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DEVELOPING AN EXPIRY DATE TRACKING AND ALERT SYSTEM FOR INVENTORY MANAGEMENT FOR GUARDIAN HEALTH PHARMACY.

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A Project Proposal Submitted to the Faculty of Computing & Informatics of
Makerere University Business School in Partial Fulfillment for the Award of the
Degree of Bachelor of Business Computing.

November 2025.

DECLARATION.

We, the undersigned, declare that to the best of our knowledge, this proposal is our original piece of work, and has never been published and/or submitted for any award in any other University or Higher Institution of Learning.

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APPROVAL

This project proposal has been submitted with my approval as supervisor and my

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MAKERE UNIVERSITY BUSINESS SCHOOL.

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SECTION ONE.

1. INTRODUCTION.

1.1. Project Background.

Managing drugs in a pharmacy is a serious matter and if expiry dates are not watched properly, patients can get medicines that no longer work thus harming their lives. This leads to loss of money through throwing away expired stock as per (World Health Organization, 2022). In Uganda, the problem hits small and medium pharmacies hardest. According to the latest National Drug Authority report (2024), it says that on average 8 out of every 100 medicines in private pharmacies reach expiry while still in their shelves.

The Guardian Health Pharmacy in Ntinda, Kampala Branch, exemplifies this challenge. They have a simple computer system that shows how many boxes and stock left in their stores, but have lack a system for monitoring expiry dates. The staff faces this gap challenge by using handwritten logs and periodic physical checks methods that are both time consuming and error prone as per (Ocan, M et al., 2021). We interviewed one of the staff member and said sometimes we get so busy thus, forgetting to check and only notice when a customer brings back a drug that is already expired. The Uganda Healthcare Federation (2024) says less than 30% of pharmacies in Kampala have a proper digital expiry tracking even though NDA has been pushing it for years.

The project will be designed to address this specific operational gap by developing and implementing a system solution that automates medication expiry date tracking. The proposed system will be integrated with Guardian Health Pharmacy's existing inventory framework to provide real time alerts, comprehensive reporting, and enhancing operational efficiency, reducing waste and ensuring regulatory compliance (National Drug Authority, 2023).

1.2. Statement of the Problem.

In a perfect pharmacy, everything would be in one system that is fully automated with seamless tracking of stock levels and expiry dates, ensuring zero expired medications are dispensed while

maximizing operational efficiency and regulatory compliance (World Health Organization, 2022).

Currently at Guardian Health Pharmacy, their system operates partially by tracking inventory quantities but lacks integrated expiry date monitoring functionality. This critical gap forces staff to perform manual, cross referenced checks using paper based logs a process that is not only time consuming but also highly prone to human error.

The reliance on outdated methods makes the pharmacy face the challenges below.

- Financial losses of annual drug expenditure as per (Kamba et al., 2017).
- Persistent risk of non-compliance with National Drug Authority regulations, which explicitly mandates systematic expiry monitoring and documentation (National Drug Authority, 2024).

We believe a tailored automated expiry tracking system is essential to eliminate these risks and align the pharmacy with both national standards and international best practice (Management Sciences for Health, 2023).

1.3.1 Project Goal.

To design, develop and implement a cheap easy to use Expiry Date Tracking and Alert System for Guardian Health Pharmacy to monitor expiry dates, minimize stock wastage and comply with UNDA compliance rules.

1.3.2 Project Objectives.

1. To find out exactly how Guardian Health Pharmacy is currently tracking expiry dates. (The real situation on ground).
2. To sit with the Guardian Health Pharmacy staff, listen to their challenges and agree on what the new system must do for them.
3. To design and develop a prototype system that connects with the existing inventory database of Guardian Health Pharmacy.
4. To test and evaluate the system's usability with the Guardian Health Pharmacy staff to see whether it makes their work safe and efficient.

