APPLIED INFORMATION TECHNOLOGY AND COMPUTER SCIENCE
e-ISSN: 2773-5141

AITCS

Vol. 6 No. 2 (2025) 1000-1019
https://publisher.uthm.edu.my/periodicals/index.php/aitcs

Pregnancy Management System (MaternityMate)

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DOI: https://doi.org/10.30880/aitcs.2025.06.02.054

Article Info

Received: 15 June 2025
Accepted: 20 November 2025
Available online: 30 November 2025

Keywords

Pregnancy, Digital, Pink Book, Medical Record

Abstract

The Pregnancy Management System (MaternityMate) is an online platform designed to streamline and enhance the management of health information for pregnant women, including medical history, baby development and appointments. It addresses inefficiencies in the current manual system, including inconsistent procedures, delayed record-keeping, and limited appointment flexibility. The MaternityMate utilising the Prototyping Model which encompasses six phases: requirement gathering and analysis, design, prototyping, user evaluation and refinement, final product development, and testing and implementation. Every stage was modified to manage confidential data while addressing Klinik Kesihatan Batu 14 Hulu Langat's specific requirements. The system integrates features such as appointment scheduling, health monitoring, aiming to enhance communication between healthcare providers and patients, simplify administrative tasks, and improve data accuracy. The implementation of this system may help the clinic enhance maternal healthcare services by resolving ineffectiveness in the current manual approach, reducing delays and create a more effective procedure for doctors and nurses.

1. Introduction

The MaternityMate pregnancy management system aims to digitalize and streamline the current paper-based processes used at Klinik Kesihatan Batu 14 Hulu Langat, where health data and appointments for pregnant women are recorded manually in the traditional "pink book" and a separate appointment log. This manual system, which relies on nurses and doctors to manage and update records, often leads to inefficiencies, limited rescheduling options, and communication issues. MaternityMate addresses these challenges by enabling patients, nurses, doctors, and administrators to manage appointments and records through an online platform, improving accessibility, consistency, and overall workflow. Appointments are arranged based on the patient's trimester and risk level, which is identified by a color-coded system (Red, Yellow, Green, or White). These color codes determines the level of care required and how frequently appointments should occur. Patients have to contact the clinic directly to reschedule, and nurses manually review and update the schedule. The MaternityMate system aims to address these challenges by digitalizing and simplifying pregnancy management processes. Patients can request reschedule to their appointments using MaternityMate's online platform. The system simplifies appointment procedures across clinics, ensuring a consistent and efficient workflow regardless of staff availability. The following papers were organized into several sections which in Section 2 will discuss the related works of the development system. Section 3 then will describe the methodology used for the Pregnancy Management System (MaternityMate) followed by Section 4 that will explain the results and discuss the system. Finally, Section 5 will consist of conclusions on the overall work.

2. Related Work

This section explains the digital pregnancy management system and study of existing system.

2.1 Digital Pregnancy Management System

The healthcare sector plays a crucial role in ensuring health promotion, maintenance, and restoration through a comprehensive range of systems and services. Maternal and prenatal care are particularly important in the healthcare system for promoting the health of expectant mother and their growing children. The significant impact of prenatal care utilization on maternal health, observing that consistent and accessible prenatal care not only enhances the health of newborns but also positively influences health behaviors among expectant mothers. Early and consistent prenatal care may be helpful in identifying and managing common pregnancy-related concerns such as gestational diabetes, high blood pressure, and preeclampsia, eventually helping to lower mother and newborn death rates [1].

In addition, implementing reminder and notification systems in pregnancy management has shown major potential in improving maternal and newborn health outcomes. Studies have shown that mobile phone reminders significantly improve attendance for postnatal care (PNC). SMS and voice call reminders sent 48 and 24 hours before appointments increased PNC compliance compared to usual care notification given at discharge [2].

The development of Pregnancy Management System will also promote Sustainable Development Goal (SDG) 3: Good Health and Well-being, particularly its targets to reduce deaths from pregnancy and ensure universal access to quality maternal healthcare. Klinik Kesihatan Batu 14 directly contributes to the achievement of SDG 3 by improving maternal and newborn health outcomes in the community through better prenatal care delivery and more dependable and accessible healthcare.

2.2 Study of Existing Related Systems

A study of the existing system has been conducted on three systems. The three existing related systems that have been chosen are Happy Preggie [3], Pantai Hospital [4] and Babycenter [5]. Then, these three systems were compared with Pregnancy Management System (MaternityMate). Table 1 shows the comparison between the existing related systems and the developed system.

Happy Preggie is an online platform that provides expectant mothers with a comprehensive and specific pregnancy experience which focuses on offering access helpful tips, track pregnancy progress includes a week-by-week activity tracker and manage appointments. Additionally, the system offers wellness and health guidance or advice covering everything from diet to exercise. Users can track weekly changes in the mother's body and fetal development at the same time they are able to save any medical records and documents. The system even allows the patient to book appointments with healthcare providers directly from other clinics and hospitals.

Pantai Hospital provided a variety of general and specialized medical services. The system offers general healthcare services such as medical consultations, diagnostics, and treatments in several specialties, including cardiology, oncology, orthopedics, pediatrics, and more. In addition to scheduling virtual consultations, patients can also access or view the medical facilities of Pantai hospital and make appointments with specialists. The hospital's website also provides a resource hub which offers information about their services, health packages and patient care options. In addition, the platform comes with features that let patients manage payments and insurance claims.

Babycenter (Babycenter,2025) is a website that supports parents and parents-to-be throughout pregnancy, parenting, and child development. Founded in 1997 and currently owned by Ziff Davis, Inc., BabyCenter has developed into a global platform, reaching millions of users each month. The website contains plenty of information that has been assessed by medical professionals, tools and community. In addition, BabyCenter offers various tools such as due date calculators, baby name finders, kick counters, and pregnancy weight gain trackers. Other than that, this website has a courses page that offers online classes to help parents with common parenting challenges. It discusses topics including solutions for sleep, newborn safety, and assisting babies in reaching developmental milestones.

Table 1 *Comparison between the existing system and developed system*

System/ Specification	Happy Preggie [3]	Pantai Hospital [4]	Babycenter [5]	MaternityMate (Developed System)
Login and Registration	Available in the system	Not Available in the system	Available	Available

Table 1(cont.) *Comparison between the existing system and developed system*

Manage Health Records	Not Available	Not Accessible Digitally (Available in Manual Form)	Not Available	Accessible digitally for tracking health information
Manage Pregnancy Progress Tracking	Provided in the system but not related with kicking counter	Not Provided in the system	Provided in the system	Available with tracking metrics
Appointment Management	Available but only send requests to other clinics not directly	Available but only manually by phone calls	Not available	Available with automated system
Manage Care Collaboration Record	Not Accessible Digitally (Available in Manual Form)	Not Accessible Digitally (Available in Manual Form)	Not Available	Available digitally
Reporting and Analytics	Reporting handled manually	Reporting handled manually	Reporting handled manually	Available
Notification and Reminder	Not Available in the system	Reminders provided manually	Not Available in the system	Automated notifications for appointment
Platform Type	Web-based	Web-based	Web-based	Web-based

3. Methodology

The methodology that is adopted for this Pregnancy Management System (MaternityMate) is the Prototyping model. The Prototyping methodology is a software development approach which focuses on iterative design and user feedback for developing systems that fulfil user needs efficiently. Prototyping model involves a rapid design step, where developers immediately design the initial version of the software after gathering requirements [6]. This stage enables us to visualise the system at an early stage of development, resulting in improved communication and cooperation between users and developers.

There are six steps in this model: requirement gathering and analysis, design, prototyping, user evaluation and refinement, final product development, and finally, testing and implementation. The phases implemented for the MaternityMate Pregnancy Management System are inspired by the process outlined in the Prototyping methodology as described by the study on Waterfall Methodology, Prototyping, and Agile Development [7]. The phases have been adjusted and modified to meet the specific needs and specifications of this project while still following the fundamental structure of the prototyping methodology. As shown in Table 2, each phase has its own task and output.

