital role in delivering specialized healthcare services to the Lango sub-region in Northern Uganda. It serves as a referral hub for lower-level facilities such as Health Centre IIIs and IVs, including Amach Health Centre IV and Barr Health Centre III, which often lack adequate equipment, essential medicines, and specialized personnel. In recent years, the hospital has experienced a significant increase in patient referrals. This surge is attributed to multiple factors, including limited capacity at exterior health facilities, absence of clear referral protocols, and socioeconomic barriers that prompt patients to bypass primary care levels.

The rising volume of referrals has placed considerable pressure on the hospital's already limited resources, resulting in longer waiting times, increased workload for healthcare providers, and potential delays in patient management. These challenges highlight gaps in the referral system and underscore the need for improved coordination, resource allocation, and policy implementation. Therefore, this study focuses on analyzing the dynamics of patient referrals to Lira Regional Referral

Hospital, with the aim of proposing sustainable strategies to optimize referral processes and enhance healthcare service delivery in the region.

1.3 Statement of the Problem

An effective healthcare referral system is critical for ensuring timely access to appropriate levels of care, improving patient outcomes, and enhancing the overall efficiency of health service delivery. However, in Uganda, particularly at facilities such as Lira Regional Referral Hospital, the referral process remains largely manual and paper-based, limiting its effectiveness. According to the Ministry of Health Uganda (2023), over 60% of inter-facility referrals are conducted using handwritten notes, contributing to a referral failure rate of approximately 25–30%. This failure is characterized by patients not reaching the intended referral facility, arriving without proper documentation, or experiencing significant delays in receiving care.

The reliance on manual referral systems has resulted in persistent challenges, including loss of patient records, poor communication and coordination between referring and receiving facilities, lack of real-time tracking and feedback mechanisms, and limited accountability within the referral chain. These inefficiencies lead to delays in treatment, increased workload for healthcare providers, duplication of services, and in some cases, preventable patient morbidity and mortality.

Despite the critical role of referral systems in healthcare delivery, there is limited adoption of digital solutions to streamline and strengthen referral processes in Uganda's regional healthcare facilities. This gap highlights the need for an efficient, reliable, and scalable solution to address the shortcomings of the existing system.

Therefore, this study seeks to develop a web-based Electronic Hospital Referral System that enables secure management of patient referral records, real-time communication and feedback between healthcare facilities, and effective tracking of referral outcomes. The system aims to improve coordination, enhance accountability, reduce delays in patient care, and ultimately contribute to better health outcomes within the Lango sub-region.

1.4 MAIN OBJECTIVE OF THE STUDY

The main objective of this study was to develop an electronic healthcare referral system (EHRS) that captured all the referrals from different lower health care facilities reduced cost and reduced mortality rates in the sub-region.

1.4.1 SPECIFIC OBJECTIVES

The specific objectives of this study were;

1. To review the literature and determine the requirements for the proposed system.
2. To analyze the requirement and design an electronic healthcare referral System.
3. To develop an electronic healthcare referral System.
4. To test and validate the electronic healthcare referral System

1.5 Scope of the Study

1.5.1 Content Scope

The web-based electronic healthcare referral system was developed specifically for Lira Regional Referral Hospital to improve referral creation, tracking, and feedback between referring health facilities and the receiving facility through designated in-charges. The system allowed users to create patient referrals, enter detailed patient information, attach supporting documents such as lab results, photos, or PDFs, and track the status of submitted referrals from creation through to acceptance or rejection.

The system supported direct submission upon referral creation, after which administrators received real-time notifications particularly for emergency cases and could accept or assign referrals by department. Users could monitor the progress of their referrals through a structured workflow managed via a web-based interface.

The system utilized a structured database to store all referral records, responses, and status logs. Administrators were able to view, filter, assign, and respond to referrals through a dedicated dashboard. The system generated basic analytics including counts of submitted, accepted, pending, and rejected referrals.

The system prioritized a responsive web interface using React and Tailwind CSS, ensuring accessibility on desktop computers. Secure data storage was implemented using SQLite, and strong authentication was enforced to protect sensitive patient information and administrative actions.

1.5.2 Geographical Scope

The study was conducted at Lira Regional Referral Hospital, located in Lira City, Northern Uganda, along with select health facilities within the Lango sub-region that fall within the hospital's referral network. Lira Regional Referral Hospital served as a representative case study for regional referral hospitals in northern Uganda facing challenges with manual referral processes, including issues of delayed referrals, loss of patient information in transit, and the absence of a formal feedback mechanism between referring and receiving facilities.

1.5.3 Time Scope

The study was conducted over a period of four months. This duration accounted for initial requirements gathering, system development using Node.js, Express, and SQLite for the back end and React with Tailwind CSS for the front end, and final testing and validation with hospital in-charges and administrators at Lira Regional Referral Hospital.

1.5.4 Technology Scope

The system was developed using React and Tailwind CSS for the front-end interface, providing both functionality and a responsive user experience. The back end was built using Node.js and Express.js to handle server-side logic and API management, while SQLite was used as the database management system for structured data storage. The system was designed as a web-based accessible via browsers of computers within the hospital's network environment.

1.6 Justification

The justification for this study is grounded in the need to address the inefficiencies associated with the traditional, paper-based patient referral processes currently used across many health facilities in the Lango sub-region, including those referring patients to Lira Regional Referral Hospital. The existing manual approach is prone to critical challenges such as loss of referral documents in transit, lack of real-time communication between referring and receiving facilities, delayed acceptance of patients, and limited accountability for referral outcomes. These shortcomings directly compromise the quality and timeliness of patient care, particularly in emergency situations.

With the increasing adoption of Information and Communication Technology (ICT) in healthcare management, there is a growing need to integrate digital solutions that enhance administrative

efficiency and patient safety. A web-based electronic referral system offers a practical and scalable solution to these challenges by providing a secure, accessible, and structured platform for initiating, managing, and tracking patient referrals across facilities.

Furthermore, the study is justified by the need to promote transparency and coordination in healthcare delivery. By enabling in-charges to submit referrals electronically and track their status in real time, the system fosters a culture of accountability and timely response between facilities. This aligns with modern healthcare practices that emphasize continuity of care and inter-facility collaboration.

In addition, there is limited implementation of such digital referral systems in many regional hospitals within similar resource-constrained contexts in Uganda, creating a significant gap that this study seeks to address. Therefore, developing and evaluating a web-based electronic healthcare referral system will not only solve a practical problem at Lira Regional Referral Hospital but also provide a replicable model for other regional and district hospitals facing similar challenges across the country.

1.7 Significance of the Study

This study is significant as it contributes to improving patient referral management and inter-facility communication within the healthcare system through the adoption of digital technologies. The development of a web-based electronic referral system for Lira Regional Referral Hospital provides a secure, reliable, and efficient platform for creating, submitting, and managing patient referrals across health facilities in the Lango sub-region. This enhances confidentiality, reduces the risk of data loss or document misplacement during transit, and ensures that referral information is systematically recorded, tracked, and acted upon in a timely manner.

The study benefits hospital administration by enabling real-time access to structured referral data, thereby supporting informed resource allocation, departmental planning, and improved patient flow management. For in-charges and clinical staff at both referring and receiving facilities, the system promotes coordinated care by providing a transparent and responsive channel through which referrals can be initiated, monitored, and acknowledged. This is likely to increase trust and collaboration among health workers across facilities, ultimately improving patient outcomes.

Additionally, the study contributes to the growing body of knowledge on the application of web-based systems in healthcare management, particularly in the areas of referral coordination, inter-

facility communication, and patient data management. It may serve as a reference for other regional and district hospitals in Uganda seeking to modernize their referral processes using ICT solutions.

Finally, the findings and the developed system provide practical insights for system developers, healthcare administrators, researchers, and policymakers on the design, implementation, and evaluation of digital referral systems, especially in resource-constrained environments where paper-based processes remain prevalent.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents a systematic review of literature on electronic healthcare referral systems and their integration within hospital information infrastructures, with specific focus on regional referral hospitals in low-resource settings. The review examines theoretical and observed studies on information systems (IS), management information systems (MIS), hospital management information systems (HMIS), and electronic healthcare referral (e-referral) systems. Drawing from peer-reviewed publications, conference proceedings, and authoritative reports published between 2023 and 2026, as well as foundational texts, this chapter establishes the theoretical foundation for the proposed electronic referral system at Lira Regional Referral Hospital (LRRH) in Lira City, northern Uganda. Lira Regional Referral Hospital serves as the primary tertiary referral centre for the Lango sub-region, receiving referrals from over 50 lower-level health centres (HC III's and HC IVs) across districts including Apac, Dokolo, Alebtong, Otuke, Kole, and others. However, the current referral process remains almost entirely paper-based, resulting in delayed patient transfers, lost clinical documentation, fragmented communication between referring and receiving facilities, and poor outcomes for critically ill patients (Okello & Acio, 2025). The Uganda Ministry of Health's Health Information Management Systems (HIMS) strategy and the Uganda National eHealth Strategy (2023–2028) have prioritised digital referral coordination as a key intervention (Ministry of Health Uganda, 2024). This review situates the development of an e-referral system for LRRH within this national digital health transformation agenda, exploring how information systems, MIS, HMIS, and e-referral platforms can collectively strengthen referral pathways, reduce avoidable deaths, and improve health system performance.

2.2 Information Systems

An information system (IS) is a sociotechnical system consisting of people, hardware, software, data, and procedures that work together to collect, process, store, and distribute information to support management, decision-making, and operational activities in organisations (Longdom, n.d.; Laudon & Laudon, 2025). Information systems help improve efficiency and reduce human error by automating tasks that were once manual. Common examples include transaction processing systems, decision support systems, and executive information systems.

In healthcare, IS play a particularly critical role because they integrate clinical workflows with administrative data, enabling seamless patient care across departments and facilities. (Akpa &

Ogunyemi, 2024) conducted a systematic review of health information systems in sub-Saharan African referral networks and found that facilities with functional digital IS experienced 47% fewer referral rejections due to incomplete documentation compared to those relying on paper-based records. The authors attribute this improvement to the ability of IS to enforce structured data entry, validate required fields, and provide real-time access to patient histories.

Contemporary IS scholarship emphasizes the convergence of technical infrastructure and human factors in determining system effectiveness. (Wickramasinghe & Goldberg, 2024) argue that the success of an IS in a hospital setting depends not only on its technical specifications but also on how well it aligns with clinical workflows, regulatory requirements, and the needs of diverse users (doctors, nurses, administrators, and patients). This perspective is particularly relevant to Lira Regional Referral Hospital, where any e-referral system must accommodate users with varying digital literacy levels, from specialist physicians to referral desk officers and community health workers at remote health centres.

The evolution of IS has also been shaped by advances in user interface (UI) design and human-computer interaction (HCI). (Tiwari & Singh, 2024) found that intuitive UI design significantly increased user adoption rates of healthcare information systems among non-technical staff in low-resource settings, with adoption rates rising from 42% to 78% following interface redesign. This finding directly informs the design of the proposed e-referral system for LRRH, which must prioritise simplicity, clear visual feedback, and minimal data entry burden to ensure high uptake among referring clinicians.

2.3 Management Information System (MIS)

A Management Information System (MIS) provides managers and administrators with timely reports and summaries that support effective decision-making (O'Brien, 2003; O'Brien & Marakas, 2024). It collects data from various departments, processes it, and presents meaningful information. In healthcare, MIS can be used to track staff performance, manage resources, monitor bed occupancy, and evaluate program outcomes. Examples include financial management systems, patient information systems, and feedback systems.

In the context of regional referral hospitals, MIS play a critical role in managing patient flow, optimising bed capacity, and monitoring referral patterns. (Nantume & Ssemakula, 2025) investigated MIS implementation in Uganda's regional referral hospitals (including Masaka, Mbarara, and Lira) and found that facilities with functional hospital-wide MIS demonstrated 35% faster patient throughput in emergency departments and significantly lower rates of ambulance

diversion compared to hospitals relying on manual logbooks. The authors attribute this advantage to the ability of MIS to provide real-time visibility into bed availability, staff schedules, and equipment status, enabling administrators to make informed decisions about accepting or redirecting incoming referrals.

MIS also support evidence-based governance by providing longitudinal data on key performance indicators. (Alavi & Leidner, 2025) argue that MIS-enabled performance monitoring reduces information asymmetries within hospital administration, ensuring that clinical directors have accurate data to identify systemic bottlenecks and allocate resources to the most critical areas. For Lira Regional Referral Hospital, an e-referral system functioning as a specialized MIS module would generate data on which referring facilities generate the most referrals, which specialty departments experience the highest referral volumes, and which conditions are most commonly associated with referral delays information that is currently unavailable due to the absence of digital tracking mechanisms.

