ITCS 6112

SOFTWARE SYSTEM DESIGN AND IMPLEMENTATION

A PROJECT REPORT

ON

NEONATAL INTENSIVE CARE UNIT (NICU) FOLLOW UP

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TABLE OF CONTENTS

1. ABSTRACT

The birth of a newborn is not only great but also involves a complex process. Both the mother and the baby undergo many physical and emotional changes during this whole process. Under such circumstances, whenever the newborn needs proper attention intensively in order to have a stable health, the baby will be admitted into a special area called Neonatal Intensive Care Unit (NICU) in a hospital. Babies will be provided intensive medical attention for particular time period depending on their health.

This web application helps the doctors to have a follow up of the newborn's health and medical condition for the whole time period and also during each and every visit to the hospital. Initially, all the required medications, health conditions and all the body measurements, vaccinations of the newborn are recorded in the application. Doctors can have a detailed follow up of the baby's health condition depending on the regular visits to the hospital. Depending on the baby's health conditions and the medical follow ups, graphs will be generated for the doctor in order to have a detailed analysis of medical and health condition of the newborns as a whole. This also makes the doctor's life easier as the doctor will be able to enter everything into the system then and there, while examining the baby. This also reduces human error, is easy to use, flexible and also paper-free.

2. INTRODUCTION

This is a portal that allows Neuro Development Assessment of a newborn followed by checkups till the age of five years. This application will be used by Neonatologists and Pediatricians to add the information about the newborn's health conditions and to monitor their growth. The doctors can also create graphs for easy monitoring of growth.

Various functionalities like Adding a new Patient, Diagnosis, Risk Factors, Immunization, Investigation, Medication should be filed initially in case of a new patient. Every new patient will be provided with a unique MRD number upon successfully completing the first visit. This number will be used for the follow ups of the patient. For the follow up visits, based on the baby's age new services like ROP and Intercurrent Illness will be added. When the doctor logs in to the portal, a dashboard will be displayed which shows the list of Total Babies, Number of babies that completed the first follow up, third month visit, number of babies that delayed the visit and also the babies that are towards high and moderate risk. As the follow ups proceed, a growth monitoring chart will be generated for tracking the baby's health. Here is a list of forms that are to be completed as an initial step of adding a new patient.

- **Add Patient:** This form contains the general details of the patient like the name, contact details, sex, actual birth date, expected delivery date, gestational age, date of admission, date of discharge etc.
- **Diagnosis:** In this form, depending on the gestational age, the baby will be classified into Pre-term, term or Post-term.
- **Risk Factor:** The baby is diagnosed for risks on a scale of Mild to High.
- **Investigation:** For the further opinion on the baby's health, required investigations like CT Scans, USG Skull, EEG, ENT etc will be advised.
- **Immunizations:** Based on the age of the baby, the required vaccinations will be suggested and the vaccines taken will be recorded.
- **Medication:** The medication that is undergone by the baby will be recorded in this form.

3. PROBLEM DEFINITION

There are many software applications which are designed for maintaining progress and follow ups of adults. These systems are mainly used by the doctors, nurses and others in the hospitals. They track a patient's health periodically. As the birth of a new born is the most essential stage in the life cycle of a human being, it is always important to track the health of newborn on a regular basis. But there are no proper website that can track a newborn's health explicitly taking all the required medical and health conditions into consideration. Combining technology with it gives best results and it also makes lives of doctors easy. Our website mainly tracks the health of the newborn up to the age of 5 years taking all the medication, vaccinations, medical investigation, diseases, body measurements and other basic details of the newborn. It also helps in tracking the baby's regular follow up visits to the doctor. Doctors can update the newborn's health conditions in the website. The system also intends to monitor the growth of a newborn and displays it in the form of an easy to understand graph. This graph will help the parents/guardians to keep a track of the child's growth as well.

4. SCOPE

The scope of the project consists of basic login functionalities, capturing general information of the patient, maintaining a track of health conditions detected during the diagnosis of the patient, maintaining patient history by recording the medications suggested and immunizations given. The system also records the probable risks determined by the doctor that could affect the patient. These risks are categorized based on their severity, so that even if there is one risk which has higher severity the doctor can recommend immediate actions. The system allows user to edit patient details so as to modify the growth and medications suggested. The system also allows the user to search for patient record based on a unique number called MRD number. Based on the search a child's parents can view the record for medication history and immunization history. We also provide a system for storing

Investigations throughout the process which include many scans like USG, CT MRI etc. The results to these scans are stored based on whether they are normal or abnormal. The application also displays a graph of the follow ups so that the doctor can keep a track of the same.

As a part of future scope for the project we plan on incorporating graphs so as to have a generalized growth monitoring for individual patient so that the doctor or child's parent can monitor the growth. There will be other graphs which help the doctors view and analyze general statistics related to diseases like which age group did a particular disease affect most? Or compare growth statistics based on gender. The doctor can save these graphs as records and revisit them after years as and when required. This serves to be valuable information.

5. FUNCTIONAL REQUIREMENTS

Add Patient

Actor - Doctor

Event - Adding a new patient

Action - Personal details of a new patient will be added in this form. These details will include:-

MRD Number: An auto-generated unique number will be populated.

Date: Will be auto populated.

Name, Sex, Phone Number, Gestational Age (GA), Birth weight, Date of Birth, Address will be entered.

Weight, Head Circumference and Length on discharge from the hospital where the baby was born will be entered.

Other details like Current Age, Date of Admission, Expected Delivery Date, Current Gestational Age and Discharge date will be calculated.

Diagnosis

Actor - Doctor, Patient

Event - Diagnosis of the baby for various diseases.

Action - The Doctor will diagnose for various diseases.

Based on the GA and Birth Date the field Preterm/Posterm/Term will be populated.

Diseases diagnosed will be recorded.

The patient can only view this screen.

Risk

Actor - Doctor

Event - Classifying the risks in Mild, Moderate, High

Action - The risks will be recorded under above mentioned categories.

An overall risk is provided which is the highest category under which a risk is identified. Example if one risk falls under the High category and two risks fall under the Average risk the overall risk will be considered High.

Immunization

Actor - Doctor

Event - List of all the vaccines given to the baby.

Action - The list of all the vaccines given to the baby will be recorded.