1.4 Project Scope Summary.

We are only focusing on the expiry date part for Guardian Health Pharmacy. The system will allow staff to input data via barcode scanning and manual entry. The scope includes modules like data input (via barcode scanning and manual entry), alert generation (via SMS, Emails and in-app

notifications), regulatory reporting. The system will be executed in four months: from talking to stakeholders, developing the system, testing and handing over the final system. We will not extend to other pharmacy management functions like sales, purchasing, or prescription handling because they are already handled and covered by the existing system.

1.5 Problem Solving Impact.

Once the system is fully implemented, we expect it to have positive effects and changes as stated below;

- Better patient safety. Patients will be much safer because no expired medicine will be sold by mistake as stated by (Kiguba et al., 2017; World Health Organization, 2022).
- Improved operational efficiency. The system's automation module will reduce staff time spent on expiry checks by 60% to *80% in comparable East African settings (Ocan, M et al., 2021).
- Reduced financial losses. The alerts module will enable the First-Expiry-First-Out (FEFO) practices, potentially cutting expiry related wastage by up to 70% (Management Sciences for Health, 2023).
- Regulatory compliance. The reports module will ensure seamless adherence to NDA good pharmacy practice guidelines (National Drug Authority, 2024).

1.6 Project Assumptions.

To ensure the successful execution of our system, the following assumptions will be made:

- Guardian Health Pharmacy will provide full access to inventory data and existing APIs for integrations purposes to our team.
- The pharmacy staff and management will be available for consultations, requirements elicitation and system testing activities so that all needs are well catered for.
- The chosen technology stack (PHP, JavaScript, MySQL) will remain compatible with the pharmacy's existing hardware and software infrastructure.
- We all expect all the six-team members to dedicate the required time and effort to meet project milestones as scheduled without any excuse.
 - Lastly, we expect all academic literature and current NDA regulatory guidelines will remain accessible throughout the project duration.

SECTION TWO.

2. LITERATURE REVIEW.

2.0 INTRODUCTION.

The management of drug expiry dates is a very critical challenge in most of the pharmacies in Uganda and across the world particularly in low resource settings. Manual tracking method dominates and this has caused wastage of drugs in a large amount or scale, financial loss from expired drugs and patient safety and trust that can best lost from selling them expired drugs (Agnes Nakyanzi et al 2015) and this review combines existing research on the extent drugs expire the limitations of the traditional inventory practices using manual entry and physical book counts. The emergency of digital solutions to guardian Africa's health center with technology such as barcode scanning SMS alerts and offline capability systems alongside implementing challenges found and outcomes. The review establishes a foundation for developing an automated expiry tracking system tailored for Guardian health pharmacy addressing gaps in integration usability and regulatory compliance.

2.1. Digital inventory management in Uganda pharmacies.

A 2023 survey by the Uganda Healthcare Federation (UHF) realized a stark digital divide where less than 35% of small and medium sized pharmacies utilize inventory software even if the Uganda national drug authority (UDA) mandated use of systems in inventory management and tracking expiry dates for drugs this was made clear in its guidelines on good distribution practices (national drug authority,2018) and this forces most pharmacies into manual tracking a practice that has proven error prone and research showing high percentage of errors this was also highlighted by daily monitor (2024) as a primary cause for annual financial los from expired drugs (Kamba et al 2017) our project directly addresses this serious need to automate expiry date tracking thereby enabling compliance with the NDA regulations preventing revenue loss and fundamentally enhancing patient safety at guardian health pharmacy.

2.2 Expiry date tracking technologies and systems in Uganda.

Effective expiry management requires an integrated digital system and the ministry of health's Essential Medicines and health supplies management manual (2019) recommends centralized databases with real time expiry monitoring and immediate alerts to enforce FEFO (first expiry,first out) .examples include Tanzania's M-TRACK system which uses barcode scanning and SMS

notifications to notify managers and pharmacists about drugs going to expire proving feasibility and effectiveness of the system.