Table 2 *Activities in the system workflow*

Phase	Task/Activities	Output
Requirement Gathering and Analysis	• Identify the existing system • Determine the user requirements with stakeholder • Collecting data by using Google Form • Determine the system requirement • Review with stakeholder	• Gantt Chart • Functional and Non-Functional Requirement • Use case diagram, Sequence Diagram, Class Diagram, Activity Diagram and Requirement Definition
Design	• Determine system architecture • Design User interface of the system • Design the database of the proposed system	• Architecture Diagram • User Interface • Schema Table
Prototyping	• Develop all the prototypes	• Prototype 1 • Prototype 2 • Prototype 3

Table 2(cont.) *Activities in the system workflow*

User Evaluation and Refinement	• Collecting feedback from user • Review feedback	• Evaluation from user feedback
Final Product Development	• Develop final version of the system	• A fully functional system
Testing and Implementation	• Create test case list • Test the system functionality • Fixed bug and error	• Test Cases • Requirement Traceability Matrix

3.1 System Requirements Analysis

In this section, use case specification, use case diagram, requirement definition, class diagram, activity diagram as well as sequence diagram will be further discussed.

3.1.1 Use Case Diagram

Fig. 1 shows use case diagram for the Pregnancy Management system that represents the overall process. In this system, there are 4 users, which are Patient, Doctor, Nurse and Admin.

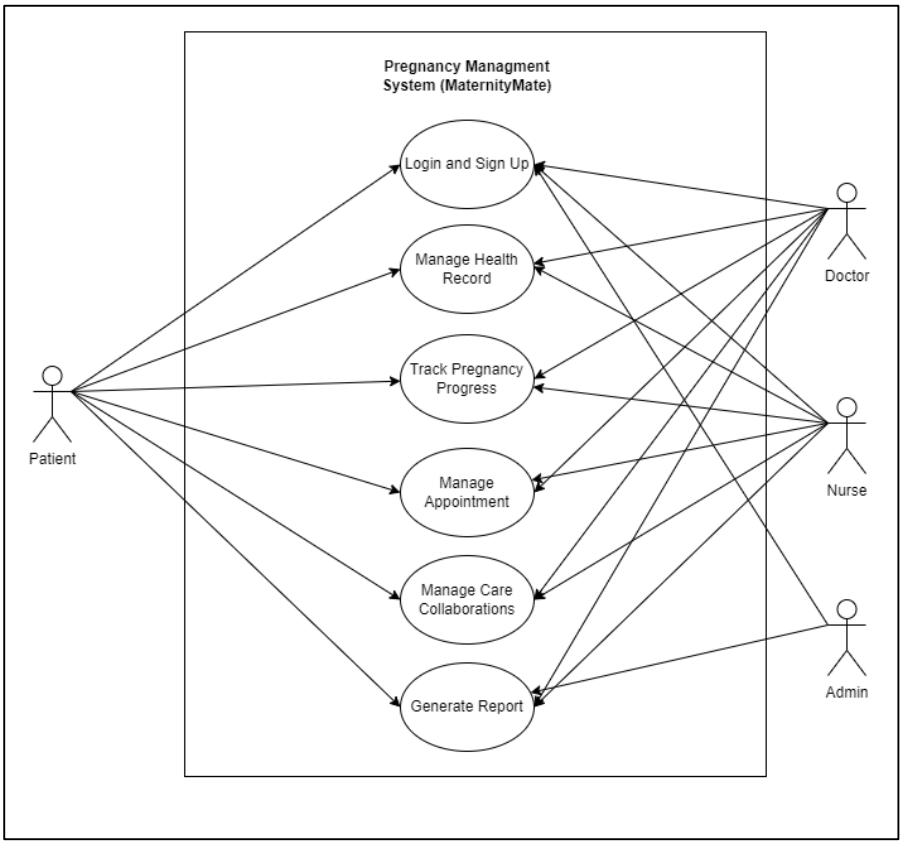

Fig. 1 *Use Case Diagram of the developed system*

The use case specification and associated activity and sequence diagram for each use case is attached in the Appendix.

3.1.2 Class Diagram

The class diagram is attached to Fig. 1 in Appendix

3.1.3 Requirement Definition

The requirement definition provides and tracks all the system requirements of the Pregnancy Management System (MaternityMate). Table 3 shows the requirements definition.

Table 3 *Requirement Definition*

Requirements	Descriptions
MaternityMate_REQ_100	**Login and Sign-Up**
REQ_101	User must select a role (Patient, Nurse, Doctor, Admin) before logging in.
REQ_102	User must enter a valid email and password to log in.
REQ_103	System redirects to role-specific dashboard after successful login.
REQ_104	System displays an error message for invalid credentials.
REQ_105	System redisplays login form for invalid login attempts.
REQ_106	System displays a password reset page if the user forgets their password.
REQ_107	System validates the registered email during password reset.
REQ_108	System allows password reset if email matches.
REQ_109	User can log in with the new password after reset.
REQ_110	System redirects to a role-specific sign-up form if the user has no account.
REQ_111	User must fill in role-specific fields (e.g., LMP for Patients, License No. for Doctors/Nurses).
REQ_112	System validates the sign-up form and shows errors for missing/invalid fields.
REQ_113	System sends a confirmation email after sign-up (pending Admin approval).
REQ_114	Admin/Nurse must approve self-registered accounts.
REQ_115	Admin/Nurse can create, update, or delete user accounts manually.
MaternityMate _REQ_200	**Manage Health Record**
REQ_201	Patient can only view their health records.
REQ_202	Doctors/Nurses can add, update and view all sections (Patient Info, Consent, Health Monitoring, Postnatal Care).
REQ_203	System validates and saves updates by Doctors/Nurses
REQ_204	The system must display existing data during updates or retrieval.
REQ_205	System must validate the data updated by user and save the updates successfully.
REQ_206	System shows error messages for missing/invalid data during submissions.
MaternityMate _REQ_300	**Track Pregnancy Progress**
REQ_301	System displays a pregnancy tracking dashboard.
REQ_302	Patients can log baby kicks.
REQ_303	System tracks and stores kick logs with timestamps.
REQ_304	System displays graphical summaries (Today/7 Days/1 Month).
REQ_305	Doctors/Nurses can view patient kick logs.
REQ_306	Patients can track due dates and pregnancy progress via dashboard.
REQ_307	System must send alerts if fewer than 10 kicks are logged within 12 hours.
REQ_308	System must allow Patients to manually add or edit logs, specifying the date, start time, and kick count.
MaternityMate _REQ_400	**Manage Appointment**
REQ_401	System calculates and predicts appointment frequency based on trimester and risk assessment, displaying it on the dashboard.
REQ_402	Nurses can schedule appointments for patients.
REQ_403	The system notifies patients when a new appointment is added.
REQ_404	Patients can input availability preferences for rescheduling (preferred days/times and reasons).
REQ_405	Nurses must review and may approve/reject/modify appointments reschedule requests.
REQ_406	The system suggests appointments based on pregnancy status/predefined frequency.
REQ_407	Nurses update appointment statuses (e.g., confirmed/rescheduled) and notify patients of changes.
MaternityMate _REQ_500	**Manage Care Collaboration**
REQ_501	System must allow patients to view all sections.
REQ_502	Doctors and Nurses must be able to update care collaboration sections, including “Examination and Procedure”, “Risk Assessment and Checklist” “Postnatal Collaboration” and "Health Education and Feedback”.
REQ_503	System must validate data entered by Doctor or Nurse and save updates successfully.

Table 3(cont.) *Requirement Definition*

REQ_504	System must highlight incomplete fields and display an error message for missing data during submissions.
MaternityMate _REQ_600	**Generate Report**
REQ_601	System displays Report interface.
REQ_602	User must be able to access and print report.
REQ_603	Doctors/Nurses must select a patient before generating reports.
REQ_604	System must display a success message for successful report generation.
REQ_605	Patients can view and generate simplified summaries of their own records.
REQ_606	Admins can generate analytics for all accounts

3.2 Design

This section will discuss the system architecture and database design for the pregnancy management system.

3.2.1 System Architecture

The architecture used in the system is three tier architecture system. The implementation of three-tier architecture in web applications, where the system is divided into three layers: the presentation layer (web server), the business logic layer (application server), and the data layer (database) [8]. In the pregnancy management system, the web server layer handles user interaction like patient registration or scheduling appointments. While in the application server it interacts with the database layer to retrieve, process or store information. For example, it validates user input to ensure a valid patient ID or avoid appointment conflicts. The database will store and retrieve all system data. For instance, when a doctor logs in, the system will be able to fetch the health record of patients. The three tier architecture diagram is shown in Fig. 14 in Appendix.

