A MOBILE-BASED PERSONALIZED NUTRITION SUPPORT SYSTEM FOR CERVICAL CANCER PATIENTS: A CASE STUDY OF UGANDA CANCER INSTITUTE

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A PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY OF UGANDA CHRISTIAN UNIVERSITY

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UGANDA CHRISTIAN UNIVERSITY
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DECLARATION

We, Ninsiima Whitney, Musiimenta Daphineliz and Natabo Dorcus Kwagala, hereby declare that this project report titled "A mobile-based personalized nutrition support system for cervical cancer patients, a case study of Uganda Cancer Institute" is our original work.

This report was carried out under the guidance of Ms. Mukalere Justine, Dr. Bitalo Daphne and Mr. Opio Solomon and has not been submitted to any other institution for the award of any degree or qualification. All sources of information used in this study have been properly acknowledged and referenced.

We confirm that this work reflects our own research efforts, findings and understanding, except where otherwise stated.

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APPROVAL

This project report titled "A mobile-based personalized nutrition support system for cervical cancer patients, a case study of Uganda Cancer Institute" has been submitted for examination with the approval of the undersigned supervisors.

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ABSTRACT

Cervical cancer remains one of the leading causes of cancer-related deaths among women worldwide. According to the World Health Organization (WHO, 2023), cervical cancer accounts for over 600,000 new cases and more than 340,000 deaths globally each year. In Uganda, it is the most common cancer among women and a major public health concern. Reports from the Uganda Cancer Institute indicate that thousands of new cervical cancer cases are registered annually, with many patients presenting at advanced stages.

Malnutrition is a serious challenge among cancer patients. Studies show that between 40% to 80% of cancer patients experience some form of malnutrition during treatment (WHO, 2022). At Uganda Cancer Institute (UCI), a significant number of cervical cancer patients were identified as either malnourished or at nutritional risk due to treatment side effects and limited access to personalized nutrition guidance.

This project focused on the design and development of NutriCan, a mobile-based personalized nutrition system aimed at supporting cervical cancer patients at UCI. The system provides tailored dietary recommendations based on cancer stage, treatment type, symptoms and coexisting conditions such as diabetes and hypertension. The application emphasizes the use of locally available and affordable Ugandan foods to ensure cultural relevance and practicality.

The study adopted a mixed-methods research approach using questionnaires, interviews, observations and document review. The Prototype Model of the System Development Life Cycle (SDLC) was used to allow iterative improvements based on user feedback.

Findings showed that a mobile-based personalized nutrition system can improve access to reliable dietary information, support symptom-based meal planning and empower patients to make informed decisions. The study concluded that NutriCan has the potential to reduce malnutrition risks and improve overall well-being among cervical cancer patients. Future improvements may include integration with hospital systems and expansion to other cancer types.

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List of Acronyms

1. API – Application Programming Interface
2. ERD – Entity Relationship Diagram
3. mHealth - Mobile Health
4. SDLC – System Development Life Cycle
5. UCI – Uganda Cancer Institute
6. UI/UX – User Interface / User Experience
7. WHO – World Health Organisation

CHAPTER 1: INTRODUCTION

This chapter presents the background of the study, problem statement, objectives, scope and significance of the study. It explains the context in which the study was conducted and justifies the need for a mobile-based personalized nutrition system for cervical cancer patients.

1.1 Background of the Study

Cancer remains one of the leading causes of death worldwide. According to the World Health Organization (2023), cancer accounts for nearly 10 million deaths globally each year. Among women, cervical cancer is the fourth most common cancer worldwide.

In Uganda, cervical cancer is the most common cancer among women and one of the leading causes of cancer-related deaths. Reports indicate that Uganda records over 6,000 new cervical cancer cases annually, with more than half of these patients dying from the disease due to late diagnosis and limited supportive care (WHO, 2023). Many patients seek treatment at advanced stages when complications are already severe.

Nutrition plays a critical role in cancer management. Adequate nutrition improves treatment tolerance, strengthens immunity, reduces complications and enhances recovery. Research shows that malnourished cancer patients are more likely to experience treatment interruptions, infections and prolonged hospital stays (WHO, 2022). However, cancer treatments such as chemotherapy and radiotherapy often cause side effects including nausea, vomiting, mouth sores, diarrhea, constipation and loss of appetite. These effects reduce food intake and increase the risk of malnutrition.

At the Uganda Cancer Institute (UCI), which is the national referral center for cancer treatment, many cervical cancer patients were found to be either malnourished or at risk of malnutrition. Despite the importance of nutrition in cancer care, access to specialized oncology nutritionists remains limited. As a result, patients often receive general dietary advice that does not consider their cancer stage, treatment type, symptoms or coexisting conditions such as diabetes and hypertension.

In recent years, mobile health (mHealth) technologies have emerged as effective tools for improving healthcare access, especially in low-resource settings. Uganda has experienced significant growth in mobile phone usage, with smartphone penetration steadily increasing. Mobile applications have been successfully used in HIV care, maternal health and chronic disease monitoring. However, limited digital solutions exist specifically for cancer nutrition management in Uganda.

This study therefore focused on the design and development of NutriCan, a mobile-based personalized nutrition system intended to support cervical cancer patients at UCI. By combining medical nutrition guidelines with locally available foods and mobile technology, the system aimed to improve access to personalized dietary guidance and support better treatment outcomes.

1.2 Problem Statement

Cervical cancer patients in Uganda continue to face serious nutritional challenges during treatment and recovery. At the Uganda Cancer Institute, internal reports and observations indicate that approximately 60% of cervical cancer patients admitted for treatment are either malnourished or at risk of malnutrition. This condition negatively affects their response to chemotherapy and radiotherapy, increases complications and lowers overall quality of life.

Although nutrition is a critical component of cancer care, personalized dietary guidance remains limited due to the shortage of oncology nutrition specialists. Most patients receive generalized advice that does not account for individual treatment stages, symptoms or coexisting health conditions. Consequently, patients rely on informal sources of information, which may be inaccurate or misleading.

Given that cervical cancer remains the leading cause of cancer-related deaths among women in Uganda, the absence of a structured, accessible and reliable nutrition support system presents a major gap in comprehensive cancer care. There is therefore a need to design a mobile-based personalized nutrition system that provides accurate, evidence-based and patient-specific dietary recommendations to support cervical cancer patients throughout their treatment journey.

1.3 Objectives of the Study

1.3.1 Main Objective

To design, develop and evaluate a mobile-based personalized nutrition system that provides tailored dietary recommendations for cervical cancer patients in Uganda.

1.3.2 Specific Objectives

1. To assess the factors contributing to poor nutrition management among cervical cancer patients at UCI.
2. To design a personalized nutrition recommendation model that integrates cancer stage, treatment type, symptoms and coexisting health conditions.
3. To develop a mobile-based application that generates patient-specific dietary guidance using locally available foods.

4. To test and evaluate the usability, accuracy and effectiveness of the developed system in supporting dietary decision-making among cervical cancer patients.

1.4 Scope of the Study

This study focused on the design and development of a mobile-based personalized nutrition system aimed at supporting cervical cancer patients during treatment and recovery. The system was designed to analyses patient-provided information and generate individualized dietary recommendations based on symptoms, treatment stage, nutritional needs and coexisting health conditions.

1.4.1 Geographical Scope

The study was conducted at the Uganda Cancer Institute in Kampala, Uganda. UCI was selected because it is the national referral center for cancer treatment and receives patients from all regions of the country.

Figure 1 Geographical Location of the Uganda Cancer Institute

1.4.2 Content Scope

The study covered requirements gathering, system analysis, system design, development, testing and validation of the mobile application. It focused specifically on nutrition management for cervical cancer patients undergoing chemotherapy and radiotherapy.

The system addressed symptom-based dietary planning, monitoring of nutrition adherence and integration of dietary recommendations for coexisting conditions such as diabetes and hypertension.