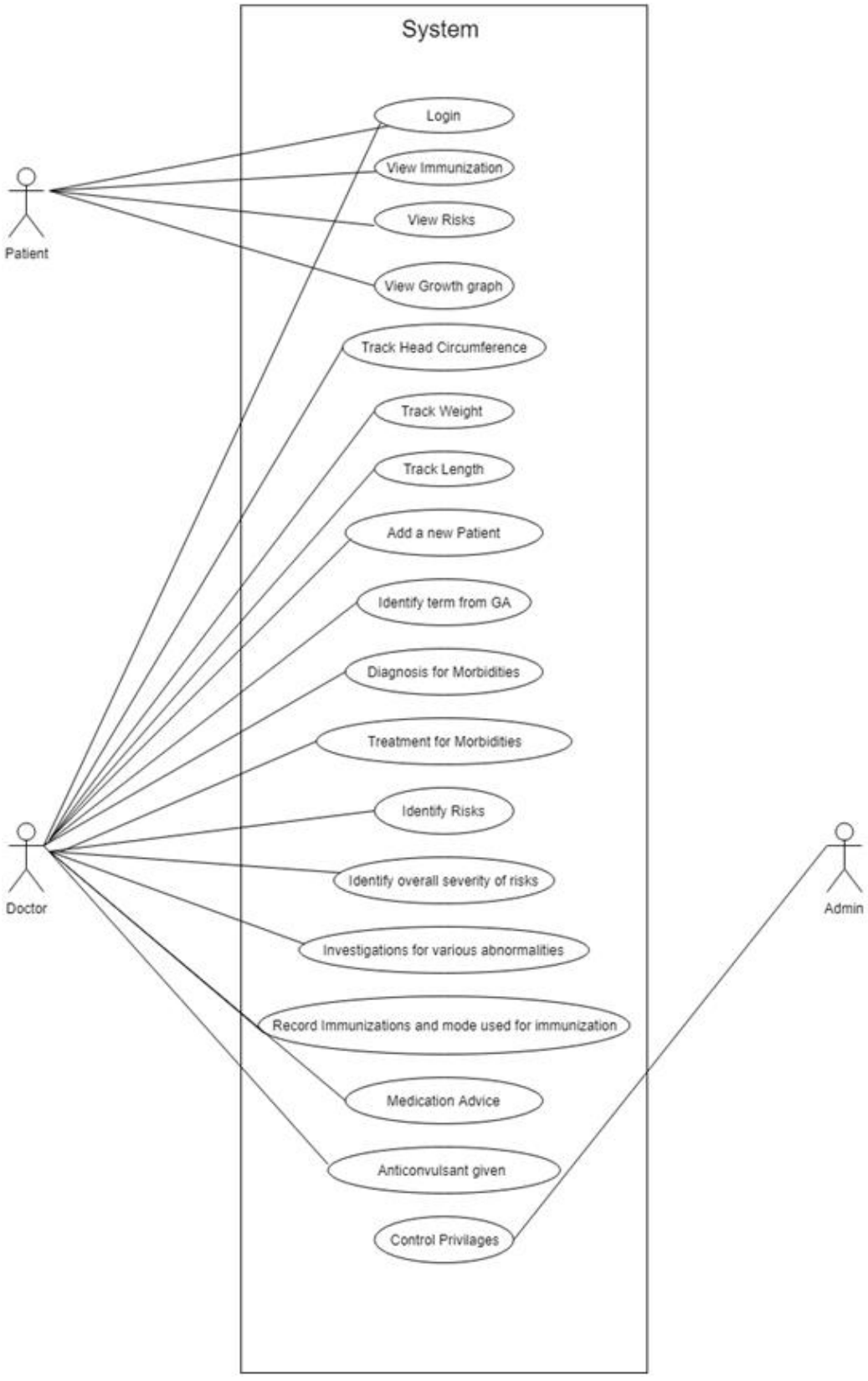
Medication

Actor - Doctor

Event - Medications suggested for the baby.

Action - Medications suggested will be recorded.

6. USE CASE DIAGRAM



7. SYSTEM CONSTRAINTS

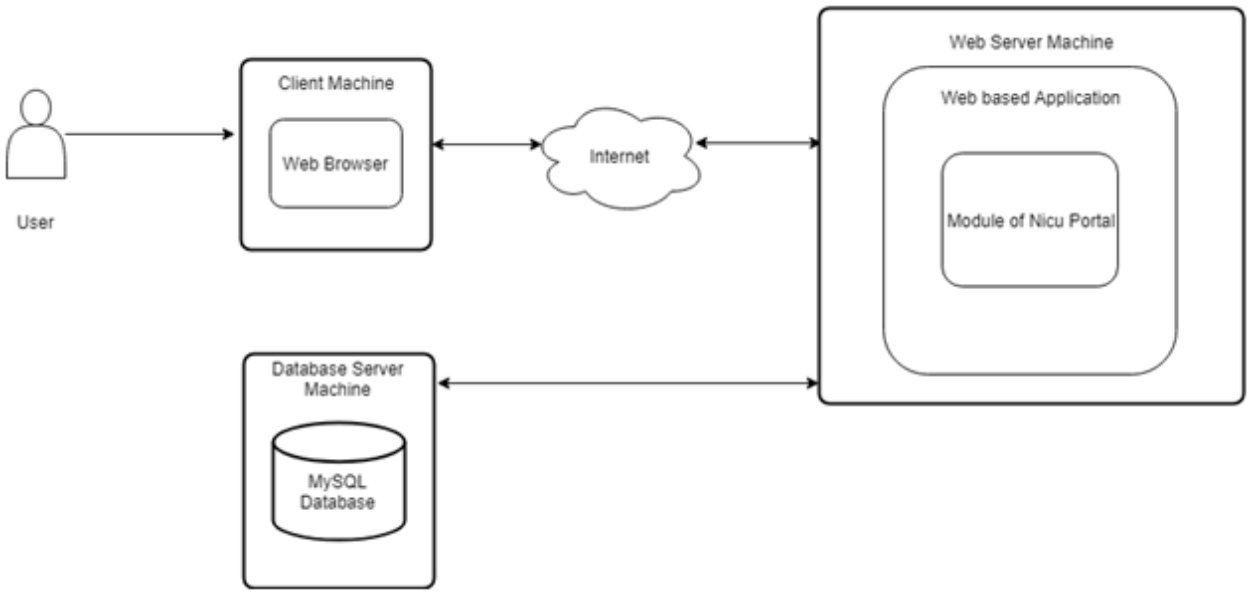
Hardware Requirements:

- Processor : Intel or AMD Processor Computer
- RAM : 256 MB or more
- Hard Disk Space : 8GB or more

Software Requirements:

- Operating System : Windows XP SP3 or above
- Database : MySQL 8.0
- Language : C#
- UI : Angular typescript
- Browser : Google Chrome Version 73.0.3683.103

8. SOFTWARE ARCHITECTURE



Why Angular TypeScript?

There are many advantages of using Angular TypeScript, amongst them are a few key benefits mentioned here

1. Consistency
2. Productivity
3. Maintainability
4. Modularity
5. Catch Errors Early

Other than these TypeScript has great tools, it provides advanced autocompletion, navigation, and refactoring. As TypeScript is object oriented it helps in making the code modular and avoid redundancy. TypeScript does validations during compilation and will show compilation errors unlike the JavaScript counterpart which is an interpreted language. Due to this programmers are able to catch errors at the early stages of development which in turn saves time of error detection and cost of rectifying errors. TypeScript makes abstractions explicit, which makes it easier to support interfaces. Lastly due to modularity and its object oriented nature TypeScript makes code easier to read and understand.

Why C#?

There are many advantages of using C# language which are mentioned below:

1. **Object-oriented:** As C# is a pure object-oriented language, which allows creation of modular maintainable applications. Making the code modular helps in creating reusable codes.
2. **Cross Platform:** C# runs on .NET framework and works across platforms.