3.2.2 Schema Table

Some of schema data that are implemented in the system have been listed in table 4.

Table 4 *Schema Table*

Table Name	Details
Users	(id, name, email, password, phone, address, date_of_birth, identification_number, role_id, created_at, is_approved, full_name, email_verified, admin_verified, verification_token, reset_token, reset_token_expiry, created_by)
Patients	(id, user_id, last_menstrual_date)
Doctors	(id, user_id, license_number)
Nurses	(id, user_id, nurse_license_number)
Nurse_Daily_Roles	(id, nurse_id, role, room_number, date, shift)
Mother_Information	(id, patient_id, full_name, registration_number, id_card_number, date_of_birth, age, clinic_phone_number, jkn_serial_number, antenatal_color_code, ethnic_group, nationality, education_level, occupation, home_address_1, home_address_2, phone_residential, phone_mobile, phone_office, nurse_ym, workplace_address, estimated_due_date, revised_due_date, gravida, para, husband_name, husband_id_card_number, husband_occupation, husband_workplace_address, husband_phone_residential, husband_phone_mobile, postnatal_address_1, postnatal_address_2, postnatal_address_3, risk_factors, has_past_pregnancy, requires_refusal_form, created_at)
Current_Pregnancy_ Examination_Details	(id, patient_id, monitoring_datetime, urine_protein, urine_sugar, hb, weight, bp, pulse, edema, gestational_age, fundal_height, presentation, fetal_heart, fetal_movement, issues_identified, management_and_treatment, next_appointment_date, examiner_name, created_at)
Blood_Collection_Consent	(id, patient_id, mother_fullname, mother_nric, consent_given, test_blood_group_rhesus, test_hemoglobin, test_diabetes_screening, test_syphilis, test_hiv, test_hepatitis_b, test_malaria, test_others, other_tests, consent_name, consent_date, witness_name, witness_nric, tests, mother_signature)
Treatment_Refusal_Forms	(id, patient_id, file_name, file_path, upload_date)

Table 4 (cont.) *Schema Table*

Blood_Pressure_Monitoring	(id, patient_id, monitoring_datetime, symptoms, blood_pressure, weight, fetal_heart_rate, urine_protein, created_at)
Preeclampsia_Monitoring	(id, patient_id, monitoring_datetime, poa_pog, blood_pressure, proteinuria, urea, creatinine, uric_acid, hemoglobin, platelets, ast_alt, examiner_name, created_at, updated_at)
Routine_Health_Examinations	(id, patient_id, examination_type, examination_date, general_pink_pallor, general_jaundice, bp_systolic, bp_diastolic, pulse_rhythm, neck_swelling, cvs_clubbing, cvs_jvp_raised, cvs_apex_beat_displaced, cvs_heart_sounds_normal, breast_normal, lungs_normal, abdomen_sfh, abdomen_fhr, abdomen_normal, lowers_limbs_oedema, lowers_limbs_calf_tenderness, notes, medical_officer_position, medical_officer_name, medical_officer_confirm, created_at, updated_at)
Postnatal_Home_Visits	(id, patient_id, visit_date, body_temperature, blood_pressure, pulse, respiration, breasts, fundal_height, lochia_odour, lochia_rubra, lochia_serosa, lochia_alba, pad_chart, perineum_episiotomy, surgical_wound, pu_status, bo_status, mobility, maternal_depression_notes, dvt_symptoms, chest_pain, difficulty_breathing, leg_pain_swelling, leg_redness, calf_tenderness, staff_name_position, created_at)
Discharge_Notes	(id, patient_id, file_name, file_path, period, uploaded_at)
Birth_Details	(id, patient_id, place_of_birth, attended_by, birth_datetime, injection_type, placenta, placenta_weight, spontaneous_delivery, instrumental_delivery, instrumental_indication, caesarean_type, caesarean_method, caesarean_indication, complications_pph, complications_retained_placenta, complications_perineal_tear, complications_other, baby_handed, baby_handed_reason, skin_to_skin, skin_to_skin_reason, birth_weight, gender, length_cm, head_circumference_cm, chest_circumference_cm, baby_condition, apgar_score_1min, apgar_score_5min, congenital_abnormalities, congenital_description, vit_k_date, vit_k_given_by, bcg_date, bcg_given_by, bcg_batch_no, bcg_expiry, hepB_date, hepB_given_by, hepB_batch_no, hepB_expiry, g6pd_date, hypothyroid_date, created_at)
Thromboprophylaxis_Schedule	(id, patient_id, medication_name, dosage, created_at)
Thromboprophylaxis_Injections	(id, schedule_id, injection_no, injection_date, injection_time, administered_by)
Breastfeeding_Checklists	(id, patient_id, visit_date, postnatal_day, visit_number, examiner_name, examiner_position, remarks, created_at)
Breastfeeding_Risk_Factors	(id, description, category)
Visit_Breastfeeding_Conditions	(id, breastfeeding_checklist_id, risk_factor_id)
Risk_Factors	(id, description, color_code, is_urgent)
Visit_Color_Checks	(id, visit_id, patient_id, visit_date, gestational_age_weeks, visit_number, week_group, examiner_name, examiner_position, assigned_color, remarks, created_at)
Visit_Risk_Conditions	(id, visit_id, risk_factor_id)
Appointments	(id, patient_id, appointment_date, reason, status, created_by, new_date, new_reason)
Visits	(visit_id, patient_id, visit_date, visit_type, queue_number, nurse1_id, nurse2_id, room_number, checkin_time, checkout_time, created_by, created_at, monitoring_type, status, monitoring_time, next_handler)
Rooms	(id, room_number, status)
Doctor_Assignments	(id, patient_user_id, visit_id, doctor_user_id, reason, assigned_by, assigned_at)
Maternal_Health_ Education_Records	(id, patient_id, topic_category, topic, education_date, staff_name, mother_declaration, signature)
Notifications	(id, user_id, message, is_read, created_at, read_at)
Push_Subscriptions	(id, user_id, endpoint, p256dh, auth, created_at)

4. Result and Discussions

This section will show the outcome of analysis and design for the developed system.

4.1 Implementation

This section will present the design of the system and the implementation of the developed system that was developed using HypertextPreprocessor (PHP) language and MySQL.

4.1.1 Login and Sign Up

Fig. 2 shows the login of the system. Each user may be able to choose each of their respective roles. Users need to input their email and password to log in to the system. Users can create an account by clicking on the label of the sign up at the bottom of screen. Meanwhile Fig. 3 shows if the user forgot their password, they could reset their password using the email and phone number. Fig. 4 displays the self-registration form page where the input fields on the form will change based on the role that is selected

Fig. 5 shows the code segment starts by storing the selected user role (Patient, Doctor, Nurse, Admin). When the login form is submitted, the system first checks if all the fields (role, email, and password) are filled in. If any field is missing, alert messages are shown, an alert prompts the user to select a role, and an error message appears if the email or password field is empty. The system will check if their email is verified if the user account exists, if not, the user will be asked to check their email first and validate their account. After that, it determines whether the administrator has authorised the account or not. If the account is still pending approval, the login is stopped, and the user is redirected back to the login page with a message stating that their account is awaiting admin approval. Once sign in successful, the user will be redirected to the respective dashboard depending on the role.