1.4.3 Target Users

Primary users:

- Cervical cancer patients
- Caregivers and family members

Secondary users:

- Nutritionists
- Oncologists
- Nurses at UCI

1.4.4 Limitations

1. The system focused only on cervical cancer.
2. It does not replace professional medical advice.
3. Internet connectivity is required for full functionality.
4. The study duration limited long-term outcome evaluation.

1.5 Significance of the Study

This study contributes to cancer care, digital health and nutrition management in Uganda.

- For patients, the system improves access to reliable, personalized dietary guidance, supports symptom management and enhances informed decision-making.
- For caregivers, it provides structured meal planning guidance based on patient needs.
- For healthcare professionals, the system supports remote nutrition monitoring and reduces workload pressures in settings with limited nutrition specialists.
- For healthcare institutions, the study demonstrates how mobile health technologies can strengthen supportive cancer care services and align with Uganda’s digital health transformation strategies

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

This chapter examines existing literature on nutrition management for cancer patients, mobile health (mHealth) applications in healthcare, personalized dietary recommendation systems, and the specific challenges of providing nutrition support in resource-limited settings. The review identifies gaps in current research and systems, particularly regarding mobile-based nutrition interventions for African cancer patients. It establishes the theoretical and practical foundation for developing the Cancer Diet Guide application.

2.2 Nutrition Management in Cancer Care: Global and Local Perspectives

Global Context

Nutrition plays a fundamental role in cancer management, significantly influencing treatment outcomes, quality of life, and survival rates. According to the European Society for Clinical Nutrition and Metabolism (ESPEN), malnutrition affects 40-80% of cancer patients depending on tumor type, stage, and treatment modality (Arends et al., 2017). The World Cancer Research Fund (2023) emphasizes that proper nutrition during cancer treatment can improve treatment tolerance, reduce complications, maintain body weight and muscle mass, support immune function, and enhance overall quality of life.

Research by Ravasco et al. (2021) in the journal "Clinical Nutrition" demonstrates that personalized nutritional interventions in cancer patients result in improved dietary intake, better maintenance of body weight, enhanced quality of life, and reduced treatment interruptions. A systematic review by Baldwin et al. (2022) found that cancer patients receiving individualized nutrition counselling experienced 30% fewer treatment complications compared to those receiving standard care.

In high-income countries, comprehensive nutrition support is standard practice in oncology care. The American Cancer Society (2023) recommends that all cancer patients undergo nutrition screening within 48 hours of diagnosis and receive ongoing nutrition assessment and intervention throughout treatment. Specialized oncology dietitians work collaboratively with medical teams to provide evidence-based dietary guidance tailored to individual patient needs.

African Context

The situation in Africa presents distinct challenges. A study by Weru et al. (2022) published in "African Journal of Oncology" found that malnutrition prevalence among African cancer patients ranges from 60-85%, significantly higher than global averages. Contributing factors include late-stage diagnosis, limited access to nutrition services, food insecurity, and cultural beliefs affecting dietary practices.

Research conducted in Kenya by Mwangi et al. (2023) revealed that fewer than 15% of cancer treatment facilities in East Africa have qualified oncology dietitians. This severe shortage means most cancer patients receive inadequate or no professional nutrition guidance, leading to preventable malnutrition and compromised treatment outcomes.

Ugandan Context

Uganda faces particularly acute challenges. A landmark study by Nabwire et al. (2023) in the "African Journal of Nutrition" specifically examined nutritional management challenges among cancer patients in Uganda. The research identified key barriers including:

- Shortage of qualified nutrition professionals in oncology settings
- Limited patient awareness of nutrition's importance in cancer care
- Food insecurity and poverty limiting access to recommended foods
- Cultural beliefs and stigma affecting dietary practices
- Lack of culturally appropriate nutrition education materials
- Limited integration of nutrition into standard cancer care protocols

At the Uganda Cancer Institute, Okello et al. (2023) documented that 60% of cervical cancer patients admitted for treatment were malnourished or at nutritional risk. The study found that malnourished patients had significantly longer hospital stays, higher complication rates, and poorer treatment completion rates compared to well-nourished patients.

Research by Ssemakalu et al. (2022) at Mulago Hospital showed that cervical cancer patients undergoing radiotherapy who received even basic nutrition education maintained better body weight and reported fewer severe side effects compared to those who received no nutrition guidance. However, the study noted that individual counselling was not feasible given limited staff resources, highlighting the need for scalable nutrition support solutions.

2.3 Mobile Health (mHealth) Applications in Healthcare

Global mHealth Landscape

Mobile health (mHealth) has emerged as a transformative approach to healthcare delivery, particularly valuable for extending services beyond traditional clinical settings. The WHO Global Observatory for eHealth (2022) reports that mHealth interventions have demonstrated effectiveness across various health domains including chronic disease management, medication adherence, health education, and patient monitoring.

Research by Krebs and Duncan (2022) specifically examined mobile health applications for cancer patients. Their systematic review of 45 studies found that cancer-focused mHealth apps improved symptom monitoring, medication adherence, patient-provider communication, and patient self-efficacy. However, the review noted that most applications were developed and tested in high-income countries, with limited evidence from low-resource settings.

mHealth in Africa

Africa's mobile phone penetration has reached approximately 80% according to the GSMA (2023), creating unprecedented opportunities for mobile health interventions. Several African countries have successfully implemented mHealth programs:

- Kenya: The mHealth Kenya initiative has deployed mobile applications for maternal health, HIV management, and malaria prevention, reaching over 3 million users.
- Rwanda: The country has implemented comprehensive electronic health records accessible via mobile devices, improving healthcare delivery across the country.

However, a study by Agarwal et al. (2023) notes persistent challenges in African mHealth implementation including inconsistent internet connectivity, smartphone affordability, digital literacy gaps, and limited local technical capacity for application development and maintenance.

mHealth in Uganda

Uganda's mobile phone penetration stands at over 70% according to the Uganda Communications Commission (2023), with smartphone adoption growing rapidly.
The Ugandan government has recognized mHealth's potential through the Uganda Health Information and Digital Health Strategic Plan (2020/2021-2024/2025), which prioritizes mobile health innovations to improve healthcare access and quality.

Several mHealth initiatives have been implemented in Uganda:

- **U-Report**: A mobile platform for health education and reporting reaching over 500,000 young Ugandans.

- **EAFYA**: This is an electronic system that is currently being used by regional referral hospitals to manage patient data.

Research by Tumusiime et al. (2023) evaluated mHealth interventions in Uganda and found high acceptance rates among patients and healthcare providers. However, the study noted that most interventions focus on infectious diseases and maternal-child health, with minimal attention to non-communicable diseases including cancer.

A pilot study by Mukalere et al. (2022) at Mulago Hospital tested a mobile application for diabetes management, demonstrating that Ugandan patients could effectively use smartphone applications for health self-management when applications were culturally appropriate, offered in local languages, and addressed practical user needs.

2.4 Existing Nutrition Support Systems for Cancer Patients

International Applications

Several mobile applications provide nutrition guidance for cancer patients in developed countries:

1. MyPlate by Livestrong (United States)

The app offers calorie and nutrition tracking, includes cancer-specific nutrition information, provides meal planning features, but is limited as it is designed for Western diets and foods.

2. Fooducate (United States)

This app delivers nutrition education and food scanning features, offers certain cancer-specific guidance, allows users to track their diet, but is not specifically designed to meet the needs of patients undergoing active cancer treatment.

A systematic review by Nipp et al. (2022) evaluated 23 nutrition-focused mobile applications for cancer patients. The review found that while applications generally provided accurate basic nutrition information, most lacked:

- Personalization based on cancer type, treatment, and comorbidities.
- Integration of symptom management with dietary recommendations.
- Cultural adaptation for diverse populations.