Furthermore, MIS support organisational communication by providing structured channels through which information flows between different levels of management. In schools, as noted by your source, MIS can track staff performance and evaluate programmes; analogously, in a hospital, MIS can track referral response times, specialist availability, and patient transfer outcomes. This principle is foundational to the design of the e-referral system, which functions as a feedback-oriented MIS module, enabling LRRH's management to systematically collect, analyse, and act on referral data.

2.4 Hospital Management Information System (HMIS)

A Hospital Management Information System (HMIS) is a digital platform that supports the coordination of clinical and administrative functions within a health facility. It integrates modules for patient registration, outpatient and inpatient management, laboratory services, pharmacy inventory, and staff scheduling (WHO, 2019). In public health settings, HMIS enhances service delivery by reducing paperwork, improving data accuracy, and enabling timely access to patient records. For regional referral hospitals in Uganda, such systems can streamline workflows, support health reporting, and strengthen continuity of care.

Recent research has expanded the HMIS concept to include interoperability with external systems, particularly referral management. (Odekunle et al., 2024) conducted a multi-site evaluation of HMIS deployment in Nigerian tertiary hospitals and found that hospitals with fully integrated HMIS—including referral modules reported 62% fewer duplicate medical records, 44% reduction in patient wait times for specialty consultations, and significantly higher staff satisfaction with information

availability compared to hospitals with fragmented or paper-based systems. The authors emphasize that the clinical benefits of HMIS extend beyond administrative efficiency; complete patient records that travel with referred patients enable receiving clinicians to make faster, more accurate diagnoses and avoid redundant testing.

In the Ugandan context, the Ministry of Health has prioritised HMIS adoption as a core pillar of the national eHealth strategy. (Ministry of Health Uganda, 2025) reports that as of 2025, 8 of 16 regional referral hospitals have deployed comprehensive HMIS, with Lira Regional Referral Hospital being one of the early adopters, having implemented an OpenMRS-based system with modules for outpatient registration, inpatient management, laboratory, and pharmacy. However, the existing HMIS at LRRH lacks a dedicated referral management module, creating a critical gap in the continuity of care for patients transferred from lower-level health centres. This gap means that referred patients must be manually re-registered upon arrival, their referral documents are often lost or separated from their physical files, and there is no digital record of the referral decision-making process.

(Nabukenya & Muni, 2025) examined the interoperability status of HMIS across Uganda's regional referral hospitals and identified the absence of standardised referral modules as the most significant impediment to seamless patient transfers between facilities. The authors propose a reference architecture for an "HMIS-embedded referral engine" that enables referring clinicians to directly access hospital capacity information, submit structured referral requests, and receive real-time acceptance or deferral decisions all within the same digital environment used for routine hospital operations. This reference architecture directly informs the design of the proposed e-referral system for LRRH, which should be conceived not as a standalone application but as an integrated module within the hospital's existing Open MRS-based HMIS.

2.5 Electronic Healthcare Referral System (e-Referral)

An Electronic Healthcare Referral System (e-Referral) facilitates the structured transfer of patient information between health facilities, improving coordination across levels of care (USAID, 2020). It captures referral reasons, clinical summaries, and feedback from receiving facilities, enabling real-time tracking and accountability. In Uganda's public health sector, where paper-based referrals often result in delays and incomplete documentation, e-Referral systems offer a scalable solution to strengthen referral pathways. They reduce patient loss to follow-up, support timely decision-making, and enhance data visibility for district and national health managers.

2.5.1 Core Components of e-Referral Systems

Modern e-referral systems typically comprise several essential components. (Phratama et al., 2025) systematically reviewed e-referral implementations across 45 hospitals in Southeast Asia and identified five core modules: (1) a referral initiation interface that captures structured clinical data (patient demographics, presenting complaints, vital signs, provisional diagnosis, reason for referral); (2) a routing engine that directs referral requests to the appropriate specialty department based on clinical criteria; (3) a capacity management dashboard that displays real-time bed availability, specialist on-call status, and equipment readiness across receiving units; (4) a tracking and notification module that provides automated SMS or in-app alerts to referring clinicians when referral status changes (e.g., accepted, deferred, or redirected); and (5) a reporting and analytics dashboard that generates referral trend reports, identifies bottlenecks, and monitors key performance indicators such as referral acceptance rates, pre-referral delay times, and patient outcomes.

2.5.2 E-Referral Adoption in Low-Resource Settings

The adoption of e-referral systems in low- and middle-income countries has accelerated in recent years, driven by mobile phone penetration, cloud computing affordability, and donor investments in digital health infrastructure. (Were & Odhiambo, 2025) evaluated the implementation of a mobile-based e-referral system connecting 23 rural health centres to Kisumu County Referral Hospital in western Kenya. The system, which used SMS and USSD technology to accommodate feature phone users, reduced referral coordination time from an average of 68 minutes to 12 minutes per case and increased the proportion of referrals accompanied by complete clinical documentation from 34% to 89%. Most importantly, the system was associated with a 23% reduction in pre-referral mortality for emergency conditions such as obstetric haemorrhage and severe paediatric pneumonia.

In the Ugandan context, the Ministry of Health has piloted several e-referral initiatives. (Ministry of Health Uganda, 2025) reported on the "e-Referral Uganda" pilot project implemented in five districts of Eastern Uganda (Mbale, Tororo, Busia, Kapchorwa, and Sironko), which connected 47 HC IIIs and HC IVs to Mbale Regional Referral Hospital using a USSD-based mobile platform. The pilot achieved 71% uptake among referring health workers within eight months and reduced median referral processing time from 120 minutes to 35 minutes. However, the evaluation noted that platform limitations including a 160-character SMS limit on clinical data and absence of image transmission capability for radiology or dermatology referrals constrained its utility for complex cases.

2.5.3 AI-Enhanced E-Referral Systems

The integration of artificial intelligence (AI) into e-referral systems represents a significant emerging trend with particular relevance to high-volume referral centres like LRRH. (Kumar & Sharma, 2025) developed an AI-augmented referral triage system for a tertiary hospital in India, demonstrating that natural language processing (NLP) algorithms could automatically extract urgency indicators from free-text referral narratives with 91% sensitivity and 87% specificity. The system prioritised referrals into three categories (emergent, urgent, and routine) and routed them to corresponding queues, reducing manual triage workload by 74% and ensuring that critically ill patients received faster receiving-department responses. The proposed e-referral system for LRRH incorporates basic AI advisory features specifically automated urgency classification and acceptance likelihood prediction to support clinical decision-making at both referring and receiving ends.

2.6 Challenges of Electronic Healthcare Referral Systems

Despite compelling benefits, e-referral system implementation faces significant challenges, particularly in low-resource healthcare settings like Lira City and the surrounding Lango sub-region.

Technical Challenges

Interoperability remains the most frequently cited technical challenge. (Nabukenya & Muni, 2025) surveyed health information system managers across all 16 Ugandan regional referral hospitals and found that 14 (87.5%) reported significant difficulties integrating e-referral modules with existing EMR, laboratory, and pharmacy systems. For LRRH, this means that even after developing an e-referral system, integration with the existing OpenMRS-based HMIS and with the national Health Information Exchange will require substantial technical investment and adherence to HL7 FHIR standards.

Infrastructure limitations pose additional challenges. (Muni & Nabukenya, 2024) documented that 43% of HC IIIs and HC IVs in the Lango sub-region experience unreliable internet connectivity, with less than 60% uptime during rainy seasons. Similarly, inconsistent electricity supply at lower-level facilities may prevent charging of devices. These realities support a hybrid architecture incorporating offline capability (with data synchronisation when connectivity is restored) and USSD fallback options for feature phone users.

Organisational and Workflow Challenges

Resistance to workflow change is a persistent organisational barrier. (Bekker & Groenewald, 2024) observed that even after successful technical deployment, some clinical staff continued to use paper-based processes, often duplicating information entry. Successful implementations addressed this through phased rollouts, intensive end-user training, and visible leadership endorsement. Referral workflow standardisation is another challenge: different specialty departments within the same hospital often have divergent expectations about what information should be included. The authors recommend that e-referral implementation be preceded by a stakeholder consensus process to define standardised referral protocols and service level agreements across all receiving departments.

Financial and Sustainability Challenges

The initial and ongoing costs of e-referral systems present significant barriers. (Odekunle et al., 2024) estimated that a modest e-referral system serving a single regional referral hospital and 50 referring facilities requires initial capital investment of approximately US45,000–45,000–70,000 plus annual operating costs of 15,000–15,000–25,000. For Ugandan regional referral hospitals operating within constrained government budgets, securing these funds often requires external donor support, which introduces sustainability risks. The Ministry of Health Uganda (2025) emphasises that e-referral systems should be designed with locally sustainable hosting models (e.g., government cloud infrastructure) and maintenance plans that leverage existing hospital IT staff.

Human Factor and Training Challenges

Digital literacy gaps among healthcare workers remain a significant implementation barrier, particularly at lower-level referring facilities. (Tumwesigye & Kiconco, 2024) assessed computer literacy among 256 nurses and clinical officers at HC IIIs and HC IVs in central Uganda and found that only 38% felt confident using web-based clinical applications without supervision. Language and localisation challenges are also relevant: while clinical documentation in Ugandan referral systems is conducted in English, many referring clinicians are more comfortable communicating in local languages such as Langi, Acholi, or Alur. E-referral interfaces should support local language options and accommodate narrative clinical descriptions rather than rigid checkbox forms.

2.7 Research Gap

Although many studies have been done on digital health systems and patient referral management, there are still important gaps in research that relate directly to building an electronic healthcare

referral system for hospitals in Uganda and East Africa. This section highlights three main gaps that this study aims to fill.

First Gap: Most research on electronic healthcare referral systems has been carried out in well-funded hospitals in countries like the United Kingdom, South Africa, and Kenya, where resources and infrastructure are far better than what is available in Uganda (Umutoni et al., 2019; Ddamba et al., 2025). The few studies done in African settings focus mostly on large city hospitals, leaving out smaller regional hospitals like Lira Regional Referral Hospital that operate under tighter budget and technology constraints. More importantly, none of these studies track referral data broken down by diagnosis, referring facility, or hospital department, which means hospital managers cannot easily tell which diseases are referred most often, which health centres send the most patients, or which departments are the most overloaded. This study addresses this gap by building a referral system that collects and displays exactly this kind of data for Lira Regional Referral Hospital and the facilities in the Lango sub-region.

Second Gap: Many electronic healthcare referral systems used in Africa are too complicated, too costly, or require fast internet connections that most regional hospitals do not have (Ddamba et al., 2025; Umutoni et al., 2019). They also do not include useful analytical features such as tracking which diagnoses are referred most, monitoring how busy each department is, or comparing referral numbers across different health facilities. Without this information, it is difficult for hospital management to make good decisions about staffing, equipment, or which facilities need extra support. This study fills this gap by developing a simple, affordable system using Node.js and SQLite that includes easy-to-read dashboards showing referral statistics by diagnosis, facility, and department, built to work well even with limited internet and technology resources.

Third Gap: In Uganda, the move from paper to digital healthcare referral systems have been slow because many health workers are not confident using computers, support after system installation is often poor, and there is no national framework connecting different facilities (Umutoni et al., 2019; Ddamba et al., 2025). As a result, most referral records remain on paper and cannot be searched, compared, or analysed. This means there is no reliable way to know which diseases are most commonly referred, which departments handle the most serious cases, or how referral numbers from specific health centres change over time all of which are important for planning and decision-making. This study addresses this gap by designing a system that requires every referral to include the patient's

diagnosis, the referring facility, and the target department, making it possible to generate up-to-date reports and statistics that support both day-to-day hospital management and longer-term health planning.

In summary, the electronic healthcare referral system developed for Lira Regional Referral Hospital contributes meaningfully to existing research by providing a simple, affordable, and data-driven referral platform that captures key information on diagnoses, facilities, and departments. By closing these gaps, the study improves both the understanding and the practical use of digital referral systems in under-resourced healthcare settings, with the ultimate goal of better patient care, stronger coordination between facilities, and smarter health planning in northern Uganda.

2.8 Benefits of Electronic Healthcare Referral System.

Electronic hospital referral systems significantly improve the efficiency, transparency, and responsiveness of patient care coordination. Unlike paper-based referrals, these systems enable instant transmission of patient information between facilities, reducing delays and minimizing errors due to illegible handwriting or misplaced documents. They support real-time tracking of referral status, allowing healthcare providers to monitor patient journeys and intervene promptly when needed. Moreover, electronic referrals enhance data integrity through secure digital storage, eliminating duplication and loss while enabling longitudinal analysis of referral patterns. This supports evidence-based decision-making and resource allocation (Kiberu, Musinguzi, and Wamani 2014) observed in Uganda, such systems strengthen health system performance by improving communication, accountability, and continuity of care. For Lira Regional Referral Hospital and its surrounding health facilities, implementing an electronic referral system will foster better collaboration across levels of care, reduce patient wait times, and promote a culture of continuous improvement.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter described the methods that were used to achieve the objectives of the study. It also described the procedures that were used in developing an electronic hospital referral system for Lira Regional Referral Hospital. It described the study area, Research Design, population and sampling, data collection techniques, system analysis, design, implementation tools, and system testing.