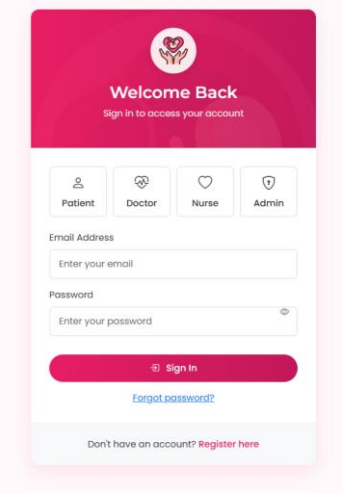

Fig. 2 *Interface of Log In*

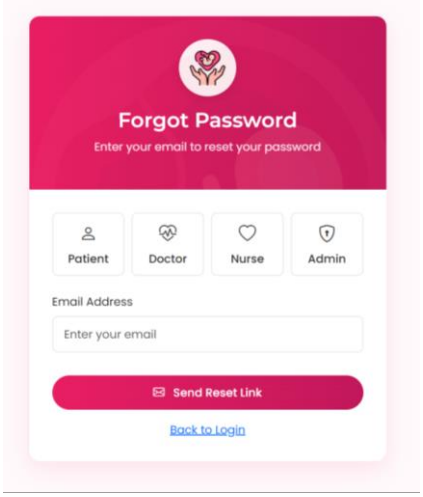

Fig. 3 *Interface of Forgot Password*

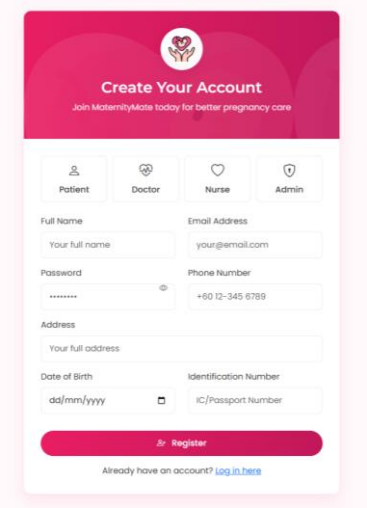

Fig. 4 *Interface Register Account*

```php
$role_id = isset($_POST['role_id']) ? $_POST['role_id'] : ''; // Get the selected role ID

if ($_SERVER['REQUEST_METHOD'] === 'POST' && isset($_POST['submit'])) {
    $email = trim(string: $_POST['email']);
    $password = trim(string: $_POST['password']);

    if (empty($role_id)) {
        echo "<script>alert('Please choose a role first');</script>";
    } elseif (empty($email) || empty($password)) {
        $error = "All fields are required.";
    } else {
        $stmt = $conn->prepare(query: "SELECT id, name, password, is_approved, email_verified FROM users WHERE email = ? AND role_id = ?");
        $stmt->bind_param(types: "si", var: &$email, vars: &$role_id);
        $stmt->execute();
        $stmt->store_result();

        if ($stmt->num_rows > 0) {
            $stmt->bind_result(var: &$id, vars: &$name, $hashed_password, $is_approved, $email_verified);
            $stmt->fetch();

            if (!$email_verified) {
            $_SESSION['error_message'] = "Please verify your email before logging in.";
            header(header: "Location: login.php");
            exit();
            }

            if (!$is_approved) {
                $_SESSION['error_message'] = "Your account is pending admin approval.";
                header(header: "Location: login.php");
                exit();
            }
```

Fig. 5 *Code Segment for Log In*

4.1.2 Manage Health Record

This module allows users to manage patient health records. Doctors and Nurses can add or update records during each visit either through the visit check-in flow as in Fig. 6 or by manually accessing the Health Record Management section from the navigation bar as shown in Fig. 7. The module consists of several sections, including patient information, consent and approval, health monitoring, and post-natal care. Patients can only see their own medical records and they are not allowed to modify them.

The code segment in Fig. 8 shows a part of the system where nurses need to complete a patient's basic information and consent information. Firstly, the code fetches two flags from the mother_information table, whether the patient had past pregnancies and whether they need to fill out a treatment refusal form. These flags determine which sections of the form should be displayed later. Then, by using a helper function the script checks if each form section like basic info, past pregnancy history and other information is completed by counting if entries exist in relevant tables. If the treatment refusal form isn't required, it is marked complete by default.

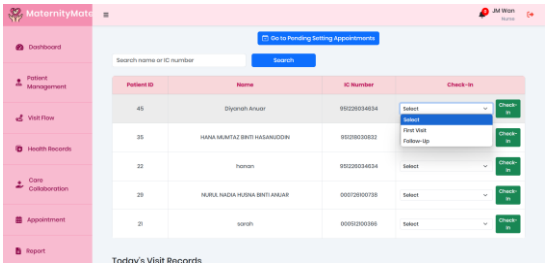

Fig. 6 *Interface of Managing Health Record*

Fig. 7 *Interface of Managing Health Record*

```php
<?php
require_once "../config.php";

if ($_SERVER['REQUEST_METHOD'] === 'POST') {
    $nurse_id = intval(value: $_POST['nurse_id']);
    $role = $_POST['role'];
    $room_number = $_POST['room_number'] ?? null;
    $date = $_POST['date'];
    $shift = $_POST['shift'] ?? 'Morning';

    // Sanitize inputs
    $role = $conn->real_escape_string(string: $role);
    $room_number = $room_number ? $conn->real_escape_string(string: $room_number) : null;
    $shift = $conn->real_escape_string(string: $shift);

    // Check if entry already exists
    $stmt = $conn->prepare(query: "SELECT id FROM nurse_daily_roles WHERE nurse_id = ? AND date = ?");
    $stmt->bind_param(types: "is", var: &$nurse_id, vars: &$date);
    $stmt->execute();
    $stmt->store_result();

    if ($stmt->num_rows > 0) {
        // Update existing record
        $update = $conn->prepare(query: "UPDATE nurse_daily_roles SET role = ?, room_number = ?, shift = ? WHERE nurse_id = ? AND date = ?");
        $update->bind_param(types: "sssis", var: &$role, vars: &$room_number, $shift, $nurse_id, $date);
        $update->execute();
        $update->close();
    } else {
        // Insert new assignment
        $insert = $conn->prepare(query: "INSERT INTO nurse_daily_roles (nurse_id, role, room_number, date, shift) VALUES (?, ?, ?, ?, ?)");
        $insert->bind_param(types: "issss", var: &$nurse_id, vars: &$role, $room_number, $date, $shift);
        $insert->execute();
        $insert->close();
    }

    $stmt->close();
```

Fig. 8 *Code Segment for Basic Info and Consent Page through Check In*

4.1.3 Track Pregnancy Progress

Fig. 9 shows the interface for patients to track their daily baby kicks. Doctors and Nurses are only able to view the information. The patient is also able to edit the log if they missed or forgot to log the baby kick for the day. As shown in Fig. 10 the system allows patients to view their kick summary in the barchart at the kick summary section.

The code segment for inserting or recording the baby kick when patient clicks on the "Log Kick" button is displayed in Fig. 11 where it manages session variables to track kick count and the 12-hour tracking window.

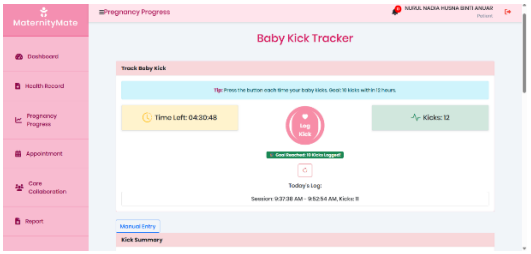

Fig. 9 *Interface of Patient Log Baby Kick*

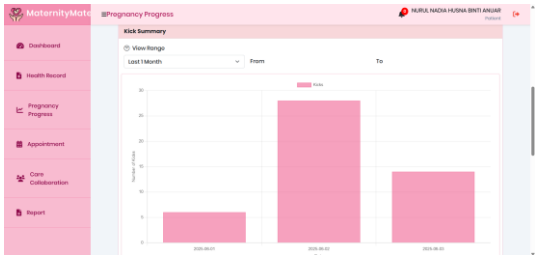

Fig. 10 *Interface of Kick Summary of Patient*

```php
// Always insert a new row for each kick
$kick_count = 1; // Each row represents a single kick
$insert = $conn->prepare(query: "INSERT INTO kick_logs (patient_id, log_date, kick_time, kick_count) VALUES (?, ?, ?, ?)");
$insert->bind_param(types: "issi", var: &$patient_id, vars: &$log_date, $kick_time, $kick_count);
$insert_success = $insert->execute();

if ($insert_success) {
    $_SESSION['kickCount']++; // Increment kick count in session
    $response['success'] = true;
    $response['message'] = 'Kick logged successfully!';
} else {
    $response['success'] = false;
    $response['message'] = 'Failed to log kick.';
```

Fig. 11 *Code Segment of Kick Log*

4.1.4 Manage Appointment

Fig. 12 shows the interface for nurses to schedule appointments for the patients. In the interface shows the recommended next appointment where system auto calculate predicted next appointment based on the patient's trimester and risk level, which is identified by a color-coded system (Red, Yellow, Green, or White). Once the appointment is set, the patient receives a notification with the details. Fig. 13 shows the interface where Patient able to request changes to rescheduled appointments. Then, these change requests will be reviewed by the nurse, who can either approve, reject, proposed change or suggest an alternative date and time.