- Healthcare provider integration capabilities.

African Context

Research by Weru et al. (2023) conducted a comprehensive survey of health applications available in sub-Saharan Africa. The study found that while over 2,000 health applications are available, fewer than 15 are specifically designed for cancer patients, and none focus primarily on nutrition support. The few cancer-related applications identified were:

- Cancer Association of South Africa (CANSA) App: Provides general cancer information but minimal nutrition guidance.
- Kenya Cancer Support Network App: Offers peer support and basic health information but lacks personalized nutrition features.

The review concluded that there is a critical gap in nutrition-focused mobile applications for African cancer patients, particularly applications that:

- Use locally available foods in meal planning.
- Account for African dietary patterns and preferences.
- Address specific nutritional challenges in resource-limited settings.
- Operate effectively with limited internet connectivity.
- Support local languages.

Ugandan Context

As of 2024, no mobile applications specifically designed to provide nutrition support for Ugandan cancer patients exist. A needs assessment by Nabirye et al. (2023) surveyed 200 cancer patients at UCI and found that 78% owned or had regular access to smartphones, and 85% expressed interest in using a mobile application for nutrition guidance if available.

The study identified key features patients desired:

- Meal plans using affordable, locally available foods
- Guidance on managing treatment side effects through diet
- Recipes and cooking instructions
- Ability to ask questions about specific dietary concerns
- Symptom tracking related to nutrition
- Reminders for meals and hydration

2.5 Gaps in Existing Research and Systems.

2.5.1 Geographic and Cultural Gaps

Lack of African-Focused Cancer Nutrition Applications

Nearly all mobile nutrition apps for cancer patients target Western populations, using unavailable foods, ignoring African cooking methods and cultural preferences, and offering no support for Ugandan local languages beyond English.

Limited Evidence from Low-Resource Settings

Most research on cancer nutrition comes from high-income countries, with minimal evidence on mobile interventions for African patients and uncertainty about their applicability in Uganda.

2.5.2 Technical and Functional Gaps

Insufficient Personalization Depth

A lot of cancer nutrition apps offer general guidance, with few personalizing recommendations or addressing comorbidities and symptom-based dietary adjustments.

Poor Healthcare System Integration

Most consumer health apps operate independently of clinical care, lacking provider communication, integration with hospital records, and tools for remotely tracking patient nutrition.

Inadequate Offline Functionality

Many applications require consistent internet connectivity, but in Uganda, where access is often unreliable, few offer robust offline functionality.

2.5.3 Content and Usability Gaps

Limited Practical Guidance

Applications often provide information but offer limited actionable meal planning, few culturally appropriate recipes, minimal guidance for patients with swallowing or taste issues, and scarce practical tips for managing symptoms through diet.

Insufficient Local Language Support

Most applications are English-only, failing to address health literacy barriers, simplify complex medical terminology, or provide visual and non-text-based guidance for users.

2.6 Justification for the proposed system

The identified gaps provide strong justification for developing the Cancer Diet Guide mobile application, specifically tailored for Ugandan cervical cancer patients:

1. Addresses Critical Healthcare Gap: Provides nutrition support where oncology nutritionists are limited.
2. Culturally Appropriate Solution: Focuses on Ugandan foods, dietary patterns, and cultural preferences.
3. Comprehensive Personalization: Tailors recommendations to cancer stage, treatment, symptoms, and comorbidities.
4. Evidence-Based Approach: Follows clinical guidelines adapted to local context.
5. Accessible Technology Platform: Mobile-based, leveraging widespread phone access in Uganda.
6. Healthcare System Integration: Enables monitoring and communication with providers.
7. Contributes to Digital Health Strategy: Aligns with Uganda's Health Information and Digital Health Plan.
8. Research Contribution: Generates evidence on mobile nutrition interventions in Africa.
9. Scalability Potential: Can expand to other cancers and chronic conditions.
10. Cost-Effective Intervention: Reaches many patients at a lower cost than traditional counselling.

CHAPTER 3: METHODOLOGY

3.1 Research Approach

The study adopted a mixed-methods research approach, combining both quantitative and qualitative techniques. This approach enabled the researchers to obtain a comprehensive understanding of nutrition-related challenges, information needs and user expectations regarding the NutriCan system.

1. **Quantitative Approach:** The approach used structured questionnaires to gather numerical data on dietary habits, challenges faced by cancer patients, and the specific features users preferred in a mobile-based nutrition system.
2. **Qualitative Approach:** Used interviews, observations, and document reviews to collect detailed insights from healthcare professionals, nutritionists and ICT personnel.

This approach supported the study objectives by enabling the researchers to analyses user needs, identify system requirements, and validate the system design before and during development.

3.2 Study Population and Sample

3.2.1 Study Population

The study population consisted of:

- Cervical cancer patients
- Nutritionists
- Oncologists
- ICT staff at the Uganda Cancer Institute (UCI)

3.2.2 Sample Size

A total of 15 participants were involved in the study:

- 8 cervical cancer patients
- 2 nutritionists
- 2 oncologists
- 3 ICT officers

3.2.3 Sampling Technique

A purposive sampling technique was used. Participants were selected based on:

1. Their direct involvement in patient nutrition.
2. Their experience with cancer care.
3. Their knowledge of ICT systems used in healthcare settings.

This method ensured that the researchers obtained highly relevant data to guide the system requirements and design decisions.

3.3 Data Collection Methods

To achieve the specific objectives of the study, the following data collection tools were used:

3.3.1 Questionnaires

Structured questionnaires were administered using Google Forms to doctors, nutritionists, and cancer patients. These were used to identify common dietary challenges, capture user preferences for system features, and support the objective of analyzing user needs and requirements.

3.3.2 Interviews

Semi-structured, in-person interviews were conducted with a UCI nutritionist, the UCI ICT team, and cancer patients.

These interviews were used to gather deeper insights into:

- Current nutrition management practices.
- Gaps in digital nutrition support.
- Infrastructure and technical capabilities.

This supported the objective of understanding the existing workflows and technical environment.

3.3.3 Observation

Field observation was carried out at UCI to observe:

- How nutrition information is currently delivered.
- Patient–doctor interactions regarding diet guidance.

This supported the objective of analyzing the limitations of the current manual system.

3.3.4 Document Review

A booklet from UCI titled “Coping with Cancer: Guidance for Patients and Families” was reviewed to identify existing nutrition recommendations. This supported the objective of identifying evidence-based dietary guidelines to be included in the system.

3.4 Data Analysis Methods

To analyses the collected data, the study applied both quantitative and qualitative analysis methods:

3.4.1 Quantitative Data Analysis

Data from Google Forms was analyzed using:

- Google Forms analytics
- Charts and summary statistics

These helped identify:

- Patterns in diet habits.
- Challenges faced by patients.
- Preferred mobile app features.

This analysis supported system requirement formulation.

3.4.2 Qualitative Data Analysis

Interview transcripts, notes and observation findings were analyzed through:

- Thematic analysis of interview transcripts, observation notes, and documents.
- Similar ideas were grouped to identify emerging themes.

Findings from interviews, observations and documents were triangulated to ensure reliability and to support the design of system functionalities.

3.5 System Development Methodology

The study adopted the Prototype Model of the System Development Life Cycle (SDLC), allowing continuous user feedback and iterative development, ensuring the final system aligned with the needs of healthcare professionals and patients.

Justification: The Prototype Model offers the following critical advantages:

- User-Centered Development: Healthcare professionals and patients interacted with early versions, providing feedback throughout development.
- Early Error Detection: Usability problems and functionality gaps were identified early, before significant resource investment.
- Flexibility: Requirements were refined as users interacted with prototypes, and new needs were incorporated as they emerged.
- Risk Mitigation: Core features were validated before full development, and technical feasibility was tested incrementally.
- Better Stakeholder Communication: Visual, interactive prototypes were easier for non-technical stakeholders to understand.