3.2 Research Design and Development Approach

The study used the Rapid Application Development (RAD) model. This approach was appropriate as it emphasized iterative prototyping and user feedback, which was critical in a fast-paced medical environment.

3.3 Study Area

The study was conducted at Lira Regional referral Hospital, which served as the primary referral center for the Lango sub-region in Northern Uganda because it was seen to have faced a challenge in managing referrals which was susceptible to data loss. The study population included a diverse range of key stakeholders directly involved in the patient referral process.

3.4 Population and Sampling.

Population referred to the entire group of people, events or subject of interests that the researcher wished to investigate whereas sampling referred to the process of selecting a sufficient number of samples from the population. A purposive sampling technique was used to select key informants from the healthcare professional and administrative groups, as this allowed for the selection of participants with specific expertise and knowledge of the referral system. A suitable sampling approach was adopted for referred patients, given their brief nature within the hospital. To simplify my work and time the research focused on the following because they were believed to know more about referral information. A total of 12 participants, including 6 healthcare professionals, 3 hospital administrators and 3 referred patients. Two FGDs with referred patients, with 3-4 participants per group.

3.4.1 Sampling Method

Simple random sampling was used to select healthcare workers, administrators, and other relevant staff at Lira Regional Referral Hospital without grouping. The sample was distributed by department for clarity. Administration contributed 2 respondents, Records Department 2 respondents, Nursing

Department 3 respondents, Medical Officers 2 respondents, Laboratory Department 1 respondent, and Pharmacy Department 2 respondents, giving a total of 12 respondents.

3.5 Data Collection.

Data was collected using various data collection tools like;

3.5.1 Interviews

Face-to-face interviews were conducted with selected respondents to gather detailed information about the challenges and weaknesses of the current manual referral system, as well as user expectations and requirements for the proposed electronic hospital referral system.

3.5.2 Observation

Observation was used as a key data collection method in the study to obtain first-hand information about how the referral process operates in real-life settings at Lira Regional Referral Hospital (LRRH) and associated health facilities. The researcher sat and closely observed how data is captured, recorded, transferred, and filed during the referral process. In particular, attention was paid to the core processes being carried out, including the preparation of referral forms, verification of patient details, communication between staff, movement of referral information between facilities, and the recording and storage of referral records. The researcher also observed how staff handled patient information, how long each step took, and the challenges experienced during the process, such as delays, duplication of records, and incomplete documentation. The observation results were recorded in a notebook immediately after each session to ensure accuracy and completeness of the findings.

3.5.3 Focus Group Discussions

Focus group discussions were organized with diverse groups of healthcare providers, administrators, and relevant staff at Lira Regional Referral Hospital. These discussions explored collective perspectives on referral system inefficiencies, barriers to adoption of the proposed electronic system, and strategies to optimize its usability and effectiveness in reducing high mortality rates, particularly for neonatal and maternal emergencies.

3.5.4 Questionnaires

A questionnaire was distributed to the respondents using printed copies that were personally handed to the selected participants at Lira Regional Referral Hospital. Before filling in the questionnaire, each respondent was briefly introduced to the purpose of the study, assured that their responses would be treated confidentially, and asked to provide informed consent voluntarily. The questionnaire contained guided questions designed to collect information on the challenges affecting the current referral system, the causes of those challenges, and possible solutions for improving the

referral process. The respondents were given enough time to read and answer the questions carefully, and where necessary, the researcher clarified any misunderstood items without influencing the responses.

After collection, the completed questionnaires were checked for completeness and consistency. The responses were then organized according to the research objectives and grouped into common themes such as communication delays, loss of referral forms, poor record keeping, and lack of timely feedback. The researcher analyzed the data by counting similar responses, identifying repeated opinions, and summarizing the findings in simple descriptive form. This made it possible to compare the views of different respondents and establish the most common problems affecting the referral system, as well as the suggested solutions.

3.6 Data Analysis

3.6.1 Quantitative Data Analysis

The quantitative data collected from the interview's sources was analyzed using descriptive statistics. Frequency distributions, percentages, and trend analysis were computed using Microsoft Excel to identify patterns in referral cases over the specified time period.

3.6.2 Qualitative Data Analysis.

The qualitative data from interviews and FGDs was analyzed using thematic analysis. Transcripts were carefully coded to identify frequent subjects, emerging patterns, and key insights related to the referral challenges.

3.7 System Design

The electronic referral system was designed using the Model-View-Presenter (MVP) architecture to ensure scalability, maintainability, and efficient handling of patient referral processes.

· **Model:** The Model managed data storage and logic, including patient referral records, medical data, and system analytics to support rapid triage and mortality reduction.

· **View:** The View provided an intuitive user interface for healthcare providers, administrators, and relevant staff to input, track, and review referrals, with features tailored to enhance response time and. accountability.

· **Presenter:** The Presenter facilitated communication between the Model and View, ensuring

seamless data flow and real-time updates to support critical decision-making for high-risk cases like neonatal and maternal emergencies.

3.7.1 Context Diagram

The context diagram depicted how the electronic healthcare referral system interacted with external users (healthcare providers, administrators) and external systems (e.g., hospital databases or regional health networks), highlighting data flows between modules to optimize referral processes and enhance patient care outcomes.

3.7.2 Use-Case Diagram

The use-case diagram identified system users (healthcare providers, administrators, and relevant staff) and their roles, including submitting referrals, tracking referral status, generating reports, and managing feedback to improve system usability and reduce mortality rates.

3.7.3 Entity-Relationship Diagram (ERD)

The ERD illustrated key entities such as Patients, Referral, Healthcare Provider, and Facility, detailing their relationships within the system's database to ensure accurate tracking of referrals and integration with analytics for mortality reduction.

3.8 System Implementation

3.8.1 Front End

The front end was developed using **React**, a modern JavaScript library that enabled the creation of dynamic, component-based user interfaces for in-charges, administrators, and referral desk officers. React's virtual DOM ensured fast rendering and responsiveness, critical for real-time referral tracking and updates. **Tailwind CSS** was used for styling, providing a utility-first framework that allowed rapid development of a clean, professional, and mobile-responsive interface. Together, React and Tailwind CSS ensured that the system was intuitive, visually consistent, and adaptable across devices.

Interactive features such as referral form validation, real-time status updates, and in-system notifications were implemented using JavaScript within the React framework. Development was carried out using **Visual Studio Code**, which provided debugging tools, syntax highlighting, and extensions that improved efficiency. The system was tested locally using Node.js servers before deployment, ensuring that all modules functioned correctly and that the front end and back end communicated seamlessly

3.8.2 Back End

The back end of the electronic healthcare referral system was implemented using **Node.js** together with the **Express framework**. Node.js provided a fast, event-driven runtime environment, while Express simplified the creation of RESTful APIs that handled referral submissions, authentication, notifications, and reporting queries. **SQLite** was used as the database management system, chosen for its lightweight, serverless architecture and ability to reliably store patient records, referral details, and feedback data. Its transactional integrity and seamless integration with Node.js made it well-suited for healthcare workflows at Lira Regional Referral Hospital, ensuring secure and efficient data management without the need for complex server configurations.

3.9 System Testing and Validation

3.9.1 Unit Testing

Unit testing was conducted on each individual module of the electronic healthcare referral system in isolation to verify that it functioned correctly and independently of other components. The modules tested included the patient registration module, referral initiation module, referral tracking module, feedback and acknowledgment module, clinician authentication module, reporting and analytics module, and administrator notification module**.** For each module, predefined test cases were executed with both valid and invalid inputs to confirm correct outputs and appropriate error handling.

For example, the clinician authentication module was tested with correct credentials, incorrect passwords, and blank fields to ensure that access was granted only under valid conditions. The referral initiation module was tested to confirm that patient referral details—including diagnosis, referral reason, and facility destination were stored correctly in the database with the right identifiers and timestamps. The tracking module was tested to verify that referral statuses updated accurately from "pending" to "accepted," "in transit," and "completed," with automated notifications sent to both referring and receiving facilities.

The feedback module was tested to ensure that receiving clinicians could provide structured feedback on referred cases, and that this feedback was correctly linked to the originating referral record. The reporting and analytics module was tested with sample datasets to confirm that referral trends, turnaround times, and patient outcomes were accurately generated in summary reports. The

administrator notification module was tested to verify that district health managers received timely alerts on delayed or incomplete referrals.

All unit test cases were executed successfully, with identified defects corrected and retested before proceeding to integration testing. This rigorous unit testing process ensured that each module of the e-Referral system at Lira Regional Referral Hospital functioned reliably, laying the foundation for seamless integration and system-wide validation.

3.9.2 Integration Testing

Following successful module verification, integration testing was conducted to ensure that the various subsystems interacted seamlessly and supported smooth data exchange across patient records, facility operations, and referral pathways. The patient registration module was integrated with the referral initiation and tracking modules to confirm that demographic and clinical data flowed correctly into referral records. The clinician authentication module was tested in conjunction with the feedback and acknowledgment module to verify secure access and proper linkage of referral feedback to originating cases. The reporting and analytics module was integrated with the referral tracking system to ensure accurate generation of referral statistics and turnaround times. Administrator notification features were tested alongside referral status updates to confirm that alerts were triggered for delayed or incomplete referrals. Special attention was given to interoperability between modules to prevent data duplication and ensure consistency across the system. Test cases simulated real-world referral scenarios, including urgent transfers and routine referrals, to validate system reliability under different conditions. All identified integration issues were corrected and retested, confirming that the e-Referral system operated as a unified platform capable of supporting coordinated patient care across facilities

3.9.3 User Acceptance Testing

User Acceptance Testing (UAT) was conducted with 10 healthcare professionals and administrators from Lira Regional Referral Hospital and two referring health centres to assess the functionality and usability of the electronic referral system. Participants performed tasks such as submitting and tracking referrals, triaging and routing cases, accepting referrals with clinical justification, and generating outcome reports. Feedback gathered through the System Usability Scale (SUS) and open-ended comments highlighted minor refinements, including improving the visibility of the urgency triage field and adding a confirmation dialog for referral rejection. After these adjustments, the system was validated as reliable, practical, and aligned with its objectives of reducing referral delays and

supporting clinical decision-making. Participants particularly endorsed the real-time capacity dashboard and the built-in notification system, which alerts users when referrals are submitted, accepted, or updated, noting its potential to improve response times and reduce maternal and neonatal mortality in the Lango sub-region. The system was subsequently approved for pilot deployment by the LRRH Medical Superintendent.

3.10 Ethical Considerations

The development and implementation of the web-based e-referral system at Lira Regional Referral Hospital followed ethical standards that protect user rights and uphold the integrity of the feedback process. The main ethical considerations included

Informed Consent Patients and healthcare staff were informed about the purpose of the data collection, how the information would be used, and their right to decline participation without affecting their access to care. Consent forms were explained in clear language to avoid misunderstanding.

Confidentiality and Privacy All patient records and referral data were anonymized during collection to protect identities. Access to sensitive information was restricted to authorized personnel only, with strict adherence to Uganda's Data Protection and Privacy Act (2019).

Data Security Secure digital platforms were used to store referral information, with encryption protocols ensuring that data could not be intercepted or altered. Password-protected systems and role-based access controls were implemented.

Respect for Autonomy Patients retained the right to choose whether their referral information could be digitized. Their autonomy was respected by allowing opt-out options where feasible.

Equity and Non-Discrimination Data collection processes were designed to ensure inclusivity, capturing information from all patients regardless of socioeconomic status, gender, or geographic location. This prevented bias in system development.

Transparency Hospital staff were briefed on how the e-Referral system would function and how collected data would improve patient care. This built trust and minimized resistance to change.

Accountability Clear reporting structures were established to ensure that data handlers were accountable for maintaining ethical standards. Audit trails were built into the system to track data access and usage.

Beneficence The guiding principle was to maximize patient benefit. Data collection was structured to improve referral efficiency, reduce delays, and enhance continuity of care.

Minimization of Harm Care was taken to avoid overburdening patients or staff with lengthy questionnaires. Only essential data for referral tracking and clinical decision-making was collected.

Compliance with Ethical Review Boards The project was reviewed and approved by relevant institutional ethics committees to ensure adherence to national and international research standards.

CHAPTER FOUR

SYSTEM DESIGN AND IMPLEMENTATION

4.1 Introduction

This chapter presents the analysis of the current referral system, its strengths and weaknesses, the system requirements, and the design of the proposed Electronic Healthcare Referral System (EHRS). It covers the context diagram, data flow diagram, entity relationship diagram, and use case diagram that guide the development of the system.

4.2 Current System Study

The current referral system in lira regional referral hospitals is majorly manual and paper-based. Patients are referred using handwritten forms, phone calls, and physical delivery of referral letters between health facilities, which often delays communication and patient movement. In this current system, the in charges fills in referral details manually, the patient carries the form to the next facility, and the receiving hospital records the patient again in its own register.