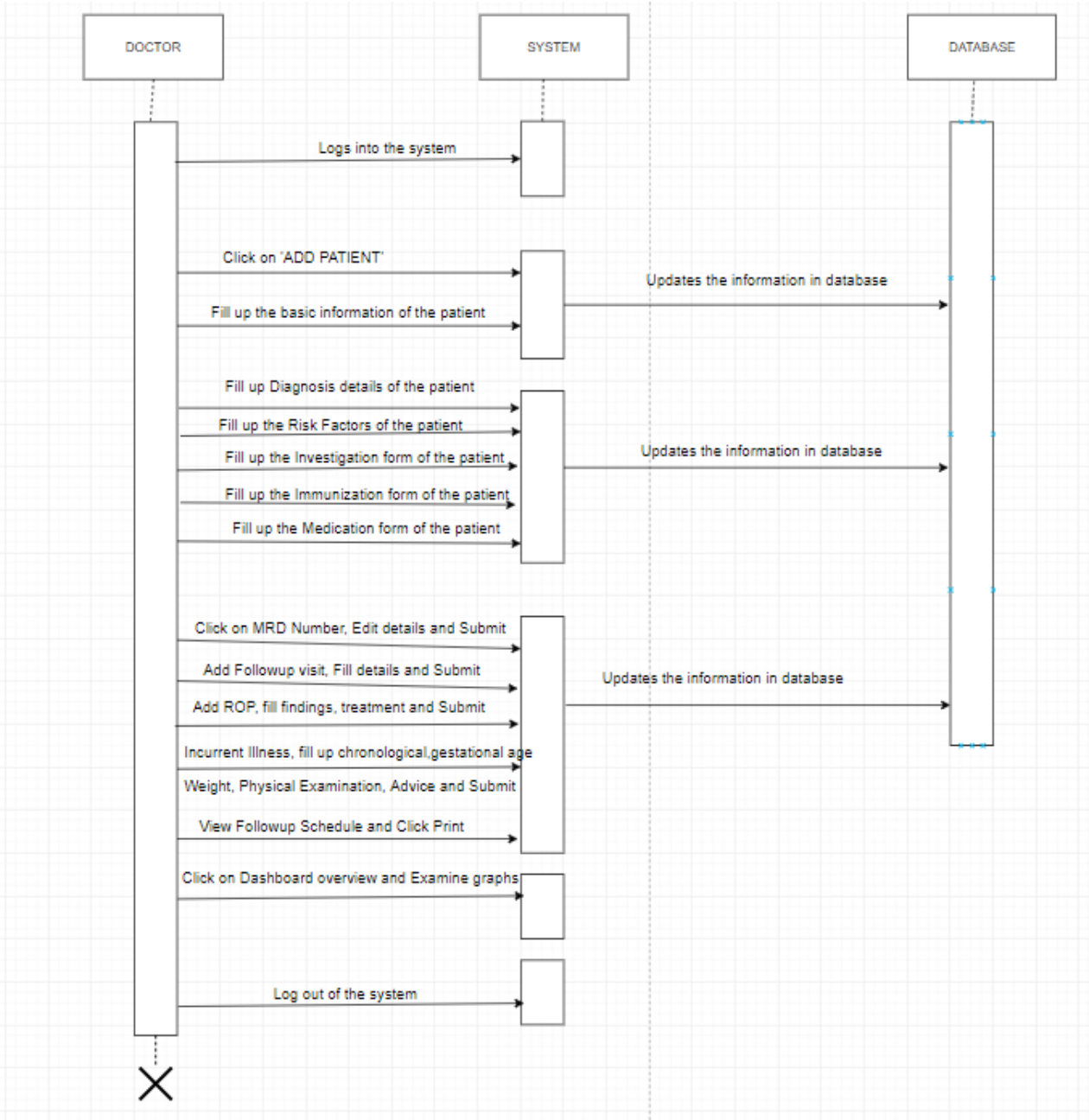
3. **Automatic Garbage Collection:** As C# programming has automatic garbage collection, which makes efficient uses of resources.
4. **Avoid the problem of memory leak:** C# programming language contains high memory backup so that memory leakage problems are resolved.
5. **Easy-to-Development:** As C# has a rich class of libraries that make many functions easy to be implemented.
6. **Better Integration:** As C# programming runs on CLR, thus making it easy to integrate with components written in other languages.
7. **Cost-benefit:** Maintenance cost is less.
8. **Familiar syntax:** It is easy to understand and work in productively if one has a working knowledge of languages like C, C++, Java as the core syntax is similar to C-style languages.
9. **Properties and Indexers:** C# has features like Properties and Indexers which are not available in Java language.

Why MySQL?

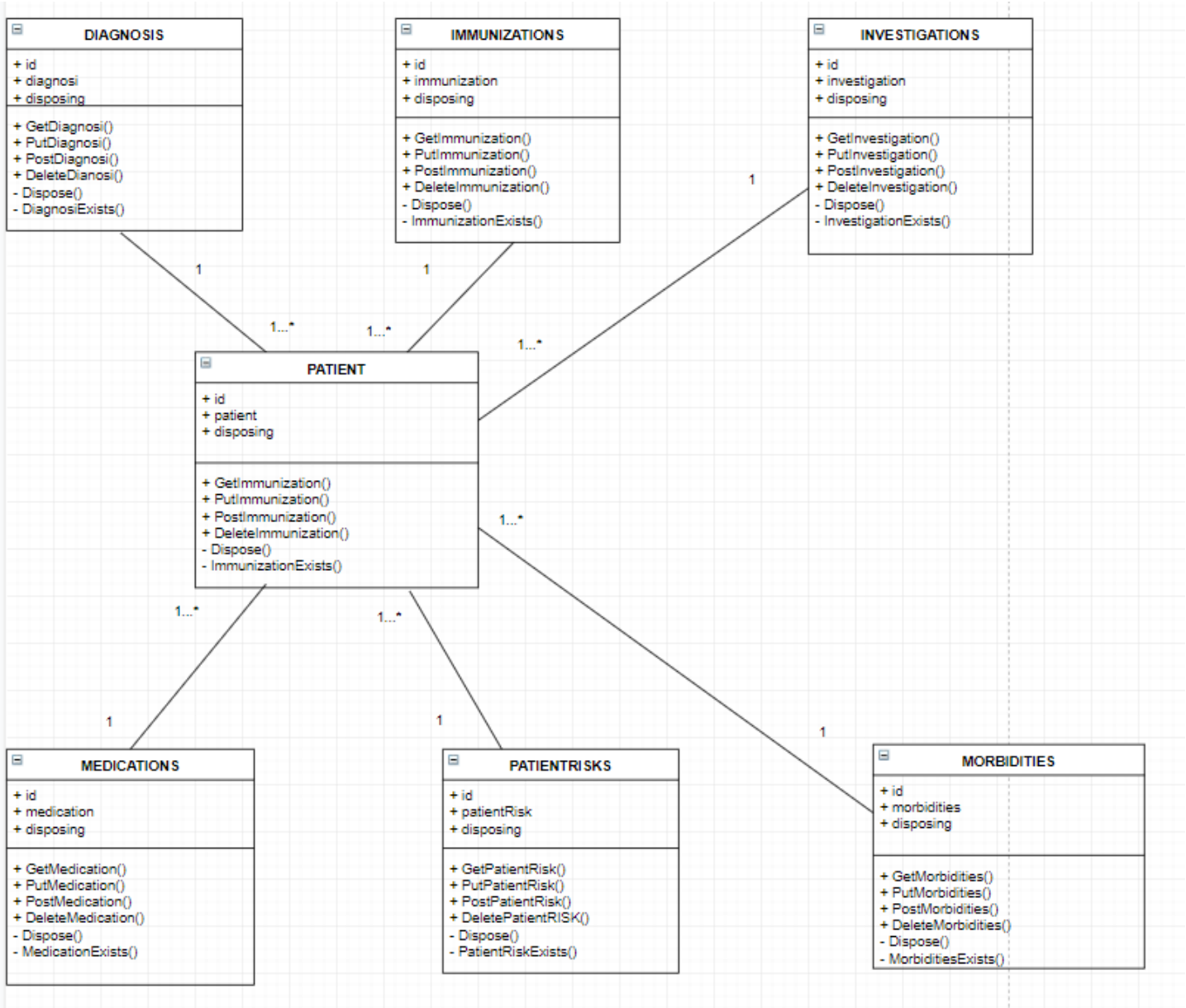
There are many advantages of using MySQL for database storage, below are a few of them:

1. **Data Security:** MySQL is one of the most secure and reliable database management systems.
2. **On-Demand Scalability:** MySQL offers scalability due to which it is possible to manage even terabytes of data with ease.
3. **High Performance:** MySQL has a unique storage-engine framework which allows the system administrators to configure the database server to provide excellent performance.
4. **Round-the-Clock Uptime:** MySQL is extensively used and so has a round the clock uptime and also has a high availability of solutions.