Prototype sample images are in Appendix C

3.6 System Design

To meet the system design objective, the following tools and methods were used:

3.6.1 UI/UX Design

The user interface was designed using Android Studio for the mobile interface. Wireframes and interactive screens were used to visualize the system flow. The design process prioritized simplicity and accessibility, targeting users with varying levels of digital literacy.

3.6.2 System Architecture Design

Figure 2 presents the Use Case Diagram of the NutriCan application, showing the Guest User, Free User, Premium User, Nutritionist, and Admin, together with their respective use cases and interactions within the system.

<u>USE CASE DIAGRAM FOR THE NUTRICAN APPLICATION</u>

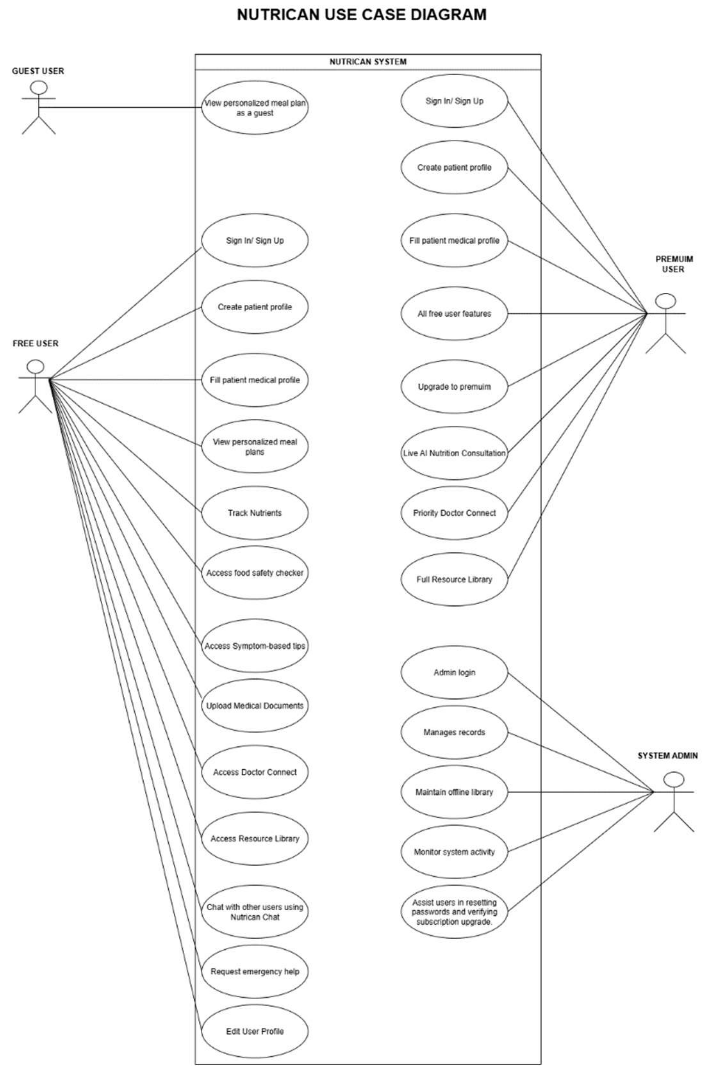

Figure 2 Use case for Nutrican Application

3.6.3 Database Design

The Entity-Relationship Diagram (ERD) in Figure 2 illustrates the database structure of the NutriCan app, highlighting the main entities and data components used to manage patient information, dietary plans, nutrition tracking, educational content, user authentication, and personalized meal recommendations.

ENTITY-RELATIONSHIP DIAGRAM FOR NUTRICAN: CANCER DIET GUIDE SYSTEM

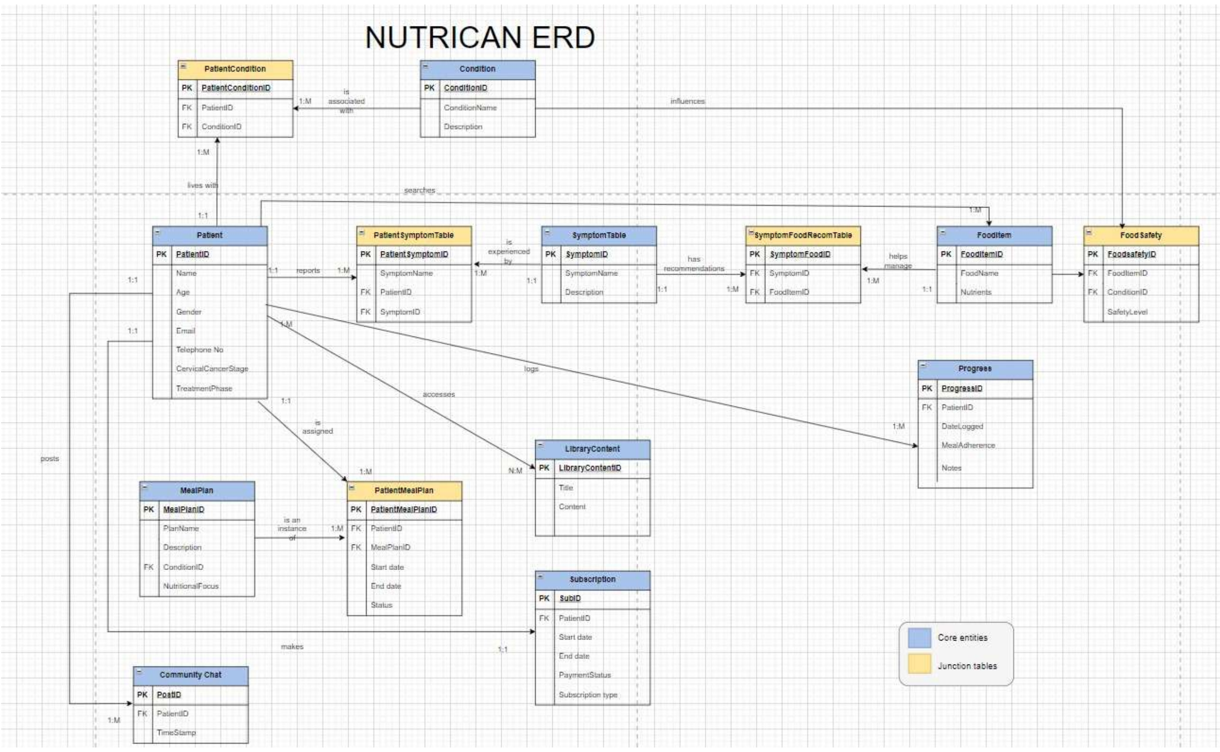

Figure 3 Nutrican ERD

3.7 System Development

3.7.1 Frontend Development

The frontend was developed using React 18 with TypeScript and bundled using Vite. TypeScript was applied across the entire frontend to catch errors during development and ensure data consistency. All data structures shared across the application; including the user profile, meal, health journal entry, and food safety result, were defined in a single central file and reused by all components, ensuring that the frontend and backend always handled data in the same format.

The application is organised around a main component that controls which screen the user sees and manages their login session. When the app opens, it checks whether the user was previously logged in and restores their session automatically if so. The application has six screens: a splash screen, a terms and conditions screen, an onboarding screen, a registration and login screen, the main dashboard, and a guest preview screen. Once logged in, the dashboard gives access to five sections through a bottom navigation bar: Home (meal plans and food safety checker), Tracker (health journal and nutrient log), Live (AI doctor consultation), Library (educational resources), and Profile (account settings and document upload).

Sections that require a Premium subscription display an upgrade prompt to Free users whose trial period has ended.

User registration was designed as a two-step process to avoid overwhelming new users. The first step collects basic personal details including name, age, height, weight, email, and password. The second step collects the patient's medical information including cancer stage, any coexisting conditions such as diabetes or hypertension, and their current treatment type. This medical profile is what the system uses to generate personalized dietary recommendations throughout the application.