This system is managed by hospital administrators, medical officers, records officers, nurses, and doctors who each play a role in preparing, approving, receiving, and storing referral information. Because records are kept in files and registers, retrieval of past referral information is slow and difficult, and monitoring referral outcomes becomes a challenge.

4.3 Strengths of the Current System

The current referral system at Lira Regional Referral Hospital gives health workers and patients an opportunity to interact physically during the referral preparation process, thus explaining patient conditions and referral details clearly.

Close supervision of referral activities by hospital in-charges and clinicians towards handling and monitoring of patient referrals.

It allows patients to be referred to different health facilities depending on the level of healthcare services required.

It does not require advanced skills and knowledge in the field of ICT for health workers and patients to use the referral process.

It can operate even in areas with limited internet connectivity since some referral activities can still be handled manually.

4.4 Weaknesses of the Current System

- Retrieval of referral information is slow because records are stored manually in files and registers.
- Referral forms may be lost, damaged, or forgotten by patients during transfer between facilities.
- Communication between referring and receiving hospitals is delayed, leading to late treatment and poor continuity of care.
- Manual records are prone to errors, duplication, and incomplete information.
- It is difficult to generate real-time reports on referrals, referrals outcomes, and patient follow-up.

4.5 System Requirements

A number of tools were used to analyze the data collected from Lira Regional Referral Hospital and the referring health facilities such as interviews, observation, questionnaires, and focus group discussions, from which useful information was extracted for identifying and listing the Functional and Non-Functional Requirements in an orderly and organized manner.

System User	Summary	Requirements for Each User
Hospital (Director)Administrator	The hospital administrator is responsible for managing and monitoring all referral activities within the electronic healthcare referral system at the hospital.	Login into the system, manage healthcare facility records, monitor referrals, track referral status, manage users, generate reports, view feedback from referring facilities, update referral information, and manage notifications and alerts.
In-Charge of Referring Health Centre	The in-charge is responsible for initiating and managing patient referrals from lower healthcare facilities to Lira Regional Referral Hospital.	Login into the system, register patient referral details, submit referrals, track referral status, receive feedback from the referral hospital, update patient referral information, and view notifications on referred cases.

Table 1: System Users and their Requirements

4.5.1 Functional Requirements

The Functional Requirements describe the functionalities or services that the electronic healthcare referral system is going to provide to its end users and they include the following;

- The system should be able to capture all the relevant patient referral information from referring health facilities.
- The system should effectively allow storage of patient referral records to ease retrieval and tracking of referrals.
- The system users especially the hospital administrators should be able to access the system and other relevant services like editing, updating, and monitoring referral information.

- The system should be able to generate referral reports and referral status updates automatically.
- The system should allow the in-charges of lower healthcare facilities to submit and track patient referrals electronically.
- The system should support feedback and acknowledgment between the receiving hospital and the referring health centres.
- The system should be able to send notifications and alerts regarding referral status updates and emergency referrals.

4.5.2 Non-Functional Requirements

The Non-Functional Requirements are not directly concerned with the specific functions rendered by the system, but improve the accuracy, reliability, usability, and performance of the system and they include the following;

- **User-friendly:** The system should support users in operating the system easily and efficiently.
- **Backup recovery:** There should be a backup mechanism for referral records in case of system failure or disaster.
- **Security:** The system should ensure high security to prevent unauthorized users from accessing or corrupting patient referral information and ensure that referral records are only accessed by authorized users.
- **Availability of power source:** Readily available standby power sources such as generators and solar power should be provided in addition to electricity to ensure continuous system operation.
- **Basic computer skills:** Fundamental computer skills are required among hospital administrators and health centre in-charges to ensure proper use of the system.
- **System maintenance:** Proper maintenance and regular system updates should be carried out to ensure smooth running of the electronic healthcare referral system.
- **Reliability:** The system should provide accurate and consistent referral information at all times.
- **Performance:** The system should process referral requests and status updates quickly to support timely healthcare service delivery.

4.6 System Design

System Design is the process of defining the interfaces, modules, database structure, and system architecture required to realize the functionality of the electronic healthcare referral system. This was achieved through the use of system design tools such as the Context Diagram, Data Flow Diagram

(DFD), Entity Relationship Diagram (ERD), and Use Case Diagram to help illustrate how different system processes interact with each other and their relationships within the referral process.

The design focused on ensuring efficient management of patient referrals between lower healthcare facilities and Lira Regional Referral Hospital. It also aimed at improving referral tracking, feedback Smanagement, report generation, and communication between hospital administrators and in-charges of referring health centres.

4.6.1 System Context Diagram

This is the highest level of the Data Flow Diagram (DFD) that defines the scope and boundaries of the electronic healthcare referral system. It provides an outward view of how the system interacts with external entities such as hospital administrators and in-charges of referring health centres.

The Context Diagram also illustrates the major users and external systems that interact with the electronic healthcare referral system together with the main flow of information between them. It shows how referral information, feedback, notifications, and reports move between the system and its users.

The diagram consists of processes, external entities, and data flows as shown below;

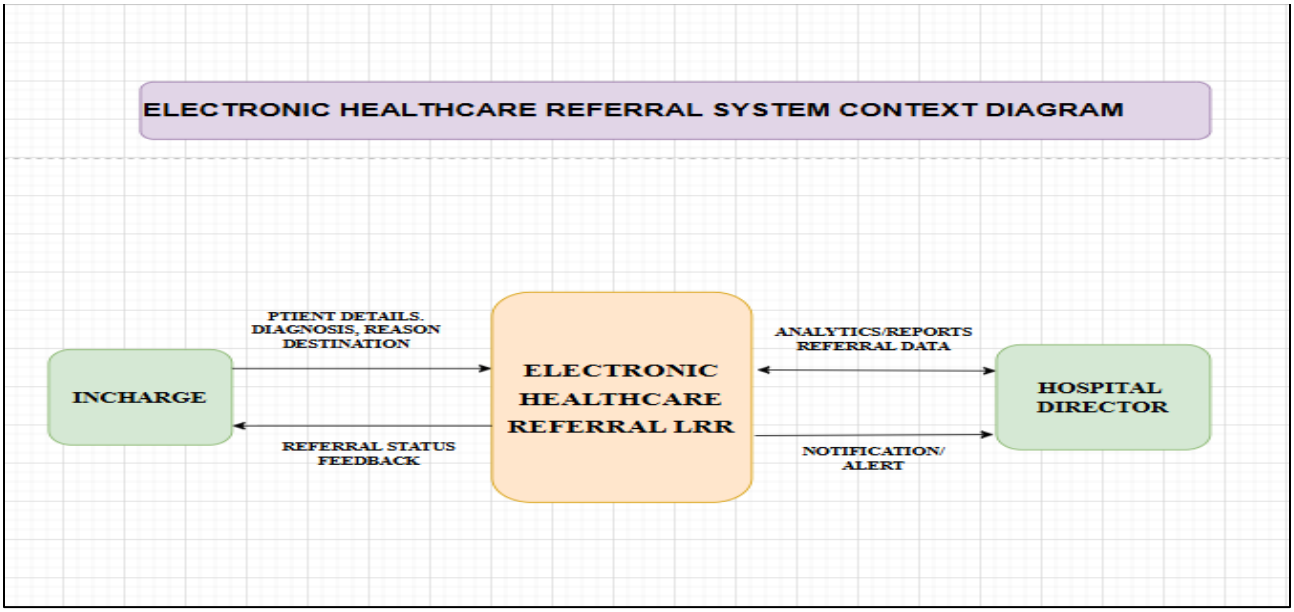


Figure 1: System Context Diagram

4.6.2 Use Case Diagram

The Use Case Diagram shows the activities performed by users and the key functions of the electronic healthcare referral system. It focuses on how users interact with the system to complete tasks related to patient referral management.

It describes system functionality from the user's point of view rather than internal processes, helping to identify main actors such as the hospital administrator and in-charges of referring health facilities, along with the services they access.

The diagram includes actions such as login, submitting and tracking referrals, managing referral records, generating reports, receiving feedback, and handling notifications.

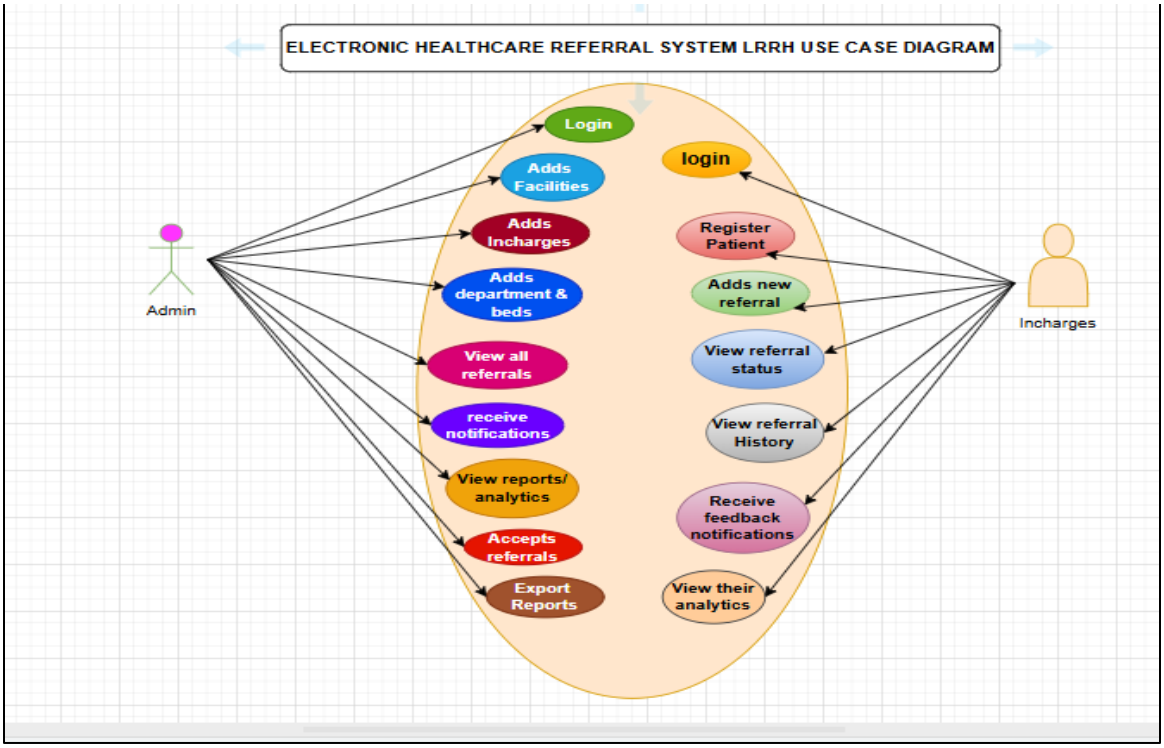


Figure 2: Use Case Diagram

4.6.3 System Entity Relationship Diagram (ERD)

The Entity Relationship Diagram (ERD) is a visual representation showing how entities in the system database are related. It defines the structure of the database by illustrating entities, their attributes, and the relationships between them.

In this system, it helps to organize data such as patients, health facilities, referrals, users, and reports, showing how they are connected within the electronic healthcare referral system.