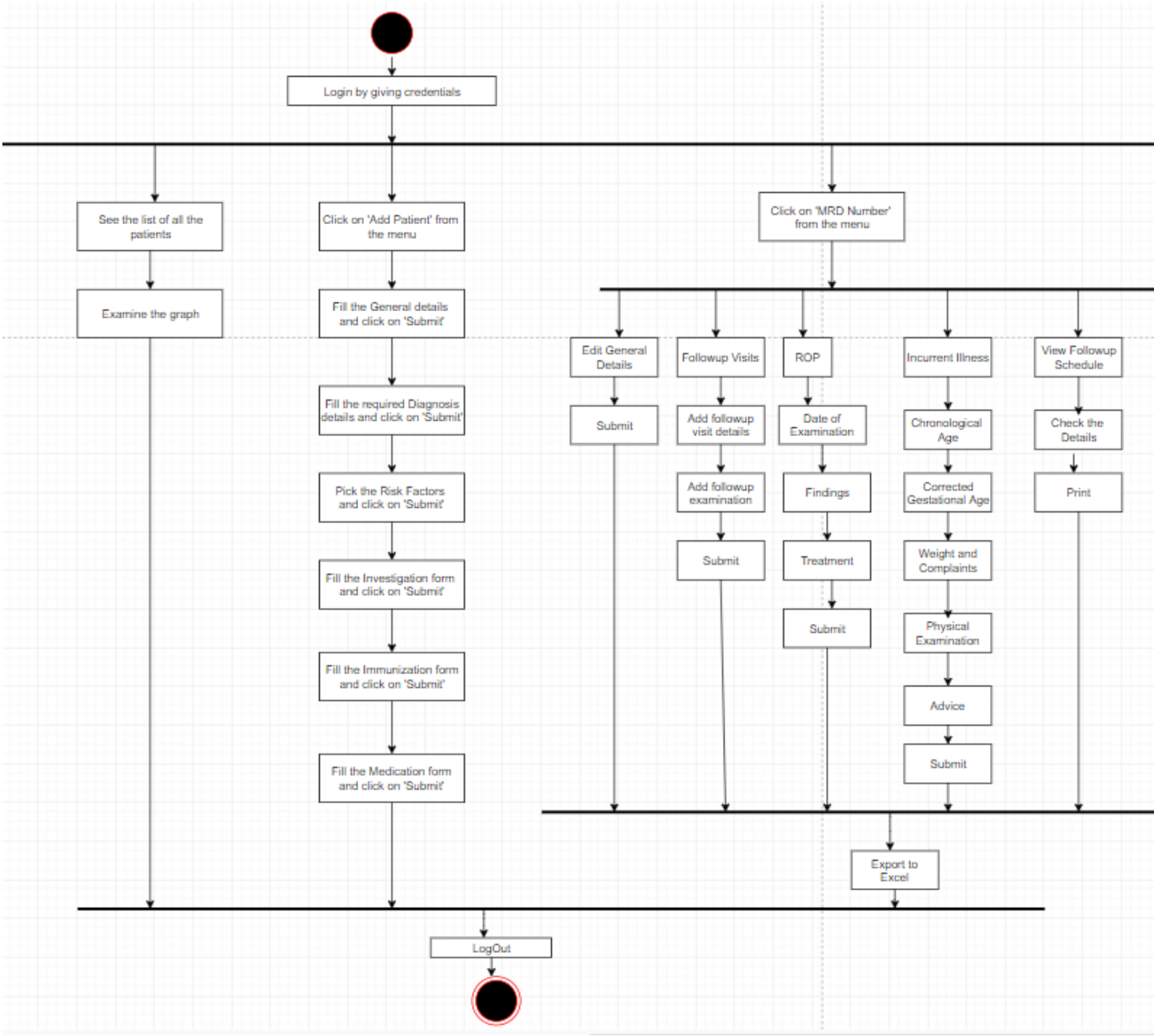
9. SEQUENCE DIAGRAM



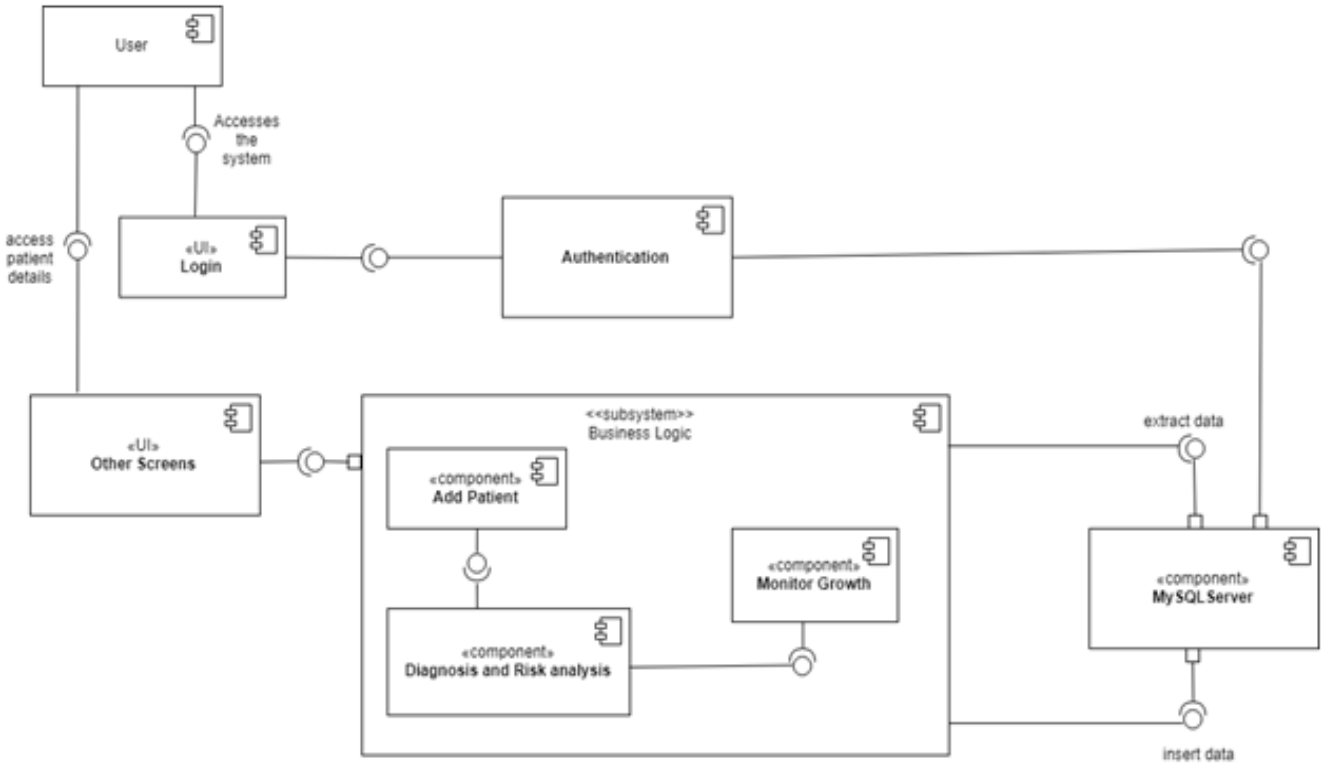
10. CLASS DIAGRAM



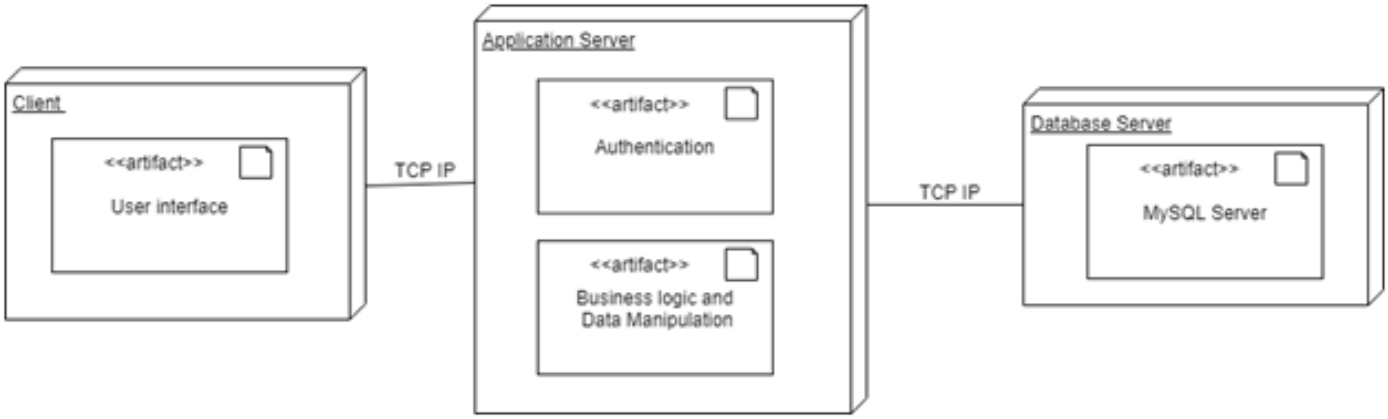
11. ACTIVITY DIAGRAM



12. COMPONENT DIAGRAM



13. DEPLOYMENT DIAGRAM



14. TECHNICAL DOCUMENTATION

a. Programming languages:

User Interface: Angular 7.0, Bootstrap, Typescript

Back End: C#, ASP.NET MVC, Entity Framework

b. Reused Algorithms and Programs:

In the back end code, where ASP.NET MVC is used, we have written web API's. Through Web API's we can have a control of the basic and advanced HTTP protocol messages through their actual and expected way of responses. It also helps in Unit Testing as we can arrive at the point of test case failure immediately. HTTPMessageHandler is the key feature through which we can perform a high level of abstraction. As our project NICU Follow up is designed right now for a limited bandwidth, usage of web API's is definitely a great idea as it makes the architecture very simple for the developers to understand and complete their tasks.

c. Tools and Environments:

The project is mainly created and the main operations are performed in the Visual Studio 2017 in which, the front end development is integrated with the back end code in order to have a successful compilation and error free