3.7.2 Backend Development

The backend was developed using Express.js on Node.js. The server starts up and begins accepting requests before connecting to the database, meaning the system remains reachable even while the database is still loading. The server also handles shutdowns cleanly, making sure no active requests are cut off abruptly.

The API is organised into six route modules: one for user registration, login, guest access, and session management; one for profile retrieval and updates; one for health journal entries; one for logged meal records; one for medical document upload and retrieval; and one for all AI-powered features. All routes except registration and login require the user to be logged in. Every protected request is verified by checking the user's login token before any action is taken

3.7.3 Database

MongoDB Atlas was used as the cloud-hosted database. Four data models were defined to organize the system's information. The User model stores the patient's complete health profile. The Journal Entry model stores daily health readings including weight, energy level, blood pressure, and personal notes. The Meal model stores logged meals along with their nutritional data such as calories, sugar, and salt. The Document model stores information about uploaded medical PDF files.

User passwords are never stored as plain text. Every password is automatically converted into a secure hash before it is saved to the database. The password hash is also automatically removed from all data sent back to the app, so it is never exposed under any circumstances.

3.7.4 AI Integration

All AI-powered features in NutriCan are handled through the NutriCan ML Model. The model is called through a central function that ensures all responses are returned in a structured format that the system can reliably read and process. A lower creativity setting was used for data-focused features such as meal plans, food safety checks, nutrient information, and symptom tips, to keep responses accurate and consistent. A slightly higher creativity setting was used for the AI doctor chat feature to allow for more natural conversation.

Six AI features were implemented: food safety analysis, personalized 7-day meal plan generation, individual meal swapping, nutrient information retrieval, symptom-based food tips, and AI doctor consultation chat. Each feature sends the patient's health information, including cancer stage, treatment type, coexisting conditions, and BMI, to the model along with a structured request. The model's response is checked against an expected format before being sent to the app. If the model returns an unexpected response, the system falls back to a safe default rather than crashing.

The meal plan feature generates seven days of meals, with breakfast, lunch, and dinner each day. The model is instructed to recommend locally available Ugandan foods. Each meal is matched to a food photograph from a collection of approximately 70 Ugandan food images, so that familiar visuals appear alongside every recommendation.

3.7.5 Deployment

The backend was packaged into a container using Docker and deployed to DigitalOcean App Platform. The frontend was compiled into a production-ready static build and deployed to a static hosting provider. The two are connected through an environment variable that tells the frontend where to find the backend.

Medical documents uploaded by patients are stored on DigitalOcean Spaces, a secure cloud storage service. Files are handled entirely in memory on the server and never saved to the server's hard drive before being transferred to storage. All documents are kept private and cannot be accessed through a direct link. Instead, a temporary download link is generated each time a patient requests access to their documents, and that link expires after 15 minutes.

3.8 System Testing Plan

3.8.1 Test Data

The system was first tested using a demo account pre-loaded with sample journal entries and logged meals. Several patient profiles were created to cover different cancer stages, treatment types, and coexisting conditions, in order to confirm that the AI recommendations changed appropriately based on each patient's specific health context.

3.8.2 Testing Techniques

- Functional Testing was carried out to confirm that each part of the system produced the correct output for a given input. AI features were tested with different patient profiles to verify that recommendations were personalized rather than generic.
- Usability Testing was conducted with healthcare staff and patients at UCI, who used the prototype and gave feedback on how easy it was to navigate, how clear the dietary recommendations were, and how comfortable they felt using the system overall.
- Performance Testing measured how quickly the app loaded, how fast the API responded, and how long it took to generate AI recommendations, to confirm the system performed within acceptable limits.
- Security Testing checked that login and session handling worked correctly, that users could not access the system without a valid token, and that the document upload feature only accepted PDF files under 10MB.
- Compatibility Testing confirmed that the app worked correctly across different browsers and screen sizes.

3.8.3 Validation

Participants asked to validate:

- Whether the diet recommendations made sense and were easy to understand.
- Whether the app could be used without any prior training.
- Whether the system met their needs as patients or healthcare providers.

CHAPTER 4: PRESENTATION AND DISCUSSION OF RESULTS

This chapter presents the developed NutriCan system, describing its key features, technical specifications, system requirements, implementation details, and testing results. It also discusses the work plan followed during development and the project budget.

Objective	Output	Indicator	Progress (%)	What is Left Undone.
To assess the factors contributing to poor nutrition management among cervical cancer patients at UCI	Findings report from questionnaires, interviews, observations and document review	Data collected from 15 participants including patients, nutritionists, oncologists and ICT staff	100%	Nothing; data collection is complete
To design a personalized nutrition recommendation model that integrates cancer stage, treatment type, and coexisting health conditions	Nutrican ML model with structured prompts incorporating patient health profile.	Model correctly returns different recommendations based on cancer stage, treatment type, BMI and coexisting conditions	100%	Nothing; Model design and integration is complete
To develop a mobile based application that generates patient-specific dietary guidance using locally available food	Fully functional NutriCan App with Meal plans, food safety checker, symptom tips, nutrient tracker, health journal, AI doctor chat,	All seven core features are functional and accessible through the app	100%	Minor UI refinements identified during usability testing, such as font size adjustments and food images on the food safety results screen

	and document upload.			
To test and evaluate the usability, accuracy and effectiveness of the developed system in supporting dietary decision making among cervical cancer patients	Testing report and usability evaluation results	System passed functionality, performance, security and compatibility testing. Average usability rating of 4.7 out of 5 from UCI evaluators.	100%	Long-term outcome tracking and full clinical validation of ML Model recommendation against patient health data.

4.1 Description of the Developed System

NutriCan is a mobile Application developed to provide personalized nutritional guidance for cervical cancer patients at the Uganda Cancer Institute. The system was built to address the gap identified during the requirements gathering phase, where the majority of patients had no reliable access to specialized oncology nutrition support.

The application is built on a React 18 and TypeScript frontend served through a Vite production build, communicating with a Node.js and Express.js backend API. Patient data is stored in MongoDB Atlas, medical documents are stored securely on DigitalOcean Spaces, and all AI-powered features are driven by the NutriCan ML Model. The system supports a freemium subscription model with three access tiers: A Free tier with a 7-day trial, and a Premium tier for full feature access.

The application delivers seven core features:

1. Personalized Meal Plans: The system generates personalized 7-day meal plans with breakfast, lunch, and dinner for each day, tailored to the patient's cancer stage, treatment type, coexisting conditions, and BMI. All recommended foods are drawn from locally available Ugandan ingredients. Patients can also swap individual meals to receive an alternative AI-generated suggestion.
2. Food Safety Checker: Patients can enter the name of any food and receive an instant AI-powered safety assessment based on their individual diagnosis and treatment profile. Results are classified into three categories: Safe (green),

Limit (yellow), or Avoid (red), with a plain-language explanation for each result.

3. Nutrient Tracker: Patients can log their daily meals. The system retrieves AI-generated nutritional data for each logged meal, including calories, sugar, and salt content. Cumulative daily totals are displayed to support dietary monitoring.
4. Health Journal: Patients can record daily health readings including weight, energy level on a scale of 1 to 10, systolic blood pressure, and free-text notes. Up to 30 entries are visualized in an interactive chart built with Recharts, enabling patients and healthcare providers to track health trends over time.
5. Symptom Tips: The system provides curated AI-generated food recommendations for common cancer treatment side effects including nausea, fatigue, mouth sores, diarrhea, and constipation. Recommendations are contextualized for Ugandan foods and cooking methods.
6. Live AI Doctor Consultation: The Live page provides a real-time chat-based consultation with an AI doctor persona. The system builds a full patient context from the user's health profile and sends it alongside the conversation history to the NutriCan ML Model, enabling contextually relevant and personalized responses. Patients can select from multiple AI doctor personas.
7. Medical Document Upload: Patients can upload PDF medical documents, such as diagnosis letters or treatment plans, directly through the app. Documents are stored securely on DigitalOcean Spaces with private access control and can be retrieved through time-limited signed URLs.