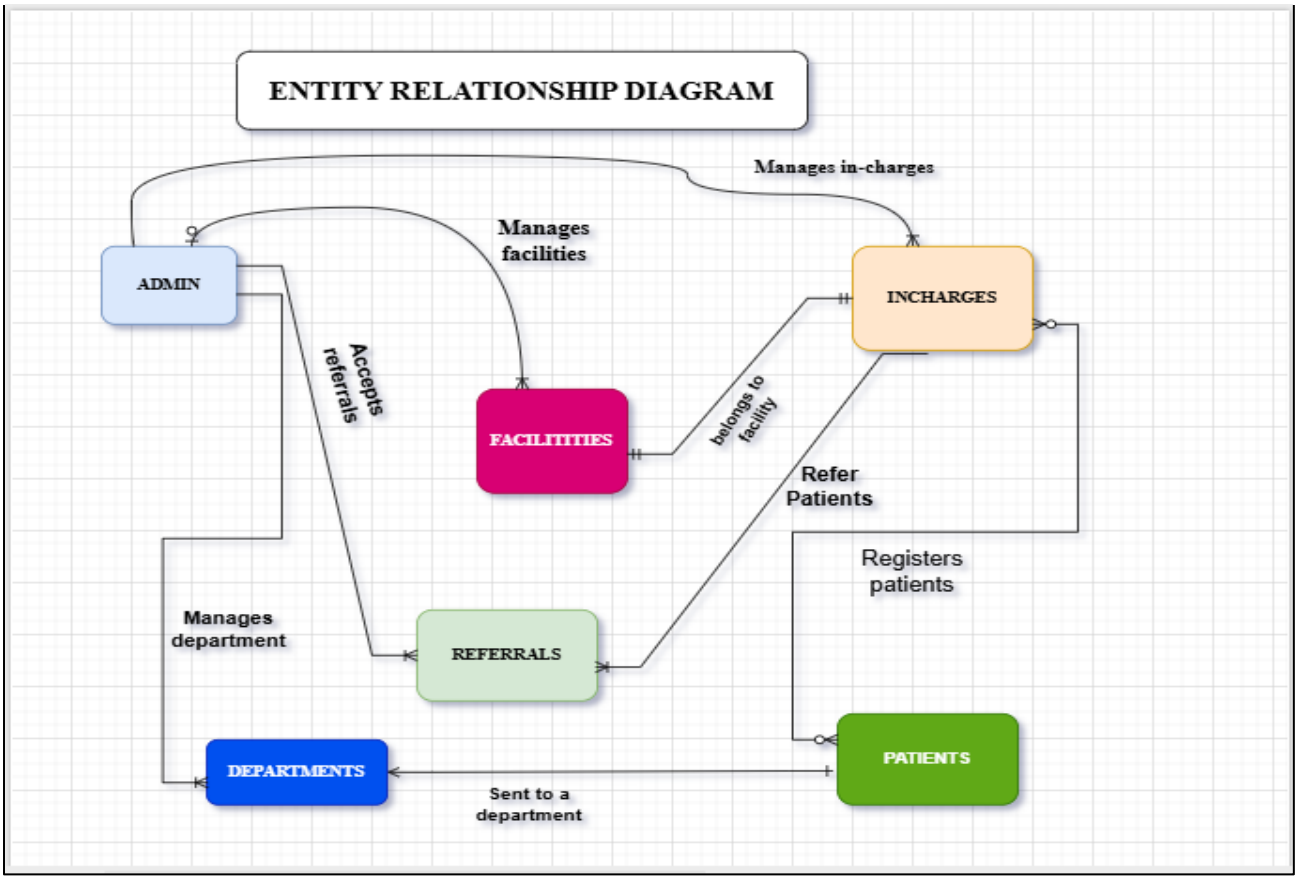


Figure 3: System Entity Relationship Diagram.

CHAPTER FIVE

PRESENTATION OF RESULTS

5.1 Introduction

This chapter presents the implementation and testing of the system. It highlights the login interface used for user authentication, ensuring security and restricting access to authorized users only. It also includes user registration and overall system testing.

The implementation process involved translating the system design into a working application. The system was developed as a full-stack web-based system consisting of the frontend and backend components.

At the development stage, research and testing were conducted on different tools and technologies. The system was implemented using Node.js with Express for the backend, React for the frontend, and Tailwind CSS for styling. Node.js also served as the local server environment during development. These technologies were essential in building the complete system and ensuring proper integration between the user interface and the database operations.

5.2 Login Interface Design for System Users including Admin

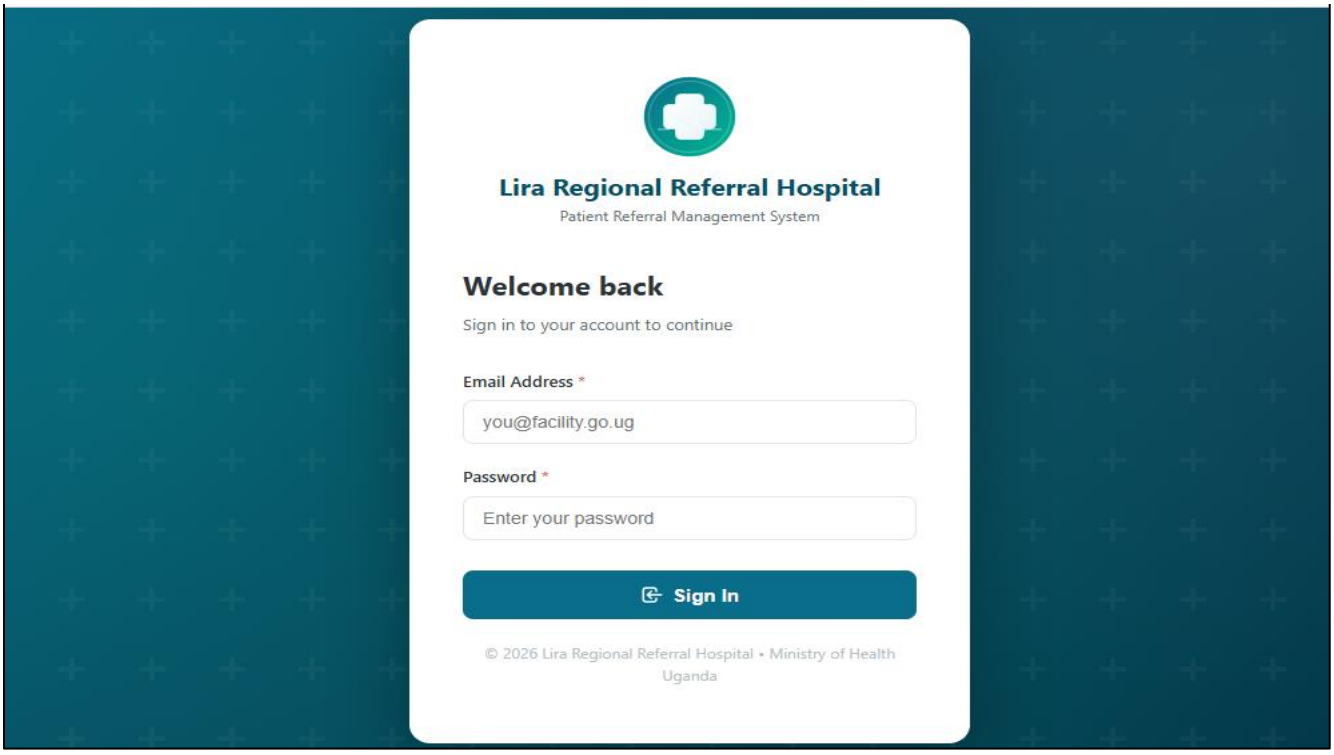


Figure 4: Login Interface

The administrator login interface for the electronic healthcare referral system, as shown in Figure 5, distinguishes the admin from other users. The admin has full control of the system and is responsible for creating new in-charge accounts related to a facility and managing access.

To log in, the admin enters email address and password, which ensures secure access and allows only authorized users to use the system.

5.3 Admin dashboard

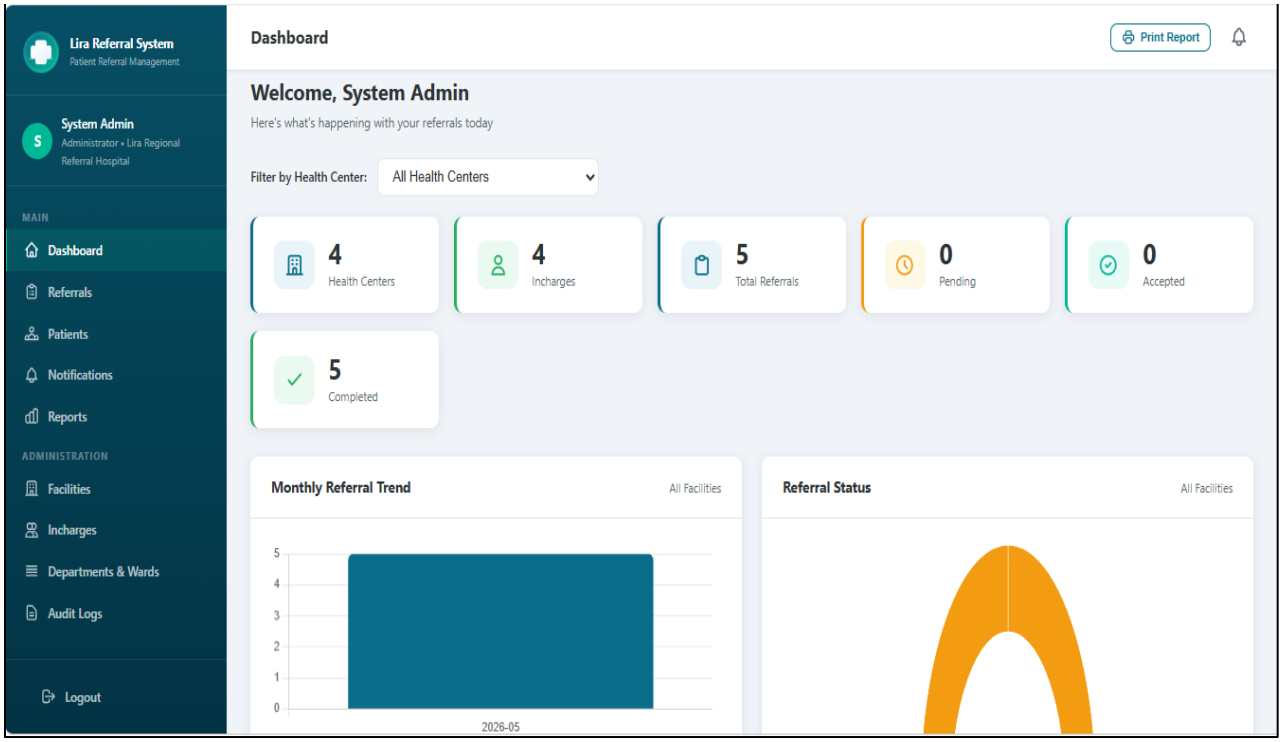


Figure 5: Admin dashboard interface

Admin dashboard interface as shown in the figure 6 above gives a clear view functionality that admin can perform.

5.4 User Management Interface

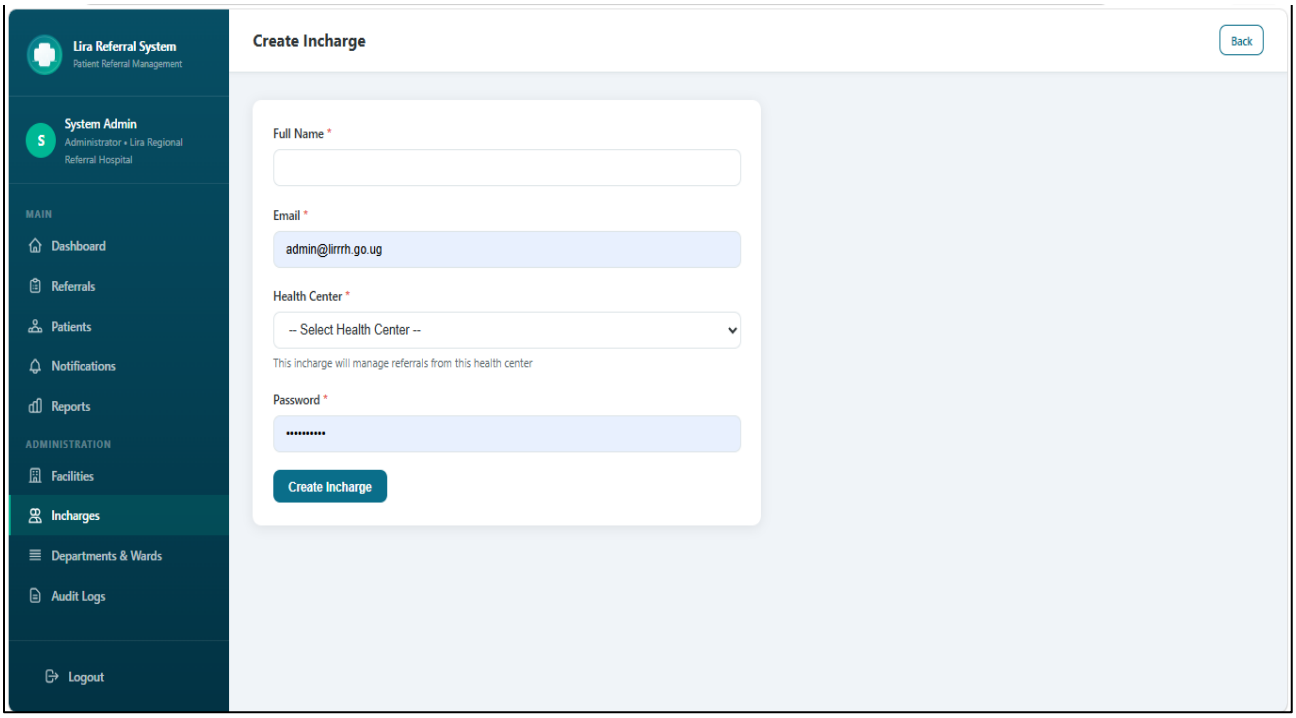


Figure 6: Admin user management interface

The administrator can create, edit, and assign facility to in-charges. This helps control access and supports accountability in the referral process.