Fig. 14 describes the code segment to send a notification to the patient when nurse schedules a new appointment. The system sends a real-time web push notification to the patient through sendPushNotification() functionality.

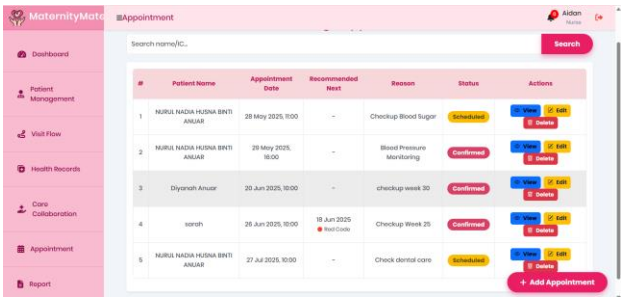

Fig. 12 *Interface of Nurse Manage Appointment*

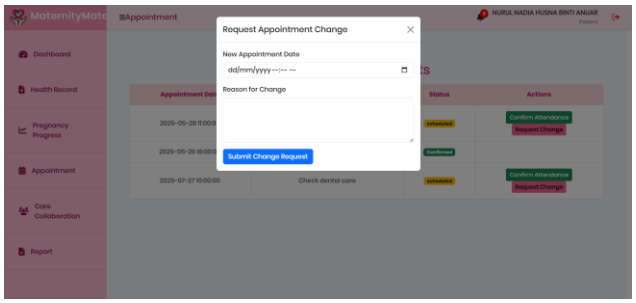

Fig. 13 *Interface of Patient Request for Reschedule*

```php
// Insert the new appointment into the database
$stmt = $conn->prepare(query: "INSERT INTO appointments (patient_id, appointment_date, reason, status, created_by) VALUES (?, ?, ?, ?, ?)");
$stmt->bind_param(types: "issi", var: &$patient_id, vars: &$appointment_date, $reason, $status, $nurse_id);

 if ($stmt->execute()) {
// Insert notification for the patient
$notification_message = "You have a new appointment scheduled for " . date(format: 'd M Y, H:i', timestamp: strtotime(datetime: $appointment_dat
$notif_stmt = $conn->prepare(query: "INSERT INTO notifications (user_id, message) VALUES (?, ?)");
$notif_stmt->bind_param(types: "is", var: &$patient_id, vars: &$notification_message);
$notif_stmt->execute();

// --- Add this: Include your notification function file ---
include_once '../includes/notification_functions.php';


// --- Then call the sendPushNotification function ---
sendPushNotification(
    title: '🗓️ New Appointment',
    body: $notification_message,
    url: '/pregnancy_management_system/display/patient_appointment.php',
    icon: '/images/notifications.png',
    type: 'appointment'
);

$success = "Appointment scheduled successfully!";
// Redirect if in next appointment mode
    if ($preselected_patient_id && $visit_id) {
        header(header: "Location: end_visit.php?patient_id=$preselected_patient_id&visit_id=$visit_id&success=next_appointment_set");
        exit();
    }

} else {
    $error = "Failed to schedule the appointment!";
}
```

Fig. 14 *Code Segment Insert Appointment Information*

4.1.5 Manage Care Collaboration Record

This Fig. 15 shows the interface of Doctors and Nurse Manage Care Collaborations Records. Doctors and Nurses must be able to update care collaboration sections, including “Examination and Procedure”, “Risk Assessment and Checklist” “Postnatal Collaboration”, “Health Education and Feedback”. Patients are only able to view all sections in a read-only mode. While Fig. 16 shows patients can view their own records.

Fig. 17 illustrates the code section that handles uploading discharge notes into the system. When the form is submitted with a file (discharge_form), the system first checks the file type. It must be a PDF. The user must also select the correct period either "Antenatal" or "Postnatal". If the file or selection is invalid an error message will be shown.

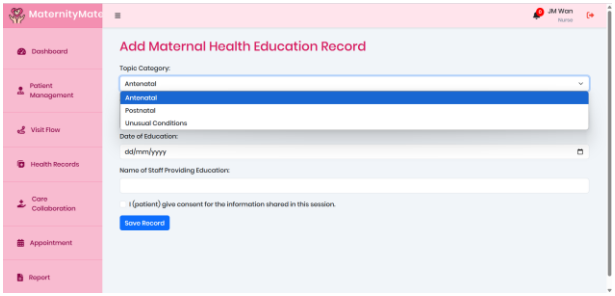

Fig. 15 *Interface of Nurse/Doctor Manage Care Collaboration*

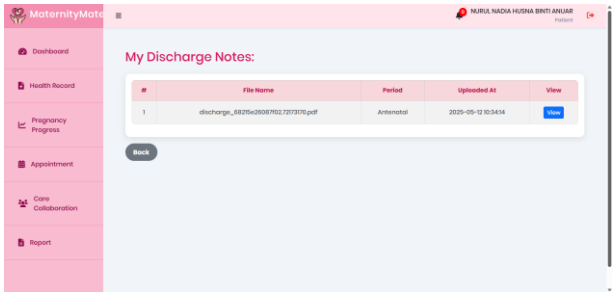

Fig. 16 *Interface of Patient View Their Own Care Collaborations Record*

```php
<?php
if ($_SERVER["REQUEST_METHOD"] == "POST" && isset($_FILES["discharge_form"])) {
    $file = $_FILES["discharge_form"];
    $period = $_POST["period"];

    // Validate file type
    $allowed_types = ['application/pdf'];
    if (!in_array(needle: $file['type'], haystack: $allowed_types)) {
        $error = "Only PDF files are allowed.";
    } elseif (!in_array(needle: $period, haystack: ['Antenatal', 'Postnatal'])) {
        $error = "Invalid period selected.";
    } else {
        // Create the upload folder if it doesn't exist
        $upload_dir = "../uploads/discharge_notes/";
        if (!is_dir(filename: $upload_dir)) {
            mkdir(directory: $upload_dir, permissions: 0755, recursive: true);
        }

        $file_name = uniqid(prefix: "discharge_", more_entropy: true) . ".pdf";
        $file_path = $upload_dir . $file_name;

        if (move_uploaded_file(from: $file['tmp_name'], to: $file_path)) {
            $stmt = $conn->prepare(query: "INSERT INTO discharge_notes (patient_id, file_name, file_path, period) VALUES (?, ?, ?, ?)");
            $stmt->bind_param(types: "isss", var: &$patient_id, vars: &$file_name, $file_path, $period);

            if ($stmt->execute()) {
                $success = "Discharge note uploaded successfully.";
            } else {
                $error = "Database error: " . $stmt->error;
            }
            $stmt->close();
        } else {
            $error = "Failed to upload the file.";
        }
    }
}
?>
```

Fig. 17 *Code Segment of Uploading File (Subsection in Care Collaboration Records)*

4.1.6 Manage Report

The Reporting and Analytics features allow doctors and nurses to access, view and export patient health data, including visit histories and risk assessments. While from patients’ perspective they can view their records and generate reports based on the records as shown on Fig. 19. Fig. 18 is from the perspective of nurses and doctor where when page loads, it shows every patient without any filters and asks the doctor and nurse to choose one. When they click on the "Generate Report" button the system will load the activity log for the chosen patient and pass their ID via the URL.