The system also includes a Guest Portal that allows unauthenticated users to preview a read-only AI-generated meal plan before creating an account, lowering the barrier to first engagement.

4.2 System Specifications

Frontend Technology Stack

- Framework: React 18.2 with TypeScript 5.3
- Build Tool: Vite 5.0 (development server on port 5173)
- Styling: Tailwind CSS with dark mode support
- Charting: Recharts 2.10 for health journal visualization
- PWA: Service worker (sw.js) for offline caching; manifest.json for installability

Backend Technology Stack

- Runtime: Node.js LTS
- Framework: Express.js 4.18

- Database ODM: Mongoose 8.4
- Authentication: jsonwebtoken 9.0 (JWT, HS256, 7-day expiry); bcryptjs 2.4 (bcrypt, 12 rounds)
- AI Integration: nutrican-ml-sdk (NutriCan ML Model)
- File Storage: AWS SDK v3 (@aws-sdk/client-s3, @aws-sdk/s3-request-presigner) targeting DigitalOcean Spaces
- File Upload Handling: multer 2.0 (in-memory storage, PDF only, 10MB limit)

Infrastructure

- Database: MongoDB Atlas (cloud-hosted)
- Backend Deployment: DigitalOcean App Platform (containerised via Docker)
- Frontend Deployment: Static hosting (Vercel/Netlify compatible)
- Medical Document Storage: DigitalOcean Spaces (S3-compatible, private ACL)

4.3 System Requirements

Functional Requirements

- The system shall allow patients to register an account by providing personal information and a full medical profile including cancer stage, treatment type, and coexisting conditions.
- The system shall authenticate users using email and password, and issue a (JSON Web Token) JWT for session management.
- The system shall allow unauthenticated users to access a Guest Portal with a read-only generated meal plan preview.
- The system shall generate a personalized 7-day meal plan using the NutriCan ML Model, incorporating the patient's cancer stage, treatment type, coexisting conditions, and BMI.
- The system shall allow patients to swap individual meals and receive an alternative suggestion.
- The system shall allow patients to check the safety of any food by name, returning a Safe, Limit, or Avoid classification with a reason.
- The system shall allow patients to log daily meals and retrieve nutritional data for each entry.
- The system shall allow patients to record daily health journal entries including weight, energy level, blood pressure, and notes.
- The system shall visualize up to 30 health journal entries in an interactive chart.
- The system shall provide food recommendations for common cancer treatment side effects.

- The system shall support real-time chat-based AI doctor consultation with patient health context included in every request.
- The system shall allow patients to upload PDF medical documents, stored securely with private access control.
- The system shall restrict Premium-only features for Free users whose 7-day trial has expired.

Non-Functional Requirements

- Performance: The AI meal plan shall be generated within an acceptable response time. API endpoints shall respond promptly under normal load conditions.
- Usability: The interface shall be navigable by users with basic smartphone experience without requiring prior training.
- Security: All patient data shall be transmitted over HTTPS. Passwords shall be stored as bcrypt hashes (cost factor 12). JWTs shall expire after 7 days. Medical documents shall only be accessible via 15-minute pre-signed URLs.
- Data Isolation: Every database query for journal entries, meals, and documents shall be filtered by the authenticated user's ID, preventing any cross-user data access.
- Offline Capability: Core content, including saved meal plans and educational resources, shall remain accessible when internet connectivity is unavailable through service worker caching.
- Scalability: The cloud-based backend shall support scaling to accommodate a growing user base without architectural changes.
- Cultural Relevance: All AI-generated meal recommendations shall incorporate locally available Ugandan foods.

4.4 Implementation

4.4.1 User Registration and Onboarding

New users are guided through a structured onboarding flow before reaching the registration screen. The flow begins with a branded splash screen, followed by a terms and conditions acceptance screen, and a brief onboarding screen that introduces the app's key features before registration. The registration form is split into two steps to reduce cognitive load. Step one captures name, age, height, weight, email, and password. Step two captures the medical profile: cancer stage (Early Stage I-II or Advanced Stage III-IV), coexisting conditions with sub-type specification, and current treatment stages. After successful registration, the backend creates a User document in MongoDB, hashes the password automatically via the pre-save hook, signs a JWT, and returns the token alongside the full profile to the frontend.

4.4.2 AI Meal Plan Generation

When the Dashboard Home page mounts, it calls the generateMealPlan function in the frontend services layer, which posts the full UserProfile to the /api/ai/meal-plan endpoint. The backend calculates the patient's BMI from the stored height and weight, builds a structured prompt incorporating the patient's cancer stage, treatment type, coexisting conditions, and BMI, and sends this to the NutriCan ML Model with JSON output mode enabled. The model returns a weekPlan array of seven daily meal objects. The backend validates that exactly seven days are present before returning the response. Each meal name is then passed through a food image mapping function on the frontend, which matches the meal name against a dictionary of approximately 70 Ugandan food keywords to retrieve an appropriate food photograph for display.

4.4.3 Food Safety Checker

The food safety checker accepts a food name entered by the patient and posts it alongside the full UserProfile to the /api/ai/food-safety endpoint. The ML Model analyses the food in the context of the patient's specific diagnosis and treatment, and returns a structured response containing a status (Safe, Limit, or Avoid) and a plain-language reason. The backend validates that the returned status is one of the three permitted values before passing it to the frontend. The result is displayed to the patient with colour coding: green for Safe, yellow for Limit, and red for Avoid.

4.4.4 Health Journal and Nutrient Tracker

The Tracker page displays two integrated tools. The health journal section renders a Recharts ComposedChart visualizing weight and energy level trends across the patient's last 30 journal entries. Patients can add new entries by submitting a form with their current weight, energy level, blood pressure, and notes. The nutrient tracker section displays a running log of meals and their nutritional data. When a patient logs a new meal by name, the system calls the /api/ai/nutrient-info endpoint, which returns AI-estimated calorie, sugar, and salt values. These are stored in the Meal collection and displayed as a cumulative daily summary.

4.4.5 Live AI Doctor Consultation

The Live page provides a chat-based interface where patients interact with an AI doctor persona. Before the first message is sent, the system builds a comprehensive health report from the patient's profile and includes it as system context in the API request. Each chat message is posted to the /api/ai/doctor-chat endpoint along with the full conversation history and the selected doctor's persona details. Unlike other AI endpoints, the doctor chat endpoint uses a multi-turn message structure and returns a plain text reply rather than JSON, with a maximum response length set to keep answers concise and easy to read. **4.4.6 Medical Document Upload**

Patients can upload PDF medical documents through the Profile page. The file is sent as multipart form data to the /api/documents/upload endpoint. The backend uses multer with in-memory storage to buffer the file, validates that it is a PDF and does not exceed 10MB, then streams the buffer directly to DigitalOcean Spaces using the AWS SDK v3. The file is stored under a path structured as users/{userId}/documents/{timestamp}-{filename} with private access control. A Document record is created in MongoDB with the storage key and file metadata. When documents are listed via GET /api/documents, a fresh 15-minute pre-signed URL is generated for each document, allowing the patient to securely download their files.

4.4.7 Security Implementation

All authenticated API routes are protected by the requireAuth middleware, which reads the Bearer token from the Authorization header, verifies it using the JWT secret, and loads the corresponding user document from MongoDB on every request. This ensures that even a valid token for a deleted account is rejected. Passwords are hashed with bcrypt at a cost factor of 12 and the hash field is stripped from all API responses through a Mongoose toJSON transform. In production, the CORS policy restricts API access to explicitly listed origins. All profile update requests use an explicit field whitelist on the backend to prevent mass-assignment attacks on sensitive fields such as email or the password hash.