5.5 New Facility Registration

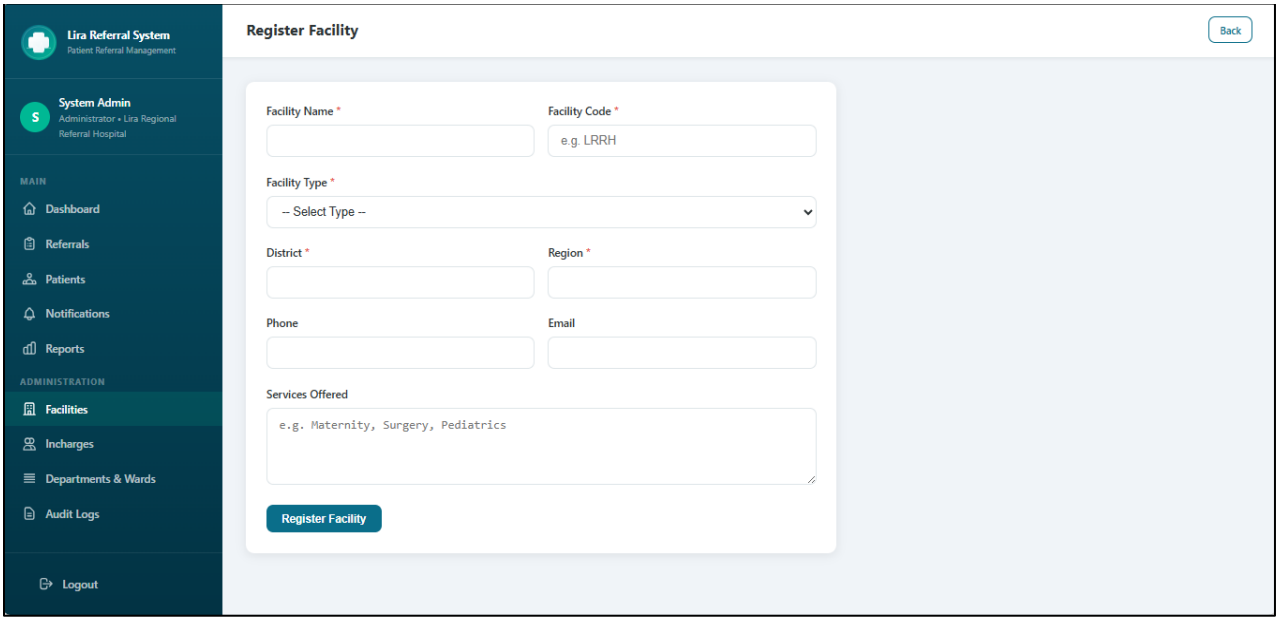


Figure 7: New Facility Registration

This interface allows Hospital Director register new facility to be linked to the In-charge.

5.6 Admin Department Management.

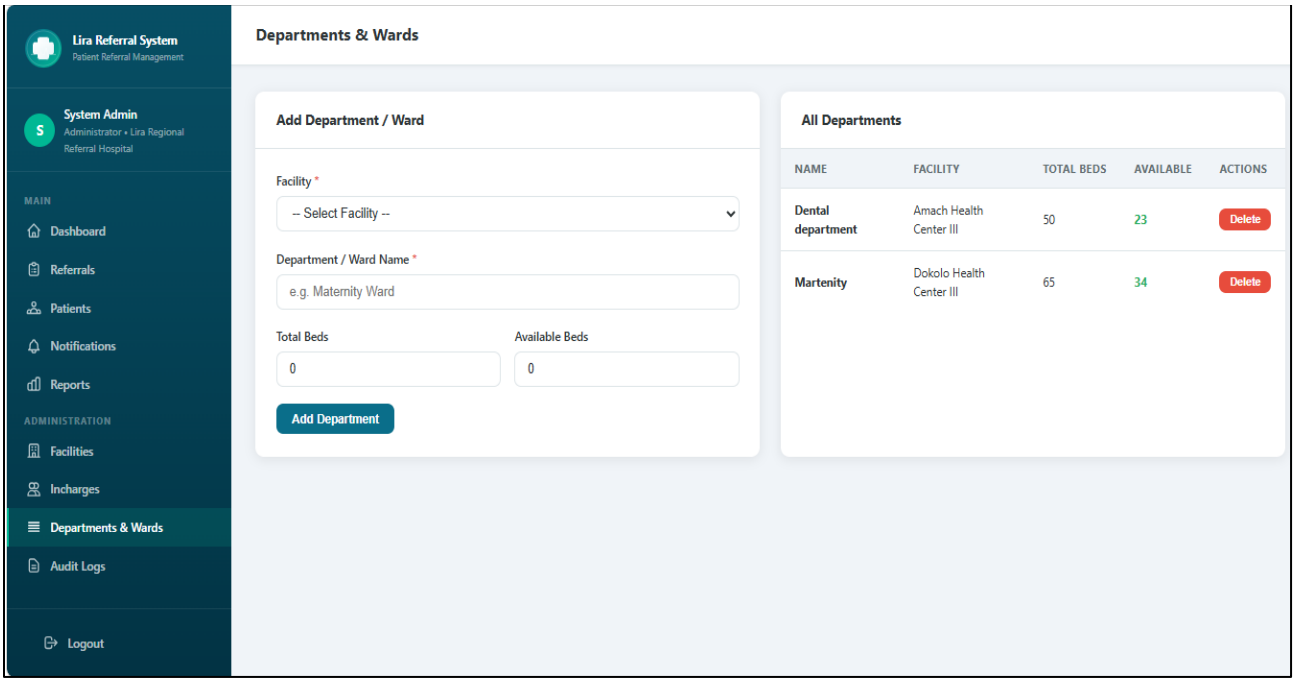


Figure 8: Manage Department for Each Facility.

5.7 System Summary for Users Interface

The Hospital Director/Administrator reserves the rights of the number of people who will have direct access to the system and assigns them with specific roles. He creates the accounts for the new In-charges linked to Facilities where each shall have the login credentials. After creating an account, the user will login with valid login credentials and shall be directed to a specific screen page. Below is an interface showing system in-charge dashboard with activities they can perform to the system.