Fig. 20 shows the page is fetching the users and patients tables joined together so able to retrieve the basic information of patients. Then it also calculates the pregnancy progress by checking if the patient has a last menstrual date (LMP)

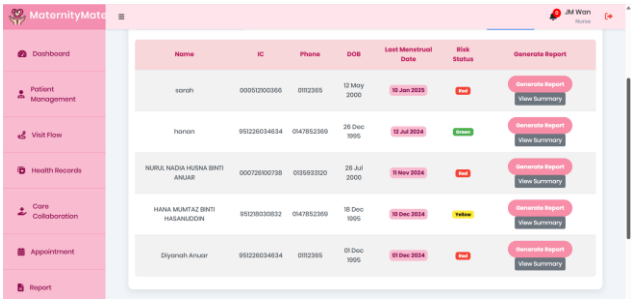

Fig. 18 *Interface of Details of Report Management*

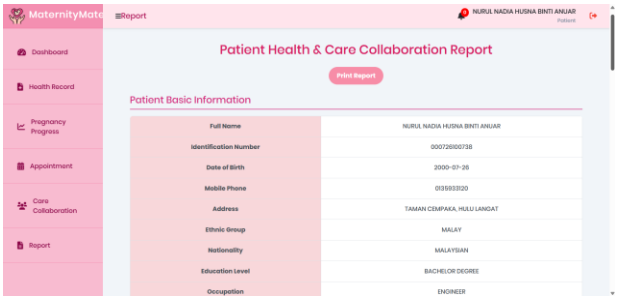

Fig.19 *Interface of Patient's Side of Report Management*

```php
// Fetch visit history
$visits_sql = "SELECT
    vcc.id, vcc.visit_date, vcc.assigned_color,
    GROUP_CONCAT(rf.description SEPARATOR ', ') as risk_factors
    FROM visit_color_checks vcc
    LEFT JOIN visit_risk_conditions vrc ON vcc.id = vrc.visit_color_check_id
    LEFT JOIN risk_factors rf ON vrc.risk_factor_id = rf.id
    WHERE vcc.patient_id = ?
    GROUP BY vcc.id
    ORDER BY vcc.visit_date DESC";

$visits_stmt = $conn->prepare(query: $visits_sql);
$visits_stmt->bind_param(types: "i", var: &$patient_id); // You'll need to get patient_id from patients table
$visits_stmt->execute();
$visits_result = $visits_stmt->get_result();
$visits = $visits_result->fetch_all(mode: MYSQLI_ASSOC);

// Calculate pregnancy progress if LMP exists
$pregnancy_progress = null;
if ($patient['last_menstrual_date']) {
    $lmp = new DateTime(datetime: $patient['last_menstrual_date']);
    $today = new DateTime();
    $days_pregnant = $today->diff(targetObject: $lmp)->days;
    $weeks_pregnant = floor(num: $days_pregnant / 7);
    $days_remaining = $days_pregnant % 7;
    $trimester = ($weeks_pregnant < 13) ? 1 : (($weeks_pregnant < 27) ? 2 : 3);
}
?>
```

Fig. 20 *Code Segment Getting Patient Summary*

4.2 Testing

In this section, the system has been tested with the stakeholders and the test cases of the websites are created to ensure all the functionality is developed according to the requirements. User Acceptance Testing (UAT) was conducted with key stakeholders at Klinik Kesihatan Batu 14, including the patients, administrators, doctors, and nurses. Table 5 shows the test cases of the system.

Table 5: *List of Test Cases*

Phase	Software Requirement	Description	Status
TC_100	**REQ_100**	**Log In and Sign Up**	**Fail/Pass**
TC_100_01	FR01-01, FR01-02, FR01-03	The registered user logs in with valid credentials and is redirected to role specific dashboard.	Pass
TC_100_02	FR01-04, FR01-05	User enters invalid credentials and error message.	Pass
TC_100_03	FR01-06, FR01-07, FR01-08, FR01-09	User enters invalid credentials and receives error message.	Pass
TC_100_04	FR01-10, FR01-11, FR01-12, FR01-13	New user register and receives verification email	Pass
TC_100_05	FR01-14	System shows message for unapproved self-registered accounts	Pass
TC_100_06	FR01-15	Admin and Nurse successfully creates accounts for patients	Pass
TC_100_07	CR01-01	System prevents login without role selection by showing message error.	Pass

Table 5 (cont.) *List of Test Cases*

TC_100_08	QR01-01	System sends verification and password reset email within 5 seconds	Pass
TC_200	**REQ_200**	**Manage Health Record**	**Fail/Pass**
TC_200_01	FR02-01	The Patient can only view their health records	Pass
TC_200_02	FR02-02	The Doctor/Nurse can add new health records (Patient Info, Consent, Health Monitoring, Postnatal Care).	Pass
TC_200_03	FR02-02	The Doctor/Nurse can update existing health records.	Pass
TC_200_04	FR02-02	The Doctor/Nurse can view all sections of health records.	Pass
TC_200_05	FR02-03	The system validates and saves updates made by Doctors/Nurses.	Pass
TC_200_06	FR02-04	The system displays existing data when retrieving/updating records.	Pass
TC_200_07	FR02-05	The system shows an error message when required fields are missing.	Pass
TC_200_08	QR02-01	All health record updates are reflected within 5 seconds.	Pass
TC_300	**REQ_300**	**Track Pregnancy Progress**	**Fail/Pass**
TC_300_01	FR03-01, FR03_06	The system displays the pregnancy tracking dashboard.	Pass
TC_300_02	FR03-02	The patient can log baby kicks by clicking the "Log Kick" button.	Pass
TC_300_03	FR03-03	The system able to record kick logs with correct timestamps.	Pass
TC_300_04	FR03-04	The system can display graphical summaries (Today/7 Days/1 Month).	Pass
TC_300_05	FR03-05	The doctors/Nurses can view patients kick logs.	Pass
TC_300_06	FR03_06	The patients can track due dates and pregnancy progress via the dashboard.	Pass
TC_300_07	FR03-07	The system is able to send an alert if fewer than 10 kicks are logged within 12 hours.	Pass
TC_300_08	FR03_08	The patient can manually add/edit kick logs with date, start time, and kick count.	Pass
TC_400	**REQ_400**	**Manage Appointment**	**Fail/Pass**
TC_400_01	FR04_01	The system calculates and predicts appointment frequency based on trimester & risk assessment.	Pass
TC_400_02	FR04_02	The nurse schedules a new appointment for a patient.	Pass
TC_400_03	FR04_03	The system sends a notification to the patient upon the new appointment creation.	Pass
TC_400_04	FR04_04	Patient is able to submit a reschedule request with preferred days/times and reason.	Pass
TC_400_05	FR04-05	The nurse able to approve a reschedule request, System updates status & notifies patient.	Pass
TC_400_06	FR04-06	The system suggests appointments based on pregnancy status/predefined frequency.	Pass
TC_500	**REQ_500**	**Manage Care Collaboration**	**Fail/Pass**
TC_500_01	FR05_01	The patient can view all care collaboration sections.	Pass
TC_500_02	FR05_02	The Doctor/Nurse is able to update the "Examination & Procedure" section.	Pass
TC_500_03	FR05_02	The Doctor/Nurse is able to update the "Risk Assessment & Checklist" section.	Pass
TC_500_04	FR05_02	The Doctor/Nurse is able to update the "Postnatal Collaboration" section.	Pass
TC_500_05	FR05_02	The system is able to validate and save updates successfully (valid data).	Pass
TC_500_06	FR05_04	The system is able to highlight missing fields and show an error message.	Pass
TC_500_07	FR05_04	The system rejects submission if file format is invalid (e.g., non-PDF file).	Pass

The summary of overall test case results is recorded in table 6. A total of 37 test cases were conducted to test the Pregnancy Management System (MaternityMate). The system has passed successfully.

Table 6 *Overall Result of Test Cases*

Test Case ID	Total Test Cases	Total Success	Total Fail
TC_100	8	8	0
TC_200	8	8	0
TC_300	8	8	0
TC_400	6	6	0
TC_500	7	7	0
TC_100	8	8	0
Total	37	37	0

User Acceptance Testing (UAT) also was conducted from the perspectives of patients, doctors, nurses, and administrators. Overall, the testing was successfully completed, indicating that the system meets the users' expectations and requirements. The UAT was carried out through an online platform using Google Forms. A total of 28 questions were presented to assess the users' perception, usability experience, and overall satisfaction with the system. The questionnaire was role-specific and designed in alignment with the modules each user group interacts with in the MaternityMate system.

The scale that has been used in this test is 1 to 5 scales where 1 indicates strongly disagree and 5 indicates strongly agree. Summary of the acceptance testing was shown in table 7.