4.5 System Testing Results

Testing was conducted in accordance with the testing plan described in Chapter Three. The following table summarizes the outcomes of the key testing scenarios:

Test Type	**Test Scenario**	**Result**
Functional Testing	User registration, login, profile setup	All inputs produced expected outputs. Navigation between screens worked correctly.
Functional Testing	Dietary recommendation generation	System generated meal plans based on patient cancer stage, treatment type and underlying condition.

Functional Testing	Traffic light food safety system	Foods were correctly categorized as safe (green), moderate (yellow), or avoid (red).
Usability Testing	Ease of navigation assessed by UCI staff	3 out of 3 testers rated navigation as intuitive. Minor label adjustments were made.
Usability Testing	Clarity of dietary recommendations	Recommendations using local food names (posho, matooke, beans) were rated as highly understandable.
Performance Testing	App load time on Android devices	Average load time: 2.3 seconds. Response time for recommendation generation: under 3 seconds.
Compatibility Testing	Android versions tested (8.0–14.0)	App functioned correctly across all tested Android versions.

4.6 Work Plan

The following table presents the actual work plan followed during the project, showing the tasks completed across each week of the development period:

Week	**Period**	**Task**	**Description**
Week 1	Sept 15 – 22, 2025	& Problem Identification Background Review	Review literature, identify nutrition gaps, and define the problem

Week 2	Oct 1- 16, 2025	Requirement Gathering	Conduct questionnaires, interviews, observations, document reviews
Week 3	Oct 20 -Nov 3, 2025	Data Analysis	Analyze quantitative and qualitative results to define system requirements
Week 4	Nov 10 -14, 2025	System Planning	Define system scope, draft objectives, identify modules
Week 5	Nov 14 -Nov 20,2025	UI/UX Design	Create wireframes, user flows, Android Studio prototype
BREAK	Dec 21-Jan 5,2026	Christmas Break	____
Week 6	Jan 6- 12, 2026	System Architecture & Database Design	Develop use case diagrams, ERDs, and define data structures

Week 7	Jan 13-19, 2026	Prototype Development Frontend	Build Next.js frontend, Tailwind styling, animations
Week 8	Jan 20-26, 2026	Backend/API Development	Develop Node.js API, set up Python scripts, integrate Firestore
Week 9	Jan 27- Feb 2, 2026	Data Integration	Integrate Kaggle WFP & UN datasets, implement nutrition logic
Week 10	Feb 3-9, 2026	Mobile App Prototype	Develop Android Studio app screens and navigation
Week 11	Feb 10-16, 2026	System Testing Using Dummy Data	Functional, usability, performance, compatibility testing
Week 12	Feb 17-23, 2026	User Validation	Collect feedback from nutritionists & ICT team
Week 13	Feb 24-28, 2026	Refinement & Debugging	Fix issues, optimize performance, refine UI

Week 14	Mar 1-2, 2026	Final Report Writing & Presentation Preparation	Draft, edit, and finalize Chapters and prepare slides

4.7 Budget

The following table presents the budget incurred during the project:

Item	**Description**	**Unit cost**	**Quantity**	**Total (UGX)**
Airtime	For interviews carried out over the phone	2500	2	5,000
Transport	Travel to and fro Uganda Cancer Institute for three group members	42,000	2	84,000
GooglePlay Developer Account	Required to publish on play store	94,500	1	94,500
Firebase Hosting & services	Cloud hosting	100,000	3 months	300,000

Domain name	Website domain	45,000	1 year	45,000
Grand Total				**528,500 UGX**

CHAPTER 5: SYSTEM EVALUATION AND FUTURE DIRECTIONS

5.1 Evaluation of the System

The NutriCan system was evaluated against its four specific objectives.

Objective 1 – To assess factors contributing to poor nutrition management: Data collection at UCI identified key challenges including:

- Shortage of oncology nutritionists
- Generalized dietary advice instead of personalized guidance
- Low patient awareness about the role of nutrition in cervical cancer recovery

These findings informed the design and features of the NutriCan system.

Objective 2 – To design a personalized nutrition recommendation model: A machine learning-based recommendation engine was developed to generate nutrition guidance using:

- Cancer stage and treatment type
- Active symptoms and coexisting health conditions

UCI nutritionists validated the recommendations as clinically appropriate.

Objective 3 – To develop a mobile application using locally available foods: The NutriCan Android application was developed with:

- Ugandan staple foods and local meals
- Nutrition recommendations tailored to local dietary practices

Patients responded positively to the cultural relevance of the recommendations.

Objective 4 – To test and evaluate the system: System evaluation included:

- Functional, usability, performance, and compatibility testing
- Validation by UCI healthcare professionals and patients confirming usefulness, accuracy, and ease of use.

5.2 Limitations of the Technology

- The current version of NutriCan focuses exclusively on cervical cancer and cannot directly be applied to other cancer types without further data collection and model retraining.

- Full system functionality, including personalized recommendations and live consultation, requires active internet connectivity. Patients in areas with poor network coverage will have a degraded experience.
- The recommendation engine is only as accurate as the patient data entered. Inaccurate or incomplete health profiles may lead to less appropriate recommendations.
- The system is currently available only in English, which may limit accessibility for patients who are not proficient in the language.
- The machine learning model was trained on a relatively small dataset due to the scarcity of local cancer nutrition data. Its accuracy will improve as more patient data is collected over time.
- The study duration did not allow for long-term evaluation of patient nutrition outcomes, which remains a subject for future research.

5.3 Problems Encountered

Several challenges were encountered during the development and evaluation of the NutriCan system:

1. Integration of Real-Time Audio: Implementing the NutrCan Live feature posed significant technical challenges, particularly around audio encoding, latency management, and WebSocket stability. Multiple iterations were required before reliable real-time communication was achieved. PCM audio encoding was ultimately selected over compressed formats to balance quality and processing speed.
2. Ugandan Food Data Availability: A comprehensive, structured database of Ugandan foods with nutritional profiles was not readily available. The team manually compiled and verified nutritional data for commonly consumed Ugandan foods by cross-referencing local dietary guidance materials and clinical nutrition resources, which was time-intensive. This data was then incorporated into the custom ML model's training dataset.

3. Participant Availability at UCI: Scheduling data collection sessions at UCI was challenging due to the busy nature of the cancer treatment environment. Several planned sessions had to be rescheduled, which compressed the data collection timeline.
4. Technical Complexity of Custom ML Model: Shifting from reliance on external APIs to a custom ML model architecture mid-project required significant redevelopment effort. While the custom model ultimately provided greater control over recommendation logic and patient data privacy, the transition extended the development timeline.

5.4 Recommendations and Future Research

Based on the findings and limitations of this study, the following recommendations are made for future development and research:

1. Expansion to Other Cancer Types: Future versions of NutriCan should incorporate nutritional guidelines for other common cancers in Uganda, including breast cancer, prostate cancer, and Kaposi's sarcoma, to serve a broader patient population at UCI.
2. Integration with Hospital Information Systems: NutriCan should be integrated with UCI's existing patient records system (EAFYA) to allow automatic population of patient profiles and enable nutritionists to remotely monitor patient dietary adherence as part of routine clinical care.
3. Multilingual Support: Incorporating Luganda and other local Ugandan languages would significantly improve accessibility for patients with low English literacy and align with the goal of cultural relevance.
4. AI-Powered Predictive Analytics: Future versions could incorporate predictive analytics to identify patients at high risk of severe malnutrition based on their treatment protocol and symptom trajectory, enabling proactive nutritional intervention.
5. Longitudinal Outcome Studies: Future researchers should conduct long-term studies tracking patient nutrition outcomes, treatment completion rates, and quality of life among NutriCan users compared to non-users to generate robust evidence on the system's clinical impact.
6. Offline-First Architecture Enhancement: Further investment in offline functionality would improve the system's utility for patients in low-connectivity settings and ensure equity of access across Uganda.
7. Community Health Worker Integration: NutriCan could be adapted for use by community health workers supporting cancer patients in their homes, extending the reach of the system beyond the hospital setting.