code. Parallelly, the User Interface code mainly consists of typescript and bootstrap techniques in Angular 7.0. The database is implemented using SQL Server in which all the tables are created and main CRUD operations were performed. We have used the technique of Entity Framework in order to connect the back end code with the database in Visual Studio. As Entity Framework provides us with the code which is auto generated, it helps us in reducing the actual development effort and time of writing the code line by line. LINQ - A querying technique which can be written in the code itself can also be implemented.

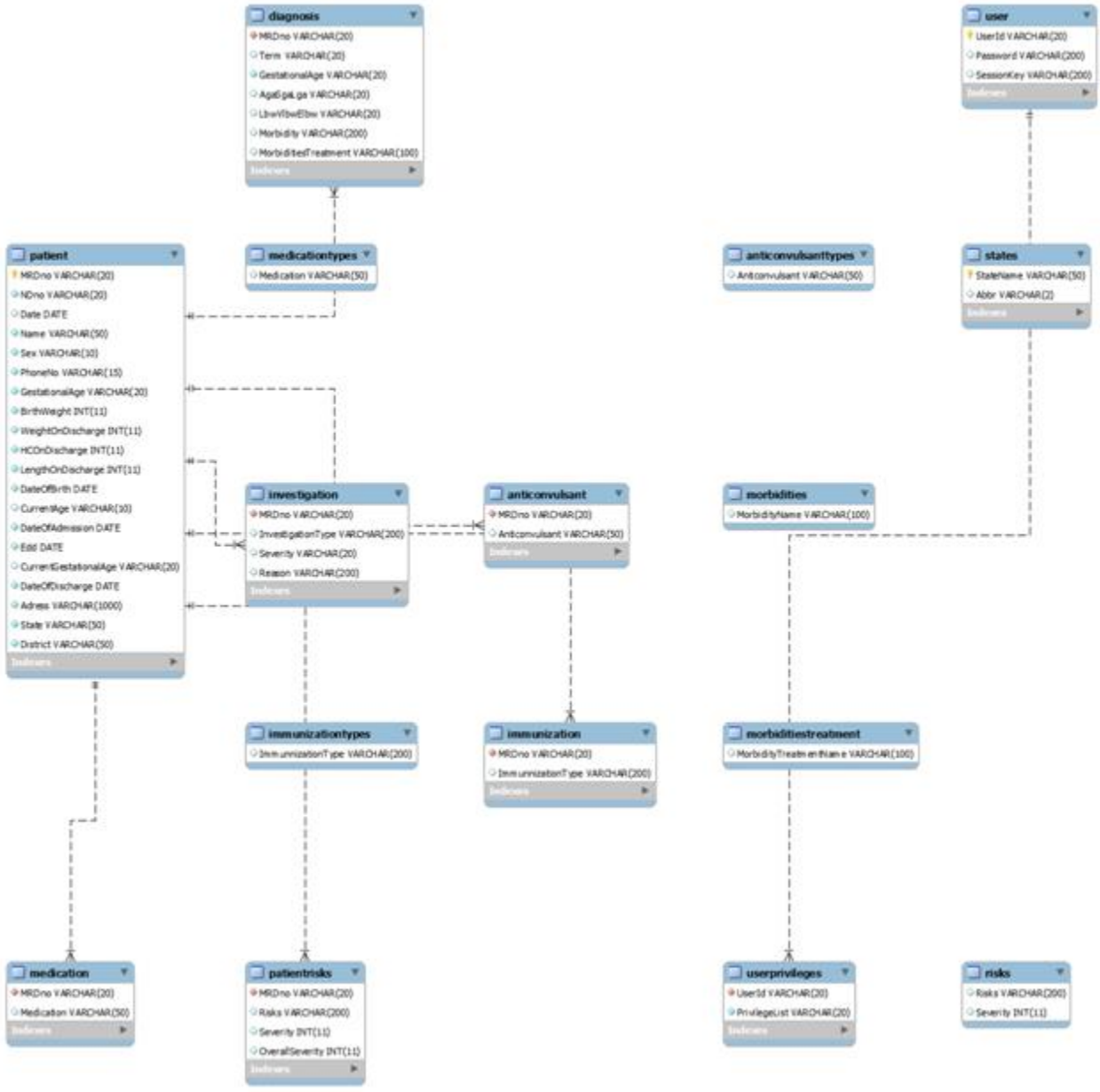
d. Database System:

We have designed a simple database so that it makes the job of the database administrators easy when there's a future upgrade for the project. Tables were created for adding a new patient's basic information, for storing the list of available states, for storing the patient's diagnosis, morbidities, required treatment for morbidities, All the type of risks, risks for a particular patient, required Investigation information, types of Immunizations available, Immunizations pertained to a specific patient, Medication types, Medications a particular patient had undergone, Anticonvulsant types and that are specific to patient.