Table 7 *Summary of Acceptance Testing*

QUESTIONS (RESPONDENT TYPE)	Category of Respondent	1	2	3	4	5
I was able to approve, reject, and manage user accounts without difficulty. (Module 1)	Admin	0	0	0	0	1
The system provided clear status indicators for user roles and account approval stages. (Module 1)	Admin	0	0	0	0	1
I was able to access and monitor updates made by doctors and nurses in health records. (Module 2)	Admin	0	0	0	0	1
The system ensured that health record data was validated and completed before being saved. (Module 2)	Admin	0	0	0	0	1
I was able to log in and access the correct dashboard based on my role. (Module 1)	Doctor/Nurse	0	0	0	0	5
The system provided clear feedback for login errors or pending account approval. (Module 1)	Doctor/Nurse	0	0	1	2	2
I could accurately update patient health records during visits or manual entries. (Module 2)	Doctor/Nurse	0	0	0	2	3
The system validated incomplete or incorrect fields clearly before submission. (Module 2)	Doctor/Nurse	0	0	0	3	2
The kick tracking summaries and alerts helped me monitor patient pregnancy progress effectively. (Module 3)	Doctor/Nurse	0	0	0	1	4
The graphical data (Today, 7 Days, 1 Month) loaded quickly and supported clinical decision-making. (Module 3)	Doctor/Nurse	0	0	0	3	2
I was able to view and manage patient appointments based on trimesters and risk. (Module 4)	Doctor/Nurse	0	0	0	0	5
Notifications about appointment updates were delivered accurately and in a timely manner. (Module 4)	Doctor/Nurse	5	0	0	0	0
I could update collaboration records (e.g., postnatal, referrals, feedback) accurately. (Module 5)	Doctor/Nurse	0	0	0	1	4
Care collaboration data was accessible and useful for team-based decision-making. (Module 5)	Doctor/Nurse	0	0	0	1	4
I was able to generate accurate and complete reports (PDF/Excel/Print) for my patients. (Module 6)	Doctor/Nurse	0	0	0	0	5

Table 7(cont.) *Summary of Acceptance Testing*

The system handled missing data scenarios and displayed appropriate messages. (Module 6)	Doctor/Nurse	0	0	0	0	5
I was able to log in or sign up easily using the "Patient" role.(Module 1)	Patient	0	0	0	0	4
I received clear messages about account status, including approval and errors. (Module 1)	Patient	0	0	0	3	1
I could access and view my health records without any issues.(Module 2)	Patient	0	0	0	0	5
The information shown (e.g., check-up results, risk status) was clear and understandable. (Module 2)	Patient	0	0	0	2	2
Logging baby kicks was easy, and the system tracked them correctly.(Module 3)	Patient	0	0	0	2	2
I received alerts or notifications when my kick counts were low or needed attention. (Module 3)	Patient	3	1	0	0	0
I was notified when new appointments were scheduled for me. (Module 4)	Patient	0	1	1	1	1
It was easy to request a reschedule and receive updates on its approval status. (Module 4)	Patient	0	0	0	2	2
I was able to view care collaboration details added by healthcare providers. (Module 5)	Patient	0	0	0	1	3
The information shared helped me understand my condition and care better. (Module 5)	Patient	0	0	1	1	2
I could view and generate simple summaries of my medical records (e.g., health reports). (Module 6)	Patient	0	0	0	1	3
The report format (PDF or screen display) was easy for me to understand and use. (Module 6)	Patient	0	0	0	1	3

5. Conclusion

To conclude, this study is focusing on developing the website of pregnancy management system. The system provides patients and healthcare practitioners with a secure, efficient, and user-friendly platform by resolving the challenges of manual approaches. All users able to use all functionalities in the pregnancy management system that will increase communication between patient and healthcare providers, facilitate appointment scheduling and reduce administrative responsibilities. From the user testing, most users were satisfied with how easy the system was to use and how it helped them do their tasks more effectively. Some of the main benefits include better communication between users, easier tracking of pregnancy progress, and faster access to patient information. It also reduces the need for paperwork and helps save time. Although the system works well, there are still some areas that can be improved, such as making alerts more responsive and improving the user interface.

Acknowledgement

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nurul Nadia Husna binti Anuar, Noraini binti Ibrahim;* ***data collection:*** *Author Y;* ***analysis and interpretation of results:*** *Nurul Nadia Husna binti Anuar, Noraini binti Ibrahim;* ***draft manuscript preparation*** *Nurul Nadia Husna binti Anuar, Noraini binti Ibrahim. All authors reviewed the results and approved the final version of the manuscript.*

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Appendix A:

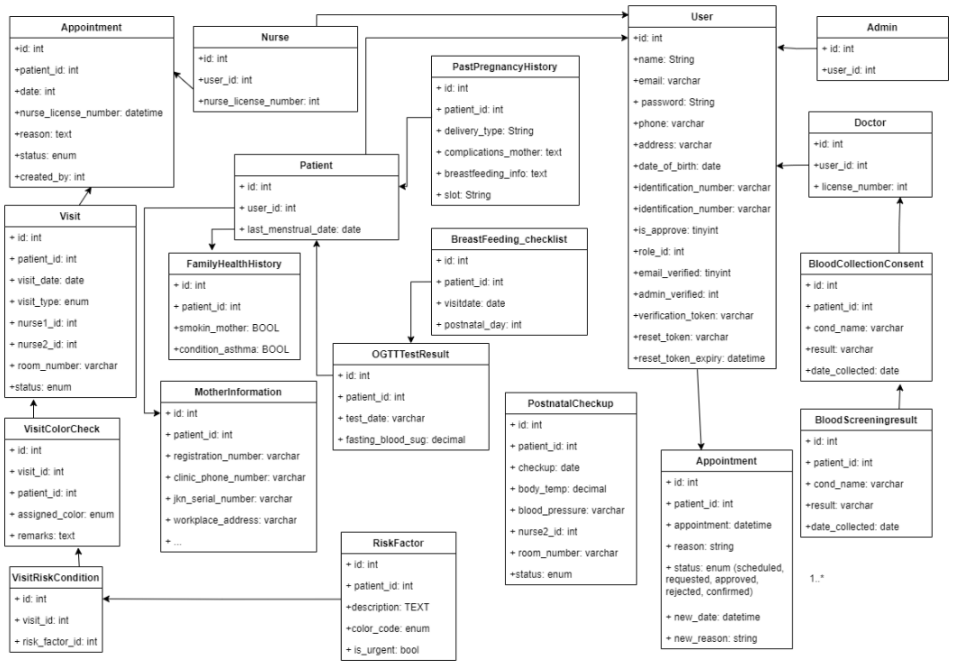

Fig. 1 *Class Diagram of the developed system*

1) Log In and Sign Up

Table 1 *Use Case Specification for Login and Sign Up*

Use Case ID	UC001		
Use Case Name	Login and Sign Up		
Feature	PMS_REQ_100 Login and Sign Up		
Created By	Nurul Nadia Husna binti Anuar	**Updated By**	Nurul Nadia Husna binti Anuar
Date Created	5 June 2025	**Last Revision Date**	5 June 2024
Actors	Patient, Doctor, Nurse and Admin		
Description	This use case is intended to authenticate the user or registers user. There are three users involved in the login: the patient, doctor and nurse. Before login or registration, the user selects their role (Patient, Doctor, or Nurse). Based on their role selection, they are directed to the appropriate login or sign-up flow. To login the user needs to login using email and password. If the system fails to authenticate the user, then the user will see an error message. Admin able to manage user account creation, updates, and deletions. Self-registered accounts require Admin approval.		