2.3 User requirements for the drug expiry date tracking system.

User centered design is good for adoption in our system. Research identifies offline functionality simple interface and basically automated reporting as core requirements in Uganda's settings (ministry of health 2021) staff in areas with unstable internet need systems that allow data entry without being connected to the internet with NDA inspections demanding this. (national drug authority 2018) open source technologies like PHP and MYSQL are preferred for there affordability and easy maintenance.

2.4 Development of drug expiry date tacking system.

Successful systems are built on the LAMP stack (linux,Apache,Mysql,PHP) widely used in health care automation for its cost friendliness and reliability frontend interface in HTML,CSS and JavaScript support responsiveness of the system across devices. Study also shows dual input methods like usb barcode scanners for efficiency and manual entry for non barcoded items Automated SMS alerts into proactive management (Agnes Nakyanzi et al 2015).

2.5 Application of the drug expiry date tracking system.

Web based platforms have demonstrated significant impact the NDA strictly recommends and emphasizes the use of digital tracking systems o prevent circulation of expired medicines a key public health goal (national drug authority 2023). These outcomes align with global best practices for improving effectiveness reducing waste and ensuring compliance in pharmacy operations.

2.6 Designing of the system.

The system must cater for local limitations. The Uganda health supply chain roadmap (2021) highlights connectivity challenges making offline capable features essential (ministry of health Uganda 2021) user center design through feedback and easy to understand interfaces ensuring high adoption rates as proven in the health tech pilots across Africa (world health organization 2021).

2.6.1 Implementation of the system.

Phased rollout is a recommended strategy WHO (2021) advocates piloting or testing in one site before fully implementing to reduce the risk and allow staff training open source tools eliminate licensing costs ensuring sustainability a key factor in resource limited settings.

2.6.2 Importance of the system.

The system being automatic delivers a lot of benefits studies show reduced staff time on manual checks and lower financial losses from expired stock (Agnes Nakyanzi et al 2015) Most important digital systems prevent dispensing of expired drugs enhancing patient safety and ensuring NDA compliance (Kamba et al 2017).

2.7 Challenges in developing and implementing the expiry date tracking system.

Implementation faces well-documented barriers unreliable internet that disrupts online only systems in multiple branch operations (ministry of health Uganda 2021) low digital literacy or knowledge among staff leads to resistance lugada E et al 2022 integration with overseas databases risks downtime.

2.7.1 Overcoming the challenges at guardian health pharmacy.

After making research it has provided solutions first providing offline functionality with local data provided reduces the issues of connectivity (world health organization 2019) Tailored training programs to be conducted to improve staff knowledge of the system functionality lugada E et al 2022 and making periodic testing to know the systems effectiveness before full usage. These strategies ensure successful adoption in real world pharmacies.

2.8 Conclusion.

The literature confirms that manual expiry tracking is inefficient and risky while digital systems cross out this issue with barcode, SMS, and offline capabilities significantly improving outcomes (Agnes Nakyanzi et al 2015) studies from Uganda and east Africa provide strong evidence for intervention and our project applies these findings by developing an integrated user friendly expiry tracking system for Guardian Health Pharmacy contributing to both operational efficiency and public health safety.

SECTION THREE.

3. Project methods.

3.1 Research design/Research Approach.

This project is created in the design science research (DRS) paradigm which is a problem solving methodology that critically emphasizes the creation and evaluation of an innovative artifact to address organizational challenges. The purpose of this DRS is to build and validate a solution artifact that demonstrates utility and relevance in this project the artifact is the expiry date tracking and alert system designed specifically for Guardian Health Pharmacy to address the limitation of manual expiry monitoring . the DRS approach ensures that the solution is both technical sound and practically applicable in the pharmacy operational environment, as reinforced by Vaishnavi and Kuechler (2025), who emphasized that real world evaluation and the step by step design cycle are central to successful artifacts development. By following DRS principles the project contributes not only to solving a practical problem but also to expanding academic understanding of how design methodologies can be applied in the Ugandan pharmacy systems.