Here are the list of tables along with their names and structures.

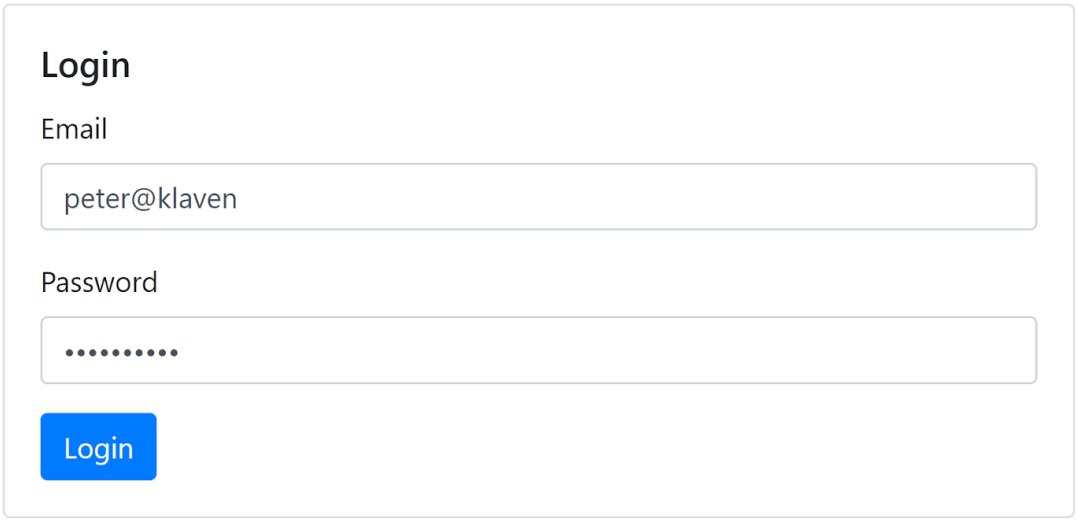
- Patient
- States
- Morbities
- MorbitiesTreatment
- PatientRisks
- Risks
- Investigation
- Immunization
- ImmunizationTypes
- Medication
- Anticonvulsant
- MedicationTypes
- AnticonvulsantTypes
- User
- UserPrivileges

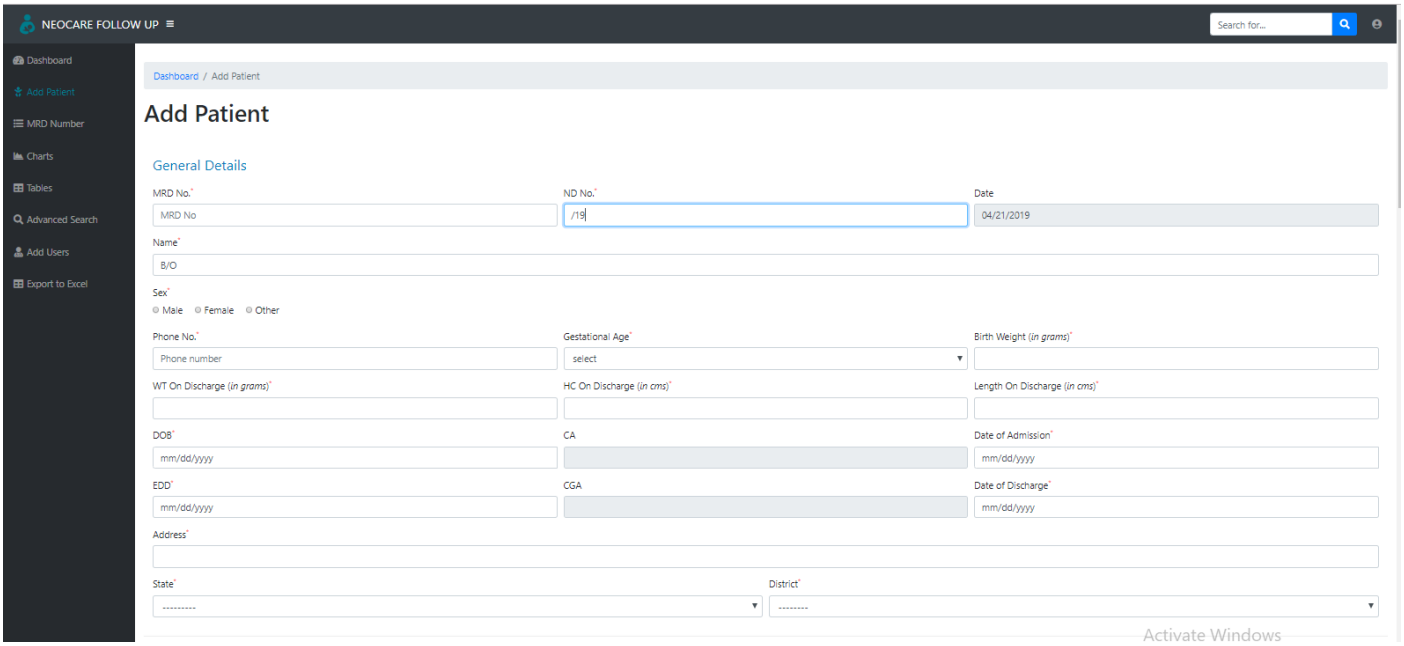
Entity-Relationship Diagram:



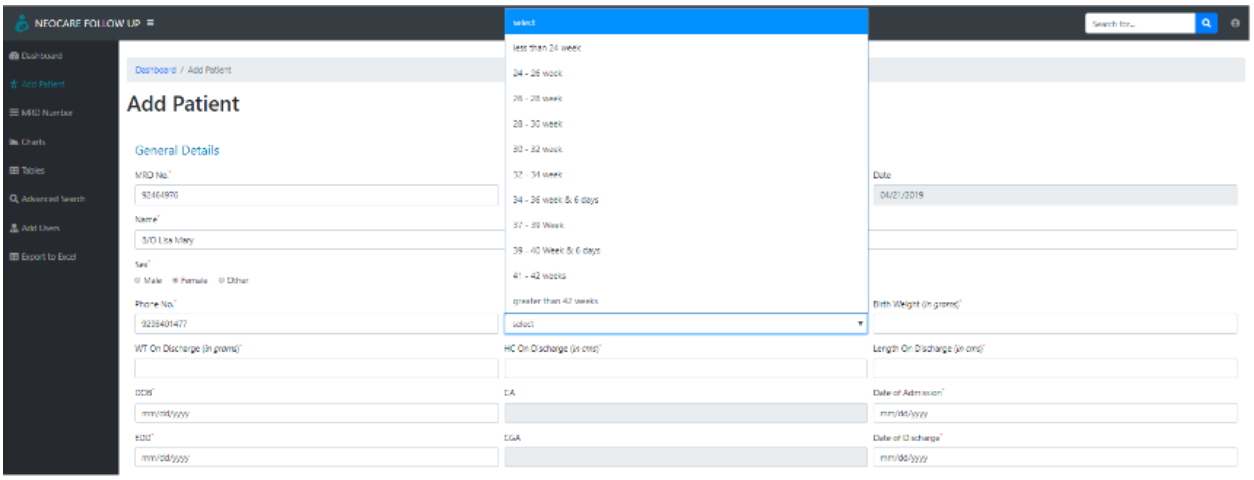
e. User Guide:

On entering the link in the url and clicking enter, the user is displayed with the Login Page. On the user page the user will enter an email id as User id and a password. The user will click Login Button. Based on the data entered if it is a valid the user is redirected to the landing page of the website. If the data entered is incorrect the user will remain on this page and an appropriate error will be displayed.