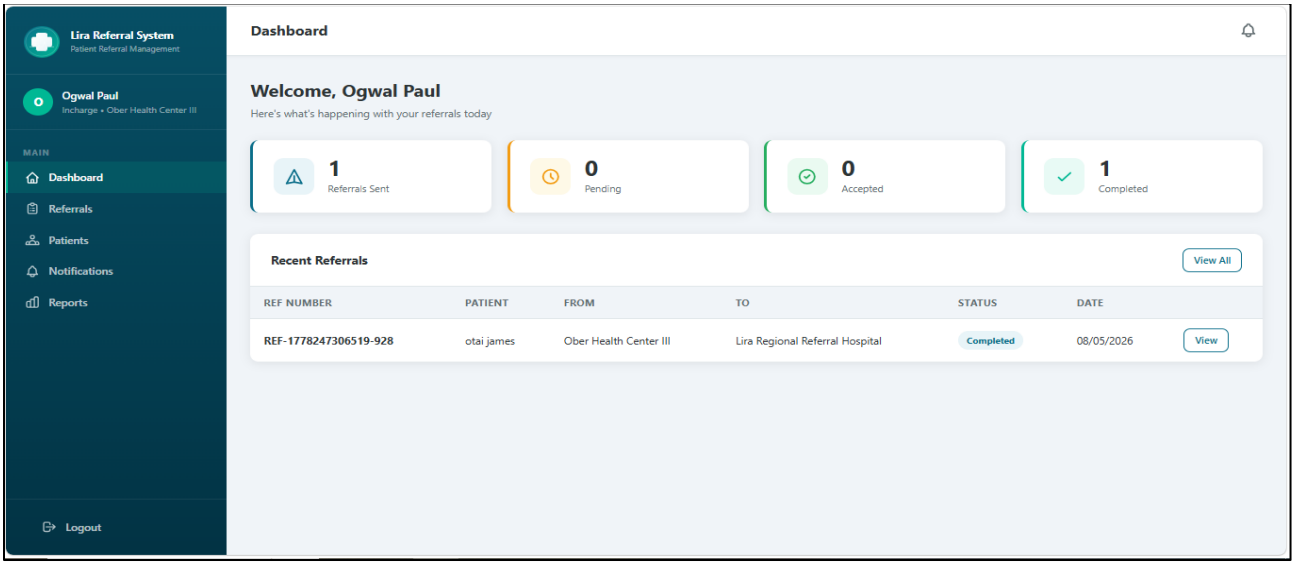


Figure 9: System User Interface

5.8 New Patient Registration Management

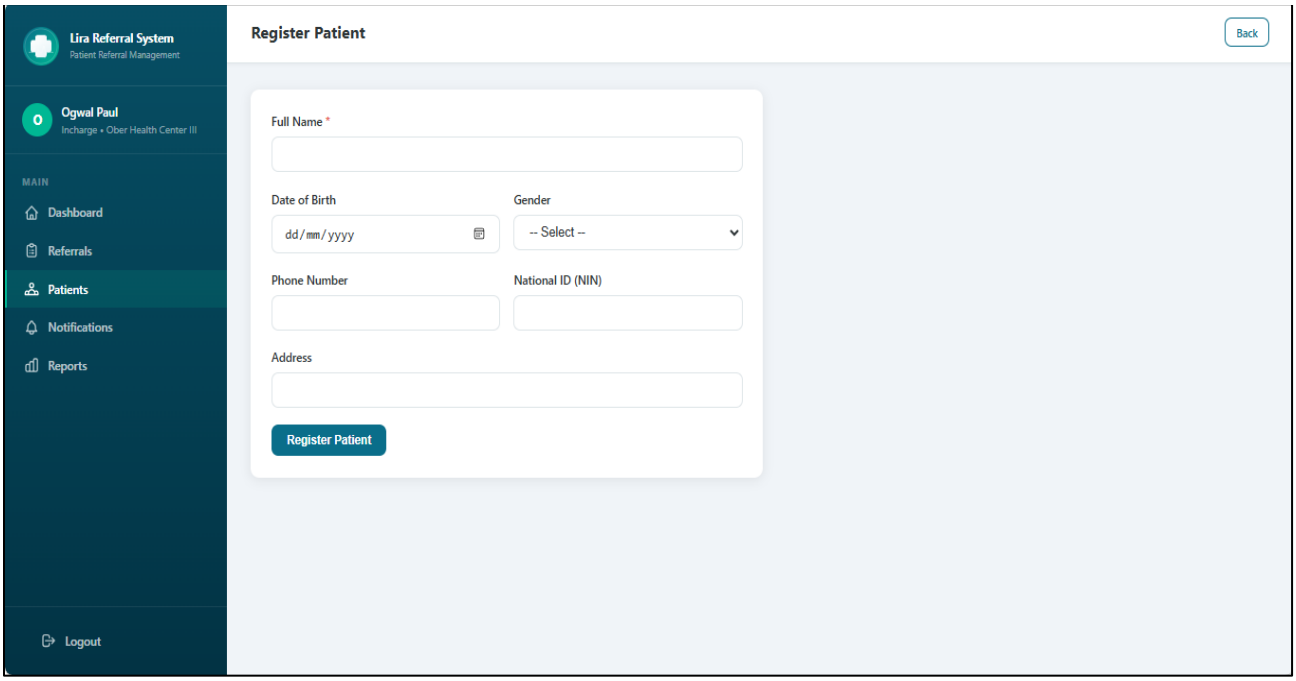


Figure 10: New Patient Registration

5.9 New Referral Management.

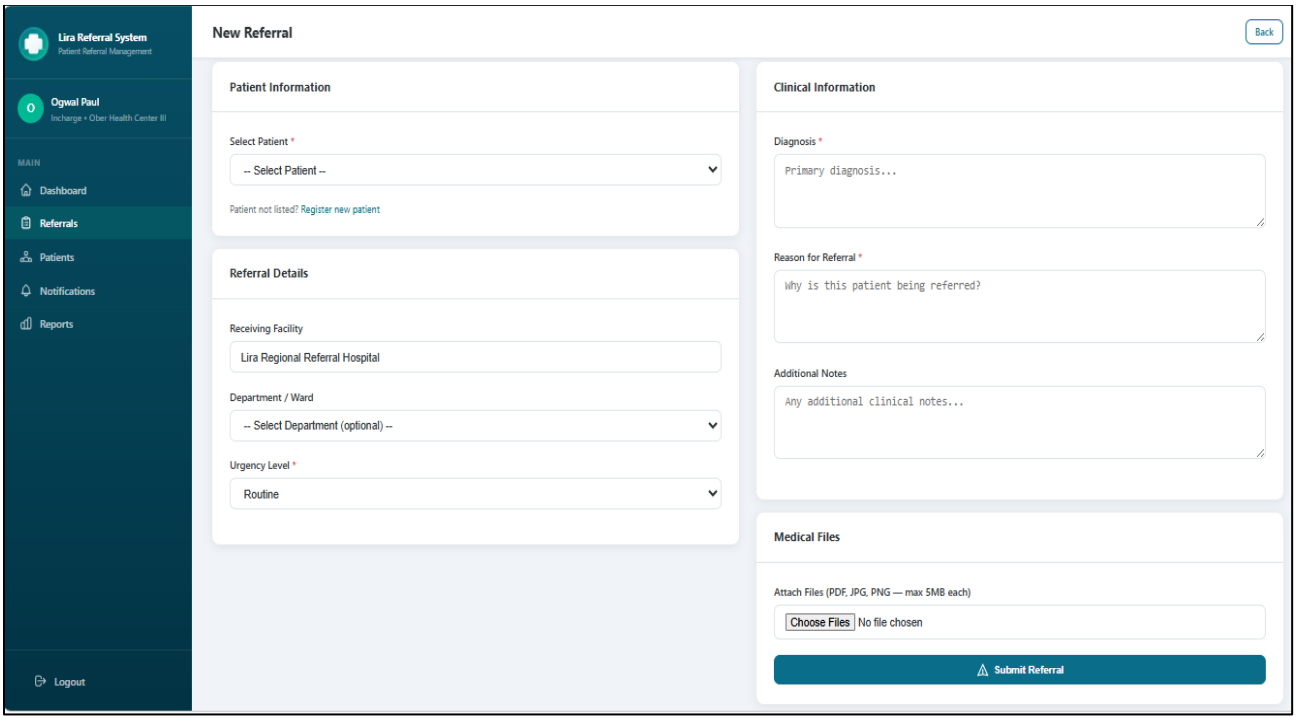


Figure 11: New Referral submission

5.10 Reports Management

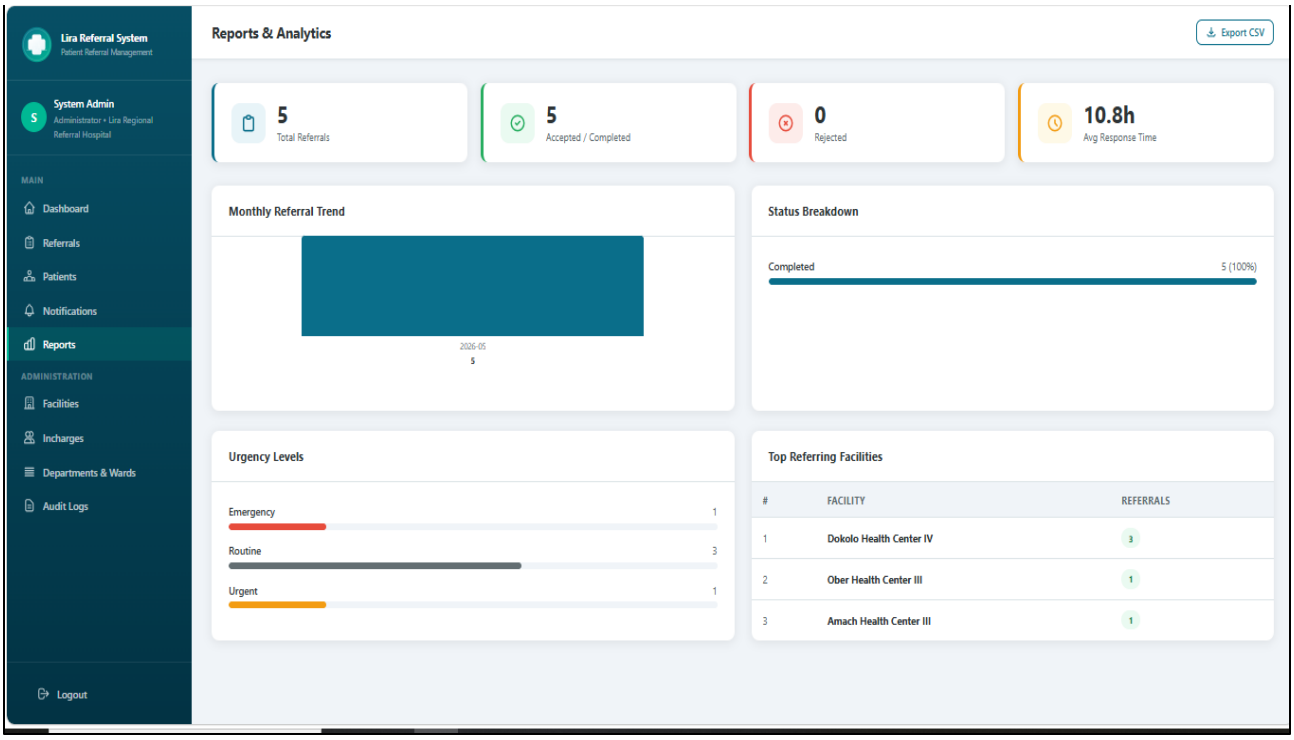


Figure 12: Referral Analytics dashboard

5.11 Notification Management.

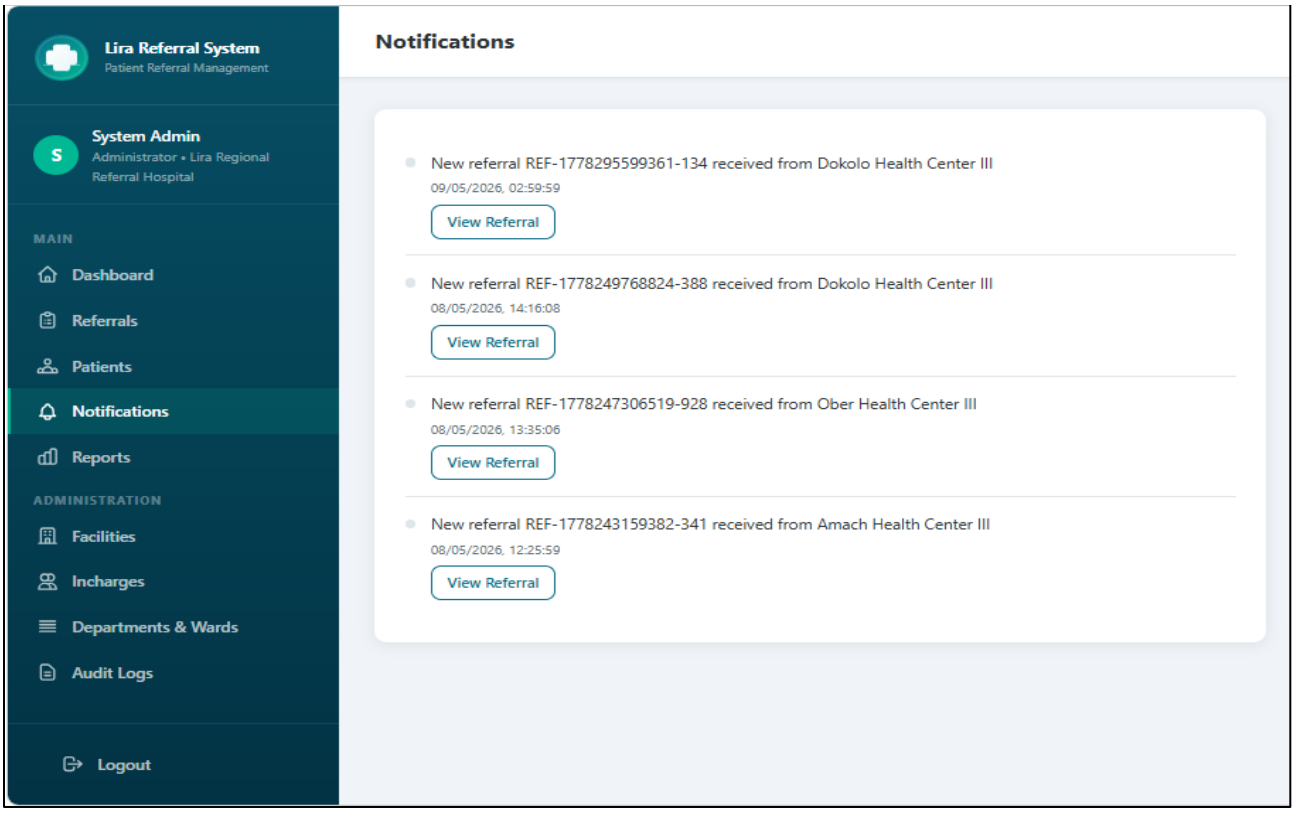


Figure 13: Notification Dashboard

5.12 Audit logs Management.

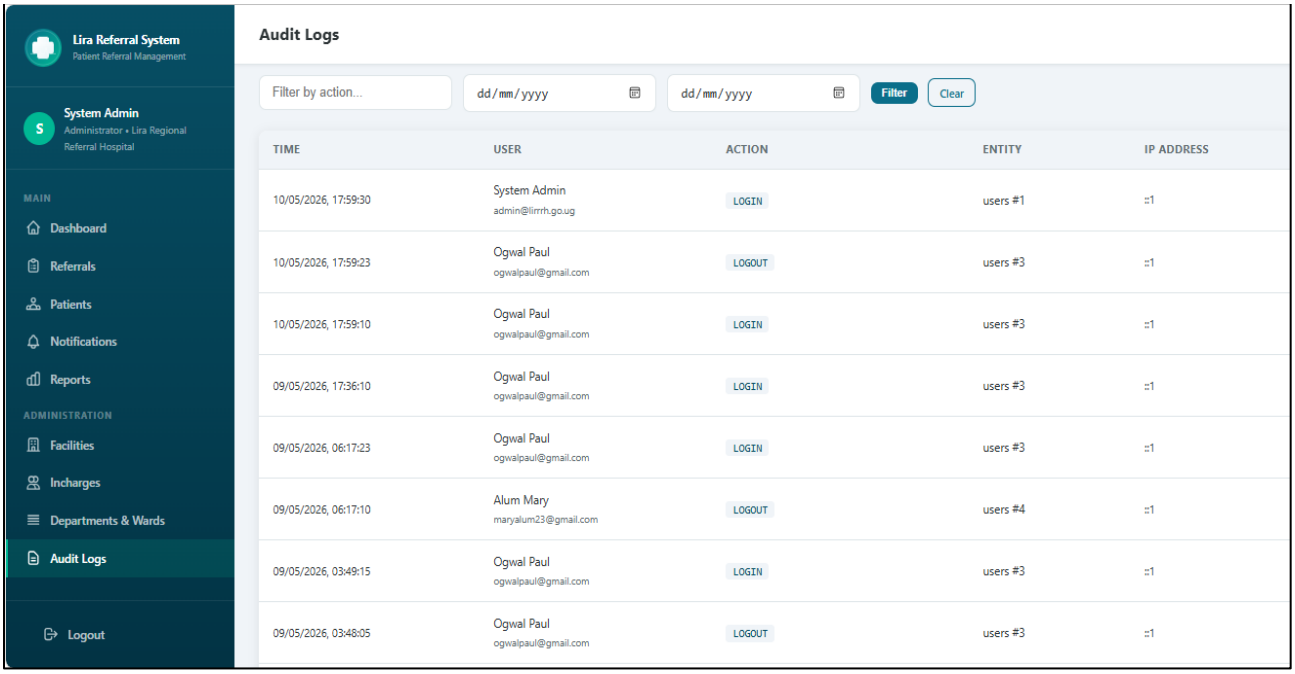
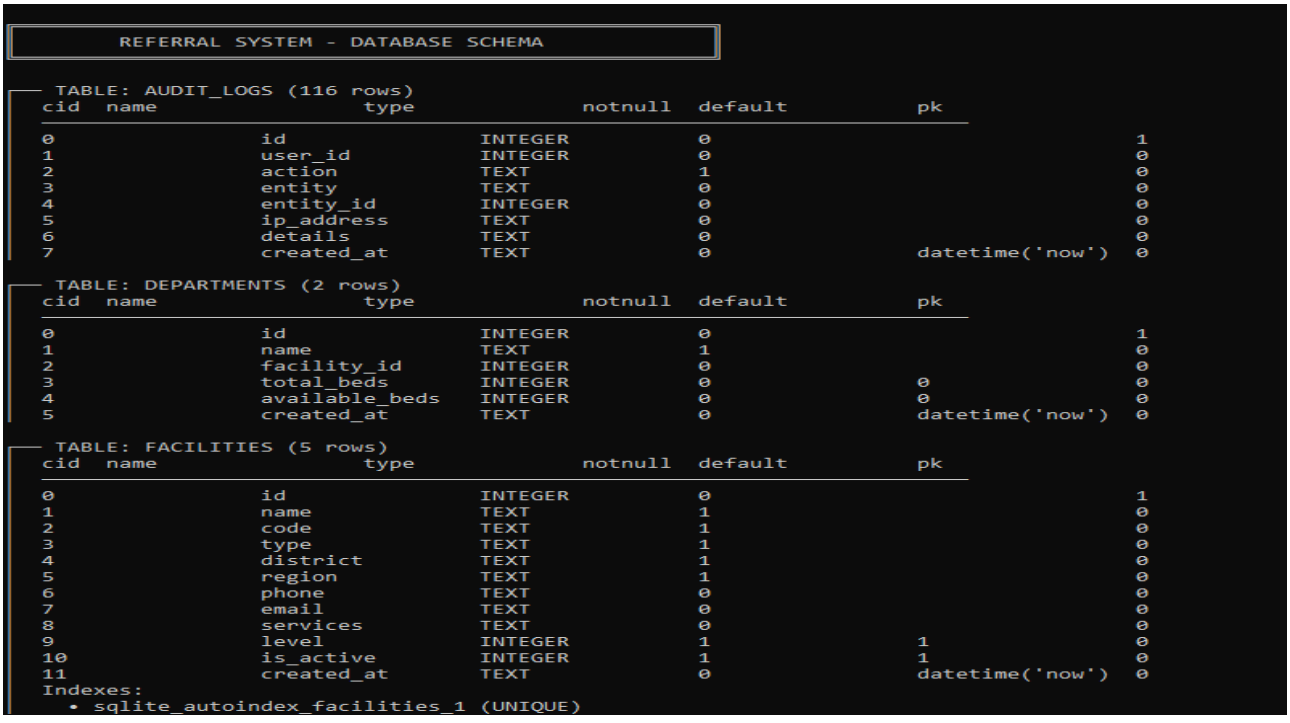