Fig. 2 *Activity Diagram of Log In and Sign Up*

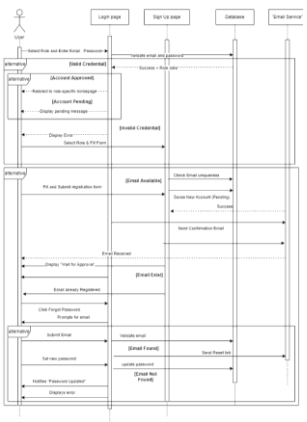

Fig. 3 *Sequence Diagram of Log In and Sign Up*

2) Manage Health Record

Table 2 *Use Case Specification for Manage Health Record*

Use Case ID	UC002		
Use Case Name	Manage Health Record		
Feature	PMS_REQ_200 Manage Health Record		
Created By	Nurul Nadia Husna binti Anuar	**Updated By**	Nurul Nadia Husna binti Anuar
Date Created	5 June 2025	**Last Revision Date**	5 June 2025
Actors	Patient, Doctor and Nurse		
Description	This module allows users (Patients, Nurses, and Doctors) to manage health records aligned with the Pink Book's requirements. Patients only can view all the information in health records. It also allows Doctors and nurses add/update/view all health records, including pregnancy-specific metrics and check-up results. Doctor and Nurses able to manage health records through two workflows: I. Visit Check-In Flow: For patients attending appointments II. Manual Entry: For records updated outside visits		

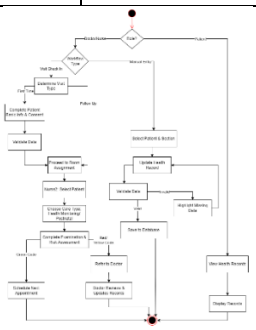

Fig. 4 *Activity Diagram of Manage Health Record*

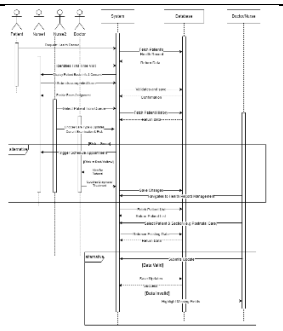

Fig. 5 *Sequence Diagram of Manage Health Record*

3) Track Pregnancy Progress

Table 3 *Use Case Specification for Track Pregnancy Progress*

Use Case ID	UC003		
Use Case Name	Track Pregnancy Progress		
Feature	USEM_REQ_300 Track Pregnancy Progress		
Created By	Nurul Nadia Husna binti Anuar	**Updated By**	Nurul Nadia Husna binti Anuar
Date Created	5 June 2025	**Last Revision Date**	5 June 2025
Actors	Patient, Doctor, Nurse and Admin		
Description	This module allows patients to log baby kicks. Doctors and nurses can view and analyze tracking data entered by patients. The system summaries, trend metrics, and alerts if conditions are not met (e.g., less than 10 kicks within 12 hours).		

Fig. 6 *Activity Diagram of Track Pregnancy Progress*

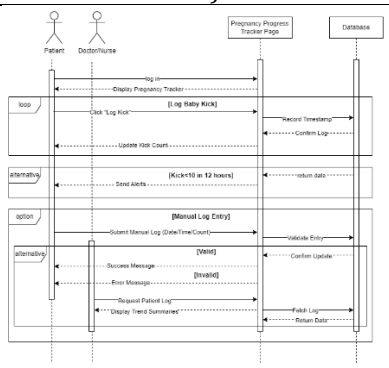

Fig. 7 *Sequence Diagram of Track Pregnancy Progress*

4) Manage Appointment

Table 4 *Use Case Specification for Manage Appointment*

Use Case ID	UC004		
Use Case Name	Manage Appointment		
Feature	PMS_REQ_400 Appointment Management		
Created By	Nurul Nadia Husna binti Anuar	**Updated By**	Nurul Nadia Husna binti Anuar
Date Created	5 June 2025	**Last Revision Date**	5 June 2025
Actors	Patient, Nurse and Doctor		
Description	This module allows nurses to schedule appointments for patient and at the same time patient able to request reschedule. The doctor will be able to view the list of appointments. After that, notifications are sent vias sendPushNotification() for appointment confirmation or any updates.		

Fig. 8 *Activity Diagram of Manage Appointment*

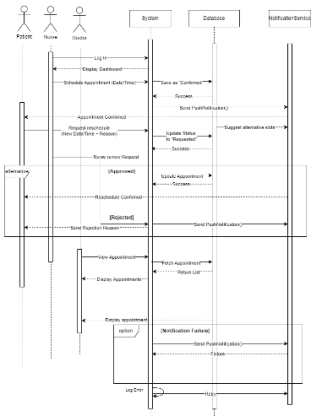

Fig. 9 *Sequence Diagram of Manage Appointment*

5) Manage Care Collaboration Record

Table 5 *Use Case Specification for Manage Care Collaboration Record*

Use Case ID	UC005		
Use Case Name	Manage Care Collaboration Record		
Created By	Nurul Nadia Husna binti Anuar	**Updated By**	Nurul Nadia Husna binti Anuar
Date Created	5 June 2025	**Last Revision Date**	5 June 2024
Actors	Patient, Doctor and Nurse		
Description	This use case supports collaborative care record where it allows external health care providers (e.g, dentist and hospital doctor) to collab with staff at Klinik Kesihatan Batu 14. Patients can only view their care details, while nurses and doctors can update collaboration-specific sections such as examinations& procedure, risk assessment& checkout, postnatal collaboration, also health education and feedback.		

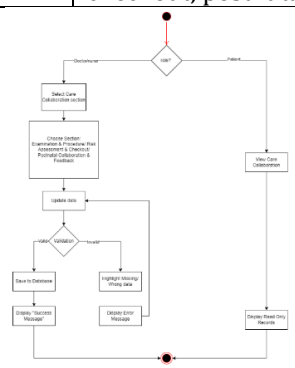

Fig. 10 *Activity Diagram of Manage Care Collaboration Record*

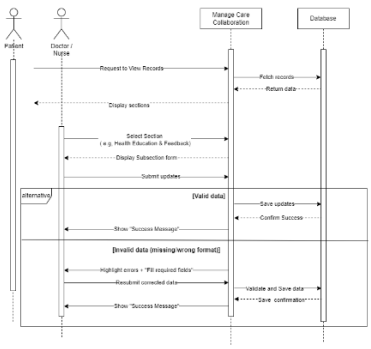

Fig. 11 *Sequence Diagram of Manage Care Collaboration Record*

6) Generate Report

Table 6 *Use Case Specification for Generate Report*

Use Case ID	UC008		
Use Case Name	Manage Report		
Created By	Nurul Nadia Husna binti Anuar	**Updated By**	Nurul Nadia Husna binti Anuar
Date Created	5 June 2025	**Last Revision Date**	5 June 2025
Actors	Patient, Doctor, Nurse and Admin		
Description	This module allows users to view, generate and export patient health reports including visit histories, risk assessment and pregnancy progress.		

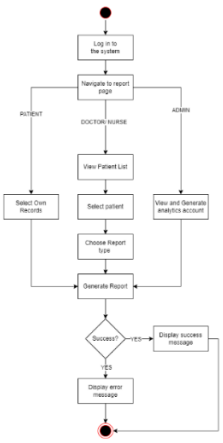

Fig. 12 *Activity Diagram of Manage Report*

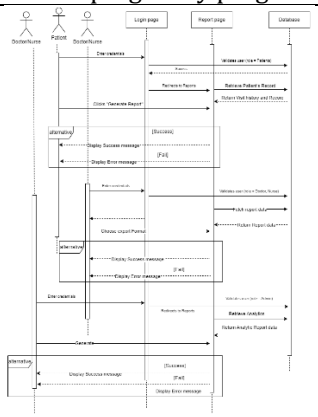

Fig. 13 *Sequence Diagram of Manage Report*

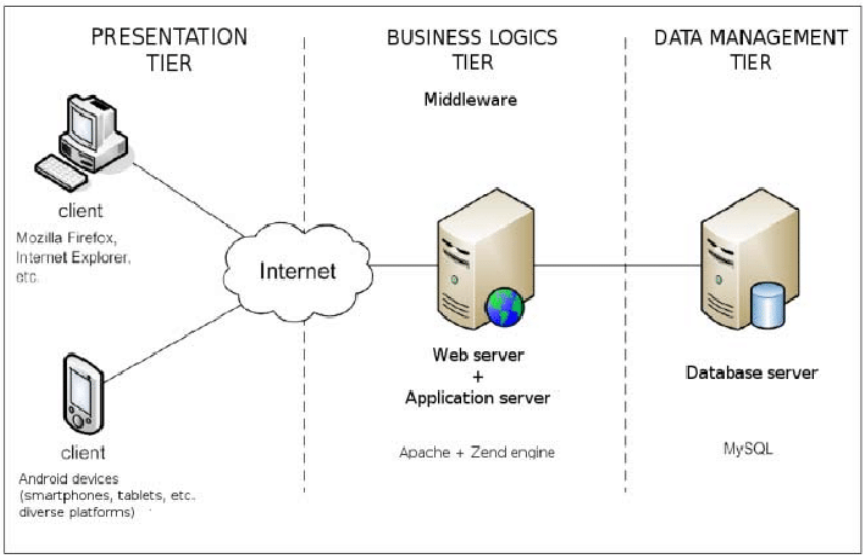

Fig. 14 *Three-tier architecture [9]*