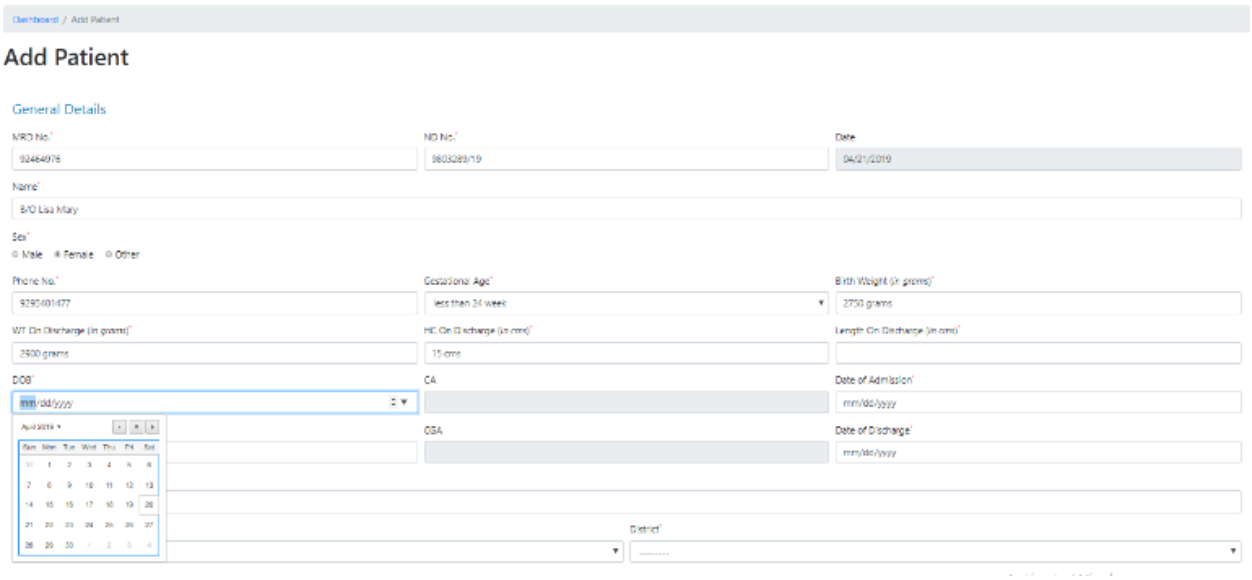




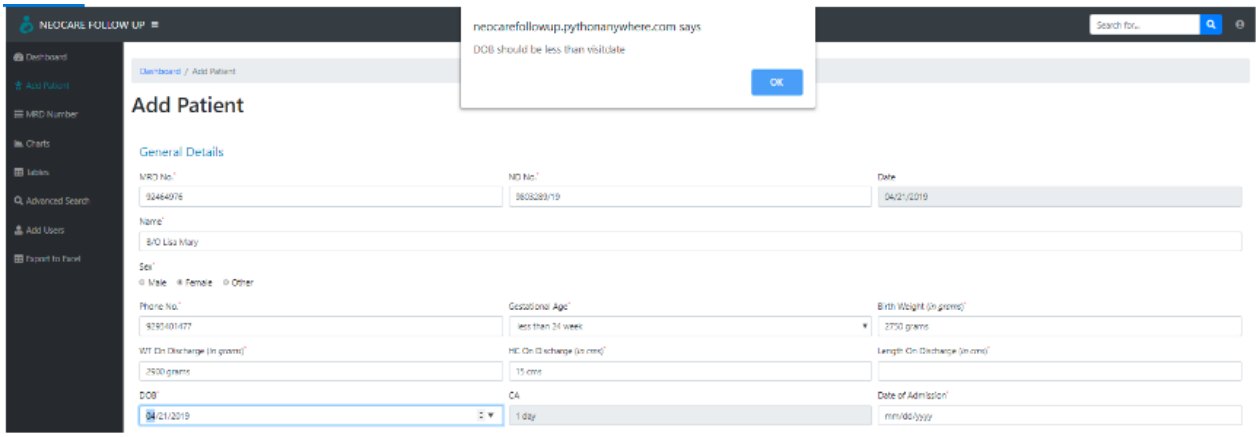
After successfully logging in, in the left pane, click on ‘ADD PATIENT’ for adding a new patient into the system. Give MRD number and ND numbers with proper constraints. Date field will be auto-populated with the current date. Fill in the other details of the newborn like the Name, Sex, Phone Number, Gestational Age, Birth Weight, Weight on Discharge, baby’s head circumference, length of the baby on discharge, date of birth, Address etc.



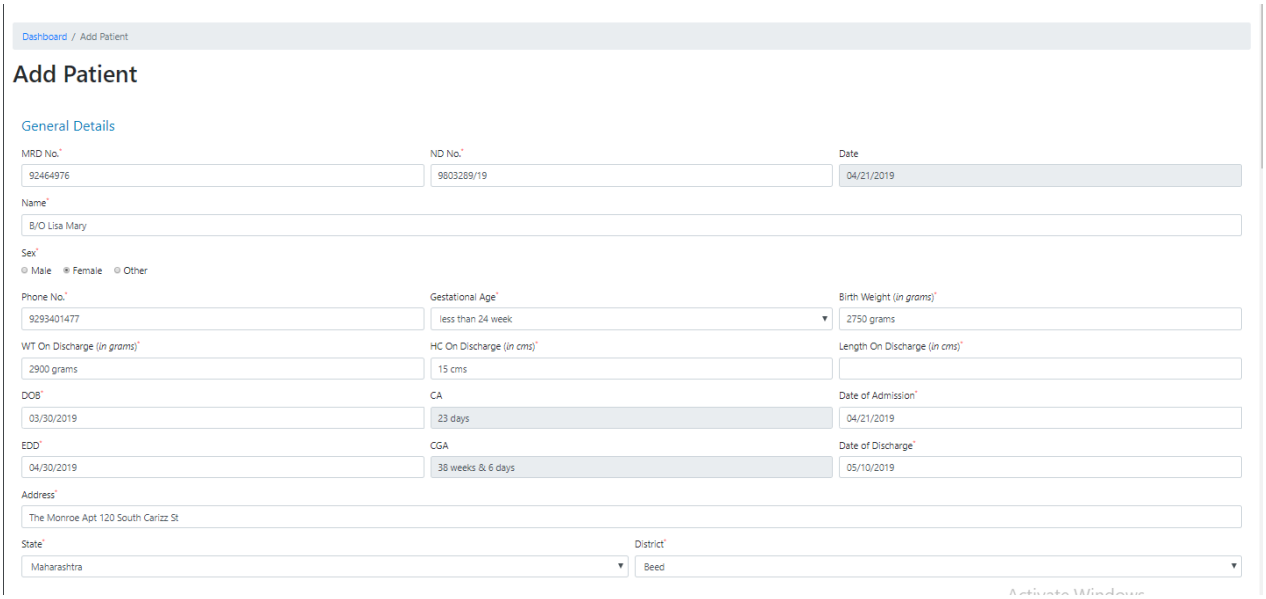
Choose the appropriate gestational age from the dropdown values.