The design science research (DRS) was chosen for this project because it directly supports the development of innovative problem solving artifacts and this is the goal of our project.

It is most effective when applied to a situation where a technological gap exists requiring high research and practical implementation. The methodology was selected for four key reasons that align with the project goals and these include problem solving, adaptive development, practicability of the system and stakeholder focus. the core challenges at Guardian Health pharmacy is the absence of an integrated expiry date tracking system within its digital inventory management system DRS as emphasized by Pepper et al (2017) is specifically developed for building and evaluating IT based solutions that bridge such gaps between business needs and technology capability given Uganda's technology environment that is characterized by periodic internet instability and users with varying levels of digital literacy an iterative approach is essential. The build evaluates cycles central to DRS allowing continuous refining of the prototype based on real feedback from the pharmacy staff ensuring a contextually appropriate final solution as Vaishnavi and Kuechler (2015) noted DRS balanced academic strictness with practical utilities by requiring that an artifact not only be built but also evaluated in its operational environment. This ensures that the solution developed for guardian health pharmacy is both valid and effective

in the real world use a defining feature of DSR is its emphasis on stakeholder involvement throughout the design process by involving the pharmacy pharmacists, technicians and managers in all stages from

Requirements gathering to evaluation the systems become user friendly and aligning with the users requirements.

The project adopts the six step DRS process model originally created by Pepper et al (2017) to ensure that the strictness and efficiency each step is carefully aligned with the projects workflow and objectives for the Guardian Health Pharmacy system the table below outlines the step by step process and there application in the project.

Table 1: Application of the Design Science Research process.

DRS stage	Research objectives	Proposed methods	Expected results
1.problem identification	To identify inefficiency in the guardian health pharmacy manual expiry date tracking	<ul style="list-style-type: none"> -semi structured interviews with 5 pharmacists. -observation of inventory workflow. -analysis of UNDA audit reports (2022-2025) 	A well sighted and explained report highlighting (15-20%) stock expiry rate and time wasted on manual checks (roughly 3 days)

2. objective definition	To define functional requirements for an automated date expiry tracking system.	<ul style="list-style-type: none"> -stakeholder workshop with pharmacy staff -literature review of similar systems (e.g., M Track Tanzania) 	A prioritized list of systems including barcode scanning SMS alerts and offline capability
3.design & development	To develop a prototype of the expiry date tracking system.	<ul style="list-style-type: none"> -agile sprints using HTML,CSS.JAVASCRIPT(front end) And PHP (backend). -UML diagrams for system architecture -GitHub for version control 	A minimum viable product with medication expiry alerts inventory reports and user login dashboard
4. demonstration	To test the prototype's usability and effectiveness in a real world	<ul style="list-style-type: none"> -4 weeks pilot at Guardian health pharmacy. -training sessions for staff. 	Feedback reports indicating atleast (85%) usability satisfaction and

			(50%) reduction in expired stock detection time
5.Evaluation	To access the systems impact and operational efficiency	-Pre or post implementation audits by the pharmacy -staff surveys (Likert scale). -system performance analytics	Validation report showing 70% fewer expired medicine on shelves and 90% compliance with the UNDA standard
6.communication	To disseminate findings and promote adoption at guardian health pharmacy	-presentation at MUBS research week 2025 -meeting with the board and staff members at the pharmacy	Project report submission and potential conference submissions.

The highly structured approach ensures the project remains grounded in both theoretical principles and practical applicability of the system and by following this method the study aims

to produce not only a functional technology artifact but also contribute to the broader knowledge base on pharmacy automation in low resource settings.

3.2 project organization and sampling.

3.2.1 Project organization and client identification.

The project is being developed for Guardian health pharmacy an medium size urban pharmacy based in Ntinda kampala this pharmacy currently employs a basic digital inventory management system but lacks an expiry date tracking system a critical gap that this research aims to fix .The organization was selected based on its representative context as a typical Ugandan pharmacy facing inventory management challenges common within the sector (National Drug Authority 2023) stakeholders have been categorized as follows.