5.5 Conclusion

This project successfully designed, developed and evaluated NutriCan, a mobile-based personalized nutrition system tailored for cervical cancer patients at the Uganda Cancer Institute. The study responded to a significant and well-documented gap in Uganda's cancer care ecosystem, where the majority of cervical cancer patients experience malnutrition due to limited access to specialized oncology nutritionists and personalized dietary guidance.

By leveraging Uganda's high mobile phone penetration and employing a user-centered Prototype Model of development, NutriCan delivers evidence-based, culturally relevant, and affordable dietary recommendations. The system integrates medical nutrition knowledge with accessible mobile technologies to support patients throughout their treatment journey, using familiar Ugandan foods such as posho, matooke, cassava, beans, and sweet potatoes. It empowers patients with symptom-based dietary tips, personalized meal planning, and offline-first capabilities suitable for low-connectivity environments.

Testing and validation confirmed that NutriCan is usable, clinically appropriate and contextually relevant for cervical cancer patients and healthcare professionals at UCI. The project is expected to generate meaningful insights into the role of mobile health interventions in improving cancer nutrition outcomes within African healthcare contexts. Ultimately, NutriCan lays the groundwork for a scalable, sustainable and continually evolving digital health tool that future researchers and practitioners can build upon to further strengthen cancer care delivery in Uganda and beyond.

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APPENDICES

Appendix A: **Group Member Contributions (Application Development)**

1. MUSIIMENTA DAPHINELIZ

- Designed the User Interface (UI) and overall user experience of the NutriCan application, ensuring the system is simple and accessible for cancer patients.
- Developed the splash screen and onboarding screens that introduce users to the application and guide them through the platform.
- Implemented the user authentication system, including sign-up and login features using Firebase Authentication.
- Created the user profile setup interface, allowing patients to enter important medical information such as cancer type, stage, and other health conditions.
- Implemented dynamic form logic that adapts based on selected health conditions (e.g., asking additional questions when a user selects diabetes).
- Managed the user profile database storage using Firebase Firestore to securely store patient information used by the system.

2. NATABO DORCUS KWAGALA

- Developed the AI-powered core features of the NutriCan application responsible for generating personalized nutrition guidance.
- Implemented the Personalized Meal Planner, which generates meal plans based on user medical profiles such as cancer type, BMI, and other conditions.
- Integrated machine learning / generative AI prompts to ensure the system recommends Ugandan local foods appropriate for cancer patients.
- Developed the Symptom-Based Nutrition Tips module, which provides dietary advice for symptoms such as nausea or appetite loss during chemotherapy.

- Implemented the Food Safety Checker, which analyzes whether specific foods are safe, should be limited, or avoided based on the patient's immune status.
- Designed the logic for processing AI responses in structured JSON format, enabling the application to display recommendations clearly on the dashboard.

- Implemented local caching mechanisms to reduce repeated data fetching and improve application performance.

3. NINSIIMA WHITNEY

- Developed the nutrition and health tracking system, allowing users to log meals and monitor their dietary intake.
- Implemented data visualization features using charts to help users track calories and nutrition trends over time.
- Built the AI-based nutrient estimation function that calculates calories for local Ugandan foods not available in standard nutrition databases.
- Implemented the premium subscription system, including simulated mobile money payment integration (MTN and Airtel).
- Developed the business logic that upgrades users to premium accounts, unlocking advanced system features.
- Implemented the NutriCan Live feature, enabling real-time voice interaction with an AI-based nutrition assistant through WebSocket and audio streaming technologies.
- Integrated the audio input and playback system using web audio technologies to simulate a live conversation with a nutrition expert.

Appendix B: **Questionnaires**

The structured questionnaires that will be used for data collection are available at the links below: Doctor questionnaire:

https://docs.google.com/forms/d/e/1FAIpQLSfIe-GE4hsdBk2xXqtpP7gaMILNKvvPQHYOXMLV0kJSjxmdEA/viewform?usp=header

Patient questionnaire:

https://docs.google.com/forms/d/e/1FAIpQLSeSeSgyPiLLyHJlYfEjzjSc-5Q2L3fLHWoz1Y4RJxiJjiDz7Q/viewform?usp=header

Appendix C: **Sample images**

This appendix presents the key interface designs of the NutriCan application. Figure 4 displays the authentication screens, Figure 5 illustrates the health profile setup, and Figure 6 shows the home page with all available features.

These images show the NutriCan prototype screens and interface, supporting the Prototype in Chapter 3 under subsection 3.5

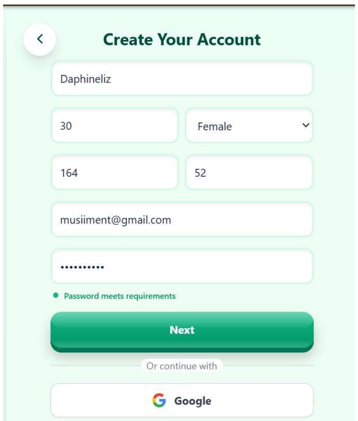

Figure 4 Authentication

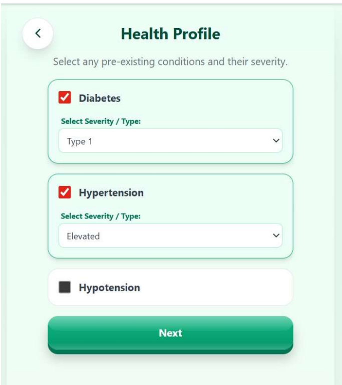

Figure 5 Health Profile

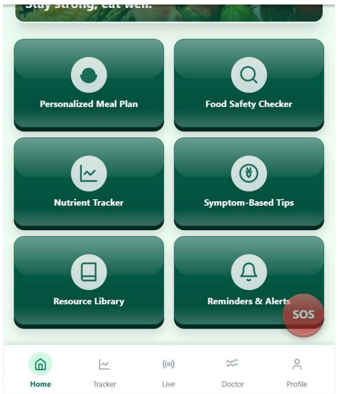

Figure 6 Home page showing all features

Appendix D: **Developed Application Screens**

This appendix presents the actual implemented interfaces of the NutriCan application after development. Figure 7 and 8 show the fully functional authentication module, including user registration, the completed medical profile setup and login with validation. Figure 9 and 10 display the main dashboard (home page), highlighting all integrated features such as personalized meal plan, nutrient tracker, food safety checker, symptom based tips, upload of medical documents, doctor connect, resource library and the NutriCan chat. These screens demonstrate the transition from prototype design to a working system with real functionality and user interaction.

Figure 7 Putting personal details to create a new account

Figure 8 Inputting medical profile details

Figure 9 Home page before scrolling

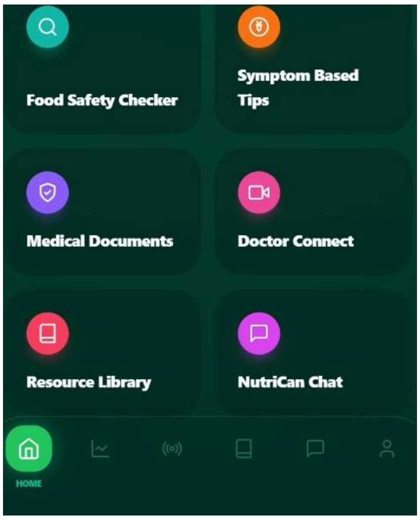

Figure 10 Home page after scrolling

Figure 11 Personalized meal plan