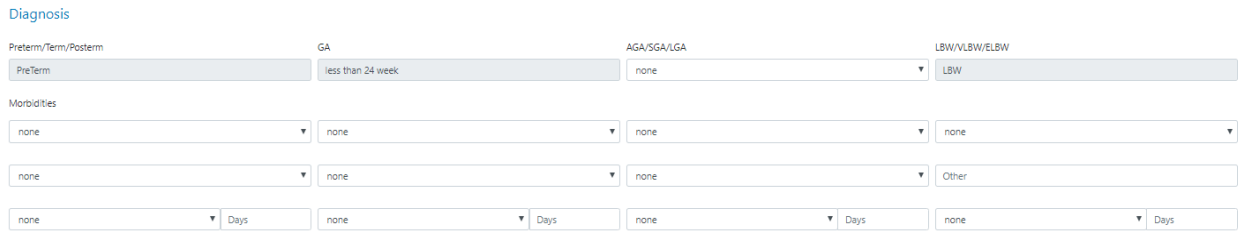
Choose the appropriate Date of Birth.



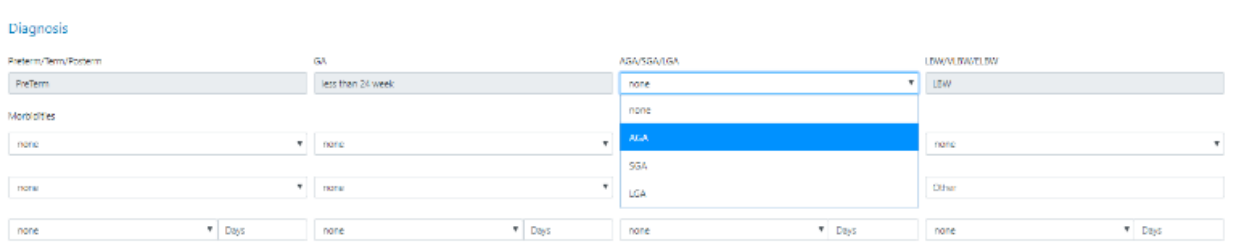
Error message will be displayed if the date of birth is more than the actual visit date.



The above screenshot gives the details, of the screen after filling the basic information.

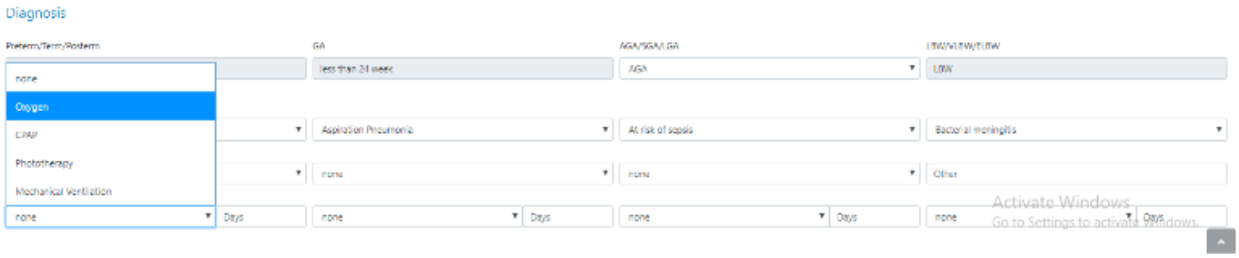


If the Gestational Age is less than 36 weeks the term is set to PreTerm. If it is between 37-41 weeks it is sent to Term and if it is 42 or more it is set to PostTerm.

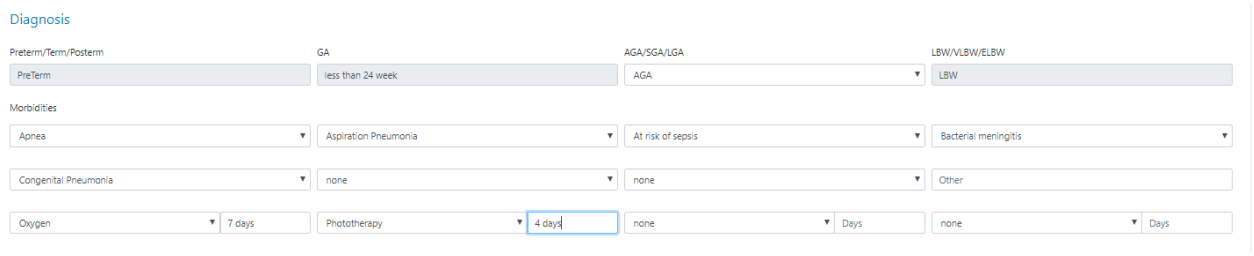


Based on the diagnosis of the baby the doctor will select the appropriate category of gestational age like Appropriate for gestational age (AGA), small for gestational age (SGA) and Large for gestational age (LGA). The LBW/VLBW/ELBW will be

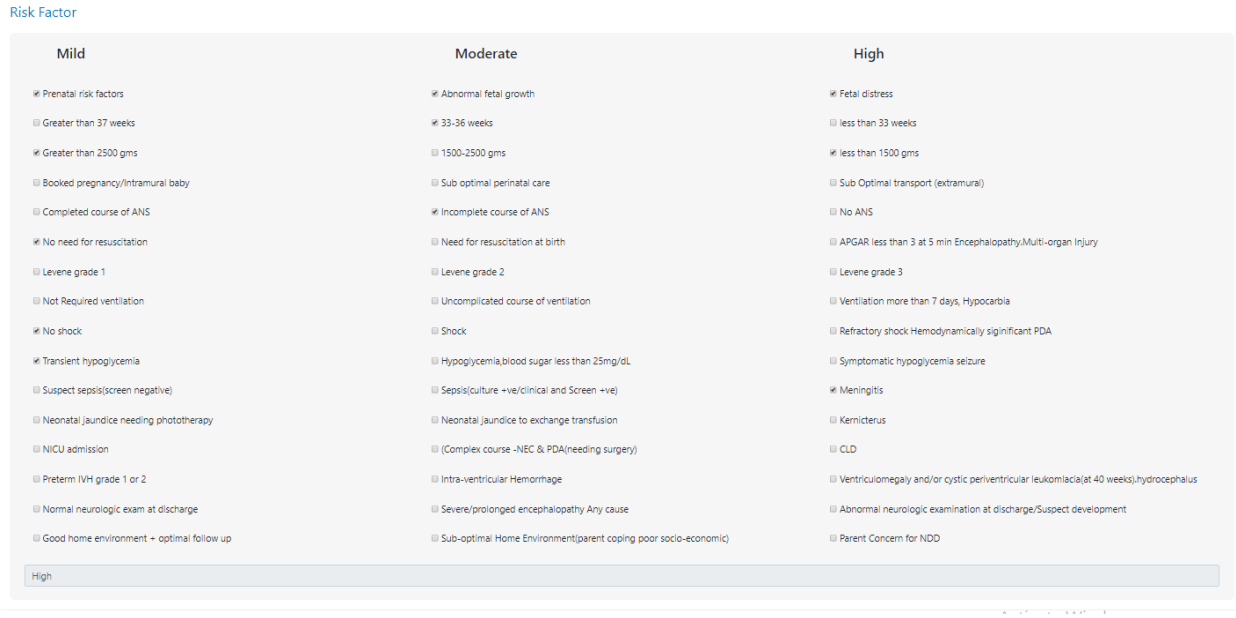
auto selected based on the weight calculated at birth. If birth weight is lesser than 1500 gms then it is categorized into very low birth weight (VLBW) and if it is less than 1000 gms it is categorized into extremely low birth weight (ELBW).