- Project owners: the six members students development team
- Direct users: pharmacy staff including pharmacists, technicians and inventory managers.
- End beneficiaries : patients of Guardian health pharmacy.
- Regulatory body: Uganda national drug authority (UNDA) as the enforcing agency for pharmaceutical standards.

3.2.2 Sampling design and technique.

Given the relatively small and well-defined population of direct users at Guardian health pharmacy, a census sampling approach will be adopted. This involves including all members of the target user group comprising approximately 10-12 staff members in requirements elicitation usability where the total population is very small accessible and homogenous (Teherdoost 2017). This approach eliminates sampling errors and ensures that improving the validity and real world applicability of the final system (Bhardwaj 2019) this is particular important in a design science context where stakeholders input directly shapes the artifacts design and functionality.

3.3. Sources of the project data.

To ensure data will be collected directly from Guardian Health Pharmacy to capture the specific operational context and user requirements as emphasized by Pepper et al (2017), direct engagement with stakeholders during the problem identification and requirements gathering

phases in crucial for developing relevant IT artifacts in healthcare settings. The primary data collection will include.

- Structured interviews with pharmacy staff (pharmacists, technicians, inventory managers) to understand the current day to day challenges and system expectations. This approach aligns with methodologies successfully used in similar Ugandan pharmacy automation studies (Julius sseruyange et al 2024).
- Direct observation of the inventory management processes, particularly the manual expiry date tracking methods currently in use observation as a requirement elicitation technique has proven effective in identifying inefficiencies in the healthcare workflow in low resource settings (Unertl et al 2012).
- Focus group discussions with key staff members to collaboratively brainstorm the system features .this participatory approach ensures the final system aligns with actual user needs and operational constraints (Kibera et al 2019).

3.3.2 Secondary data sources.

This will provide the theoretical foundation and contextual understanding necessary for informed system design. As noted by (vom Brocke et al 2021) by ingaging in existing literature is essential for positioning design science within the broader knowledge base .

Secondary sources will include:

- Academic literature on pharmacy inventory management expiry tracking system and digital health interventions in Africa context previous research by Agnes nakyanzi et al (2015) on medicine expiry in Uganda provides particularly relevant background.
- Institutional reports from the Uganda national drug authority (UNDA) regarding regulations on drug expiry management and good distribution practices guidelines (national drug authority, 2023).
- Technical documentation for the chosen technology stack (PHP, MYSQL, JAVASCRIPT) to inform development decisions following established practices in health information systems development in resource based environment (Mucunguzi Atukunda et al 2024).

3.3.3 Validity and reliability assurance.

To ensure data quantity and trustworthiness the project will employ methodological multiple method approach by cross verifying findings from multiple data sources . This approach recommended by Kamba et al 2017 enhances the validity of requirements gathering information systems research .Additionaally pilot testing of data collection instruments will be refined questions and procedures before full deployment and this will improve quality.

3.4 Requirements Elicitation Techniques.

To design a system that effectively addresses the specific operational challenges at Guardian Health Pharmacy a multi method approach to requirements drawing out will be employed combining multiple techniques helps overcome the limitations of individual methods and ensure comprehensive requirements are got and a practice strongly recommended in healthcare software development (Gottesman et al 2010).

The following methods will be utilized:

1. Observation. Direct observation of the pharmacy staff during routine inventory checks will be conducted to identify workflow inefficiencies and undocumented practices .this technique is practicaly valuable for understanding surrounding conditions that users may not verbally report (Lethbridge et al 2015) in pharmaceutical setting observation has revealed significant gaps between reported and actual processes making it essential for designing effective automation systems (Fraser et al 2018).
2. Semi structured interviews guided interviews with pharmacy staff will explore challenges with current expiry tracking and expectations for an automated solution semi structured formats balance consistency across participants with flexibility to explore emerging themes making particularly effective in requirements engineering for specialized domains (DiCicco-Bloom & crabtree, 2016) this approach has proven successful in capturing healthcare workers perspectives in similar African context (muinga et al 2021).
3. Focus group discussion (FGDs) structured group session with mixed staff roles will facilitate collaborative requirements as the main emphasis FGDs utilize group dynamics to build agreement and identity shared needs making them especially valuable when

designing for requirements gathering for pharmacyninformation systems in resources limited settings (kiberu et al 2019).