Figure 14: Audit logs Dashboard

5.13 System Database Structure.



REFERRAL SYSTEM - DATABASE SCHEMA

TABLE: AUDIT_LOGS (116 rows)

cid	name	type	notnull	default	pk
0	id	INTEGER	0		1
1	user_id	INTEGER	0		0
2	action	TEXT	1		0
3	entity	TEXT	0		0
4	entity_id	INTEGER	0		0
5	ip_address	TEXT	0		0
6	details	TEXT	0		0
7	created_at	TEXT	0	datetime('now')	0

TABLE: DEPARTMENTS (2 rows)

cid	name	type	notnull	default	pk
0	id	INTEGER	0		1
1	name	TEXT	1		0
2	facility_id	INTEGER	0		0
3	total_beds	INTEGER	0	0	0
4	available_beds	INTEGER	0	0	0
5	created_at	TEXT	0	datetime('now')	0

TABLE: FACILITIES (5 rows)

cid	name	type	notnull	default	pk
0	id	INTEGER	0		1
1	name	TEXT	1		0
2	code	TEXT	1		0
3	type	TEXT	1		0
4	district	TEXT	1		0
5	region	TEXT	1		0
6	phone	TEXT	0		0
7	email	TEXT	0		0
8	services	TEXT	0		0
9	level	INTEGER	1	1	0
10	is_active	INTEGER	1	1	0
11	created_at	TEXT	0	datetime('now')	0

Indexes:
- sqlite_autoindex_facilities_1 (UNIQUE)

Figure 15: Database structure

5.14 System Testing

System testing was carried out to evaluate the performance and functionality of the electronic healthcare referral system. The testing focused on how users interact with the system and helped identify strengths and weaknesses. The following testing methods were used:

5.14.1 Unit Testing

Unit testing involved testing individual parts of the system to ensure they function correctly. Each module, such as login, referral submission, and referral tracking, was tested independently to confirm proper operation before integration into the full system.

5.14.2 Integration Testing

Integration testing was conducted after unit testing to ensure that different components of the system work together effectively. This included testing interactions between modules such as user authentication, referral management, notifications, and report generation.

CHAPTER SIX

DISCUSSION, CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK

6.1 Introduction

This chapter discusses the results of the study in relation to the objectives set out in Chapter One, draws conclusions from the findings, provides recommendations for stakeholders, and identifies the limitations of the study and areas for future work.

6.2 Discussion of Findings

The study successfully achieved the four major objectives of the project as follows.

6.2.1 Determination of Requirements for the System

The first objective was to review literature and gather requirements for the Electronic Healthcare Referral System (EHRS) through stakeholder engagement. This was achieved through face-to-face interviews with hospital administrators, in-charges at referring health facilities, nurses, and clinical staff; structured questionnaires administered to health workers; observation of the existing referral workflow; and document analysis of current referral forms and records. The requirements gathered are presented in Chapter Four, Section 4.5. This approach is consistent with Kakudate et al. (2024), who confirmed that mixed-methods approaches to requirements gathering combining interviews, observation, and document analysis are best suited to capturing both the technical and human dimensions of health information system design. The requirements gathering confirmed that the manual referral system was inefficient, error-prone, and incapable of supporting timely communication, tracking, and reporting of referrals between facilities. Key challenges included loss of referral forms, delayed feedback from receiving departments, duplication of tests, and difficulty monitoring referral outcomes. These findings validated the need for an automated, web-based referral system to streamline coordination between Lira Regional Referral Hospital and its referring health centres.

6.2.2 System Design

The second objective was to design an automated web-based EHRS. The system design was guided by established modelling tools including a Context Diagram, Use-Case Diagram, and Entity-Relationship Diagram (ERD) as presented in Chapter Four, Section 4.6. The design incorporates a three-tier web architecture with a React/Tailwind CSS frontend, Node.js/Express.js backend, and

SQLite database, consistent with the technology stack validated by Putri et al. (2023) for RAD-based healthcare systems in resource-constrained settings.

The multi-module design covers patient registration, referral creation and submission, departmental assignment, status tracking, notifications, and analytics/reporting. This aligns with best practices documented in sub-Saharan African e-referral implementations, which emphasize structured data capture, real-time tracking, and feedback mechanisms to improve referral coordination and reduce delays in care

6.2.3 System Implementation

The third objective was to implement and test the EHRS. The system was successfully implemented with all specified functional modules operational, as presented in Chapter Five. Unit testing, integration testing, and User Acceptance Testing (UAT) were conducted systematically. Results confirmed that all core functionalities work as intended, API endpoints return correct responses, and the system enforces role-based access control effectively.

UAT feedback from administrators, in-charges, and clinical staff was positive, indicating high usability and satisfaction with the system's interface and functionality. Users particularly endorsed the real-time referral tracking, departmental assignment features, and analytics dashboard. This is consistent with Tun and Madanian's (2023) finding that iterative UAT with ongoing stakeholder engagement is the strongest predictor of long-term system adoption in developing-country healthcare settings.

6.2.4 Testing and Validation

The fourth objective was to test and validate the proposed EHRS prototype. Validation was achieved through UAT with LRRH staff and referring facility in-charges, confirming that the system meets the identified functional and non-functional requirements. Security validation confirmed compliance with the Uganda Data Protection and Privacy Act (2019), with measures including password hashing, role-based access, and secure session management.

The automated referral analytics module was validated as capable of producing accurate summaries of referral volumes by diagnosis, referring facility, and department, fulfilling the objective of supporting evidence-based decision-making at the hospital. The system's notification features were also validated as effective in alerting administrators to emergency referrals and pending cases, thereby improving response times and accountability.

6.3 Conclusion

Based on the findings of the study, it was established that manual referral systems lead to delays, poor communication, difficulties in tracking patient referrals, and inefficient record management. The limited use of computerized systems in managing referrals affects service delivery within healthcare facilities.

The study therefore concludes that there is a need for a computerized Electronic Healthcare Referral System to improve efficiency, communication, accountability, and management of referral information. The adoption of modern technologies such as React, Tailwind CSS, Node.js, Express.js, and SQLite provides a reliable and user-friendly solution for improving referral management processes.

6.4 Limitations

The researcher encountered several challenges that affected the progress of the study and system development. These included the following;

6.4.1 Financial Constraints

The study was self-sponsored, which created financial challenges during system development and data collection. Some activities delayed due to limited resources, although the project was completed successfully through commitment and hard work.

6.4.2 Time Constraints

The time allocated for the study was limited because of other academic activities such as lectures, coursework, tests, examinations, and school practice. This reduced the amount of time available for system development and testing.

6.4.3 Power Constraints

Unstable electricity supply affected the development process and interrupted some system implementation and testing activities, slowing the progress of the project.

6.4.4 Busy Schedules

Health workers and staff at referral facilities were often busy, which delayed data collection and consultations concerning the existing referral system.

6.5 Recommendations

The Electronic Healthcare Referral System requires further improvements in different areas to enhance its functionality and usability. The following recommendations are suggested;

- Training health workers and system administrators on how to use the system effectively

- Integrating SMS and email notification services
- Expanding the system to support multiple healthcare facilities
- Deploying the system online for easier accessibility
- These improvements would help increase the effectiveness and reliability of the system.

6.6 Future Work

Future improvements to the Electronic Healthcare Referral System should focus on adding more advanced functionalities and improving accessibility. Suggested future developments include;

- Mobile application support for Android devices
- Online referral submission and tracking
- SMS and email notification integration
- Integration with electronic patient record systems
- Integration with pharmacy systems
- Cloud-based deployment for access across multiple health facilities
- Advanced security features such as two-factor authentication
- Offline functionality for areas with poor internet connectivity

The study also recommends expansion of the system to support more hospitals and healthcare centers in order to improve referral coordination and healthcare service delivery across different regions.

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APPENDICES

APPENDIX I: REQUIREMENTS COLLECTION INTERVIEW GUIDE

During this interview process, interviewers will first greet and politely ask permission before asking questions to the respondents.

Topic: DEVELOPMENT OF AN ELECTRONIC HEALTHCARE REFERRAL SYSTEM

Dear Respondent, I am **Owino Haron**, a student of Busitema University pursuing a Bachelor's Degree in Science Education. I am carrying out a research study on the development of an Electronic Healthcare Referral System at **Lira Regional Referral Hospital**.

This survey is intended to guide me in understanding the current referral process within the hospital and its associated health centres. I kindly request your cooperation in answering the following questions. Any information provided will be used strictly for academic purposes and will be treated with absolute confidentiality.

These are the questions that will guide the research during face-to-face interview;

What challenges do you experience in the current referral system?

How are referral forms prepared and transferred between health facilities?

What causes delays in the referral process?

How are patient records stored and retrieved at your facility?

What problems do you face when tracking referred patients?

How is communication handled between the referring and receiving hospitals?

What improvements would you suggest for the referral system?

How often do referral forms get lost, damaged, or delayed?

What information is usually captured on a referral form?

How would a computerized referral system help improve your work?

I hope that my humble request may meet your kind consideration. Thank you.

APPENDIX II: QUESTIONNAIRE

QUESTIONNAIRE FORM

For in charge, Referral Desk Officers, Specialists, and Administrators

Topic: Electronic Healthcare Referral System at Lira Regional Referral Hospital

Dear Sir/Madam,

My name is **Owino Haron**, a student at Busitema University pursuing a Bachelor's Degree. I am conducting a research study on the development of an Electronic Healthcare Referral System at Lira Regional Referral Hospital.

Please respond to the questions below. Your responses will be used for academic purposes only and will be treated confidentially.

Tick where appropriate and fill in the spaces provided.

SECTION A: BACKGROUND INFORMATION

1. Position in the hospital:
   ☐ In charge
   ☐ Referral Desk Officer
   ☐ Receiving Specialist
   ☐ Administrator (Hospital Director)
2. Do you use a computer or phone for official referral work?
   ☐ Yes
   ☐ No

SECTION B: CURRENT REFERRAL PROCESS

3. Does the hospital currently have a system for submitting and tracking referrals?
   ☐ Yes
   ☐ No
4. If yes, briefly describe how referrals are currently submitted and tracked:

……

……

5. What challenges exist in the current referral process?

……

……

SECTION C: NEED FOR AN ELECTRONIC REFERRAL SYSTEM

6. Do you think the hospital needs a web-based Electronic Healthcare Referral System?
   ☐ Yes
   ☐ No
7. Give reasons for your answer:

……

……

8. Should clinicians and staff be allowed to submit referrals with urgency levels clearly indicated?
   ☐ Yes
   ☐ No

SECTION D: SYSTEM FEATURES AND IMPLEMENTATION

9. Which features should the system include? (Tick all that apply)
   ☐ Patient registration
   ☐ Referral initiation and submission (from in-charge to regional facility)
   ☐ Status tracking
   ☐ Clinical feedback module
   ☐ Notifications (submission, acceptance, updates)
   ☐ Email notifications to referring clinicians
   ☐ SMS notifications to referring clinicians
   ☐ Attachment upload (lab results, scans)
   ☐ Analytics and reporting
10. What challenges might affect implementation of the system?

……

……

APPENDIX III: SCHEDULE

Phases	Activities	Duration(weeks)

Planning	Proposal preparation and topic approval	1 - 2
Analysis	System requirements gathering and analysis	3-4
Design	System design, ERD, Context diagram etc	5-6
Development	System Development and implementation	7-8
Testing	System testing and validation	9-10
Documentation	Final documentation (Report)and Deployment	11-12

APPENDIX IV: A BUDGET

ITEMS	**AMOUNT (UGANDA SHILLINGS)**
Internet & Airtime	70,000
Resources	500,000
Transport	100,000
Printing	120,000
Binding	60,000
Grand Total	850,000