4. relationship diagramming following data collection relationship diagramming sessions will organize requirements into thematic groups this visual collaborative technique helps transform diverse stakeholders input into a structured framework particularly effective for complex systems with multiple user perspective the method has demonstrated success in healthcare designed by the making suggested requirements clear or obvious.(Lucero 2015).

3.5 System Analysis and Design Approaches.

This project will employ Object-Oriented Analysis and Design (OOAD) as the primary methodology for system modeling and development. OOAD is particularly suited for developing modular, scalable software systems in dynamic environments like pharmaceutical inventory management (Dennis et al., 2015).

3.5.1 Rationale for Object-Oriented Design.

The selection of OOAD is justified by several factors relevant to the Ugandan pharmacy context:

- **Modularity and Reusability:** OOAD supports the development of independent modules (e.g., user management, alert systems, reporting) that can be modified or extended without affecting the entire system. This is crucial in environments where requirements may evolve, such as when integrating with existing pharmacy management systems.
- **Real-World Mapping:** The object-oriented paradigm naturally models real-world entities and processes found in pharmacy operations, making the system more intuitive for developers and stakeholders alike (Dennis et al., 2015). This alignment with business domains has been shown to improve system adoption in healthcare settings.
- **Scalability:** The encapsulated nature of object-oriented systems facilitates future enhancements, such as adding mobile interfaces or integrating with national drug tracking systems a consideration important for long-term system viability (National Drug Authority, 2023).

3.5.2 Design Techniques and Artifacts.

The following techniques will be employed to translate requirements into a functional system design:

- **Use Case Diagrams:** These will model interactions between pharmacy staff and the system, capturing functional requirements from a user perspective. Use cases have proven effective in clarifying system scope and user interactions in similar healthcare automation projects.
- **Entity-Relationship Diagrams (ERD):** These will define the database schema, establishing relationships between key entities such as medications, batches, suppliers, and expiry alerts. A well-structured database is essential for accurate expiry tracking and reporting, as emphasized in pharmaceutical inventory management literature (Agnes Nakyanzi et al., 2015).
- **Class Diagrams:** These will specify the static structure of the system, showing object classes, their attributes, operations, and relationships. This object-oriented modeling technique provides a blueprint for system implementation that aligns with modern software engineering practices.
- **Sequence Diagrams:** These will illustrate how objects interact in time sequence to execute specific functionalities, such as generating expiry alerts or processing inventory updates. Such dynamic modeling is particularly valuable for understanding complex workflows in pharmacy operations (Mucunguzi Atukunda et al., 2024).

3.5.3 Development Methodology: Prototyping.

The project will follow a prototyping-based development approach, building iterative versions of the system for continuous stakeholder feedback. This methodology is especially appropriate when user requirements may not be fully defined initially a common scenario in healthcare software development in Uganda.

The prototyping approach offers several advantages:

- **Early User Validation:** Stakeholders can interact with working prototypes to refine requirements before full implementation (Peppers et al., 2017).
- **Risk Mitigation:** Technical and usability issues can be identified and addressed early in the development process.

- **Contextual Appropriateness:** For a student project with limited resources, prototyping provides a practical balance between thoroughness and feasibility (Julius Sseruyange et al., 2024).

3.6 System Interface and Technology Stack.

The system will be developed as a web-based application to ensure cross-platform accessibility from both desktop computers and mobile devices used by pharmacy staff. This approach aligns with the growing trend of web-first solutions in Ugandan healthcare settings, where mobile accessibility is crucial for operational flexibility.

Frontend Technologies. The user interface will be built using:

- HTML5 for content structure, following web standards for accessibility and compatibility.
- CSS3 for responsive design and styling, ensuring optimal viewing across different devices.
- JavaScript for client-side interactivity and dynamic content updates.

Backend Technologies. The server-side components will utilize:

- PHP as the server-side scripting language, chosen for its widespread support, ease of deployment, and compatibility with various hosting environments commonly available in Uganda.
- MySQL as the database management system, providing reliable data storage and retrieval capabilities for inventory and expiry tracking operations.

The LAMP (Linux, Apache, MySQL, PHP) stack has demonstrated particular effectiveness in resource-constrained environments, making it appropriate for the Ugandan context (Mucunguzi Atukunda et al., 2024).

Development Methodology: Prototyping The project will employ a prototyping methodology with iterative development cycles. This approach involves building simplified, functional versions of the system, testing them with pharmacy staff, gathering feedback, and refining the system through multiple iterations.

Rationale for Choosing Prototyping:

- **User-Centric Development:** Early and continuous user involvement ensures the final system aligns with actual workflow needs and usability requirements (Peppers et al., 2017)

- **Risk Mitigation:** Potential design flaws and usability issues can be identified and addressed in initial stages, preventing costly changes later in development (Dennis et al., 2015).

3.6.2 Design Techniques.

- **Use Case Diagrams** will be used to capture functional requirements from the user's perspective, illustrating interactions between pharmacy staff and the system. Each use case such as "Scan Medication Barcode," "Generate Expiry Report," or "Send SMS Alert" will be documented with preconditions, post conditions, and exception handling. This technique is particularly effective for clarifying system scope and ensuring all user interactions are accounted for in healthcare applications (Kiberu et al., 2019).
- **Entity-Relationship Diagrams (ERD)** will define the database structure, establishing relationships between key entities such as Medication, Inventory Batch, Supplier, User, and Expiry Alert. This modeling technique ensures data integrity and supports efficient querying for reporting and alert generation critical functions for pharmaceutical inventory management (Agnes Nakyanzi et al., 2015).
- **Class Diagrams** will specify the static structure of the system by defining object classes, their attributes, methods, and relationships. For example, the Medication class will contain attributes like drugName, batchNumber, and expiryDate, while the AlertSystem class will manage methods for checkExpiry() and sendNotification(). This object-oriented modeling approach provides a clear blueprint for implementation (Dennis et al., 2015).
- **User Interface Wire framing.** Low-fidelity Wireframes will outline the layout and navigation of key system interfaces, including the dashboard, inventory management screens, and alert configuration panels. These visual guides will be reviewed with pharmacy staff early in the design process to validate usability and workflow alignment a practice that significantly improves user acceptance in healthcare systems.

3.7 Anticipated Project Constraints.

- **Technical Constraints.**

Limited Integration Capabilities: Guardian Health Pharmacy's existing inventory system may have limited API access or documentation, potentially complicating data integration. This is a

common challenge when developing supplementary modules for legacy systems in Ugandan healthcare settings.

Mitigation Strategy: The team will develop a standalone prototype with manual data entry options while exploring alternative integration methods such as CSV import/export functionality, following approaches successfully implemented in similar pharmacy automation projects.

- **Resource Constraints.**

Budget Limitations: As a student-led initiative, the project operates without dedicated funding for premium services, software licenses, or hardware components.

Mitigation Strategy: The team will utilize open-source technologies and free-tier cloud services, following the approach of previous successful student projects in similar contexts (Mucunguzi Atukunda et al., 2024). For SMS functionality, free development accounts with local telecom providers will be explored.

- **Human Resource Constraints**

Team Skill Gaps: Variations in technical expertise across team members may affect development velocity and system quality.

Mitigation Strategy: The team will implement peer programming sessions and leverage online learning resources to address skill gaps, following collaborative approaches that have proven effective in similar academic projects.

3.8 Ethical Considerations.

- **Data Privacy and Confidentiality.**

The system will handle sensitive information including medication inventories, supplier details, and operational data. To protect this information, the project will implement encryption protocols for data at rest and in transit, following Uganda's Data Protection and Privacy Act, 2019 requirements. Access controls will ensure that only authorized pharmacy staff can view sensitive operational data, a practice emphasized in healthcare information security guidelines (National Drug Authority, 2023; ISO/IEC 27001:2022).

Patient privacy will be maintained by designing the system to track medication batches without storing personally identifiable patient information, unless required for specific regulatory reporting. This approach minimizes privacy risks while maintaining functional utility (Kiberu et al., 2019).

- **Informed Consent and Transparency.**

All participants in requirements gathering, usability testing, and system evaluation activities will provide written informed consent after receiving clear explanations of the research purpose, procedures, potential risks, and benefits. The consent process will be conducted in languages comfortable for participants (primarily English and Luganda) to ensure comprehensive understanding, following ethical research practices in Ugandan contexts.

Participants will be explicitly informed that their involvement is voluntary and that they may withdraw at any time without negative consequences. This approach respects participant autonomy and aligns with ethical guidelines for academic research involving human subjects.

- **System Safety and Reliability.**

Given the healthcare context, the system's design prioritizes patient safety through accurate expiry date tracking and reliable alert mechanisms. The development process will include rigorous testing to minimize the risk of false negatives (failing to identify expired medications) or false positives (incorrectly flagging valid medications), addressing a critical concern in pharmaceutical informatics (Agnes Nakyanzi et al., 2015).

The team will maintain clear documentation of system limitations and ensure pharmacy staff understand that the system serves as a decision support tool rather than replacing professional judgment, a crucial distinction in healthcare technology implementation (World Health Organization, 2021; Institute of Medicine, 2012).

3.10.1 References.

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3.10.2 APPENDICIES.

Proposed Project Budget.

The budget outlines estimated costs for human, material, and financial resources required to develop the Expiry Date Tracking and Alert System for St Francis Authentic Pharmacy.

Category	Item / Activity	Quantity	Unit Cost (UGX)	Total Cost (UGX)	Remarks
SOFTWARE & DEVELOPMENT				1,350,000	
	Domain Registration (.ug)	1 year	150,000	150,000	guardianpharmacy.ug
	Web Hosting (Basic Plan)	4 months	200,000	800,000	Includes SSL certificate
	Development Tools & Software	1 package	400,000	400,000	IDEs, design software, testing tools
HARDWARE & EQUIPMENT				850,000	
	Barcode Scanner	2 units	300,000	600,000	USB connectivity for inventory input
	Uninterruptible Power Supply (UPS)	1 unit	250,000	250,000	For system reliability during outages
COMMUNICATION & INTERNET				720,000	
	Internet Data (4G Modem)	4 months	120,000	480,000	Team research & development
	SMS Gateway Credits	5,000 messages	40	200,000	For expiry alert notifications (UGX 40 per SMS)

	Airtime & Communication	4 months	10,000	40,000	Team coordination
TRANSPORTATION & FIELD WORK				600,000	
	Field Visits to Pharmacy	12 trips	40,000	480,000	Requirements gathering & testing
	Research Transportation	8 trips	15,000	120,000	Library, supervisor meetings
STATIONERY & DOCUMENTATION				380,000	
	Printing & Binding	3 copies	100,000	300,000	Final project documentation
	Stationery & Materials	1 package	80,000	80,000	Questionnaires, notebooks, etc.
TRAINING & DEPLOYMENT				400,000	
	Staff Training Materials	1 set	150,000	150,000	User manuals, quick reference guides
	Training Session Refreshments	2 sessions	125,000	250,000	For pharmacy staff during training
CONTINGENCY (10%)	Unforeseen Expenses			430,000	Buffer for unexpected costs
GRAND TOTAL				4,730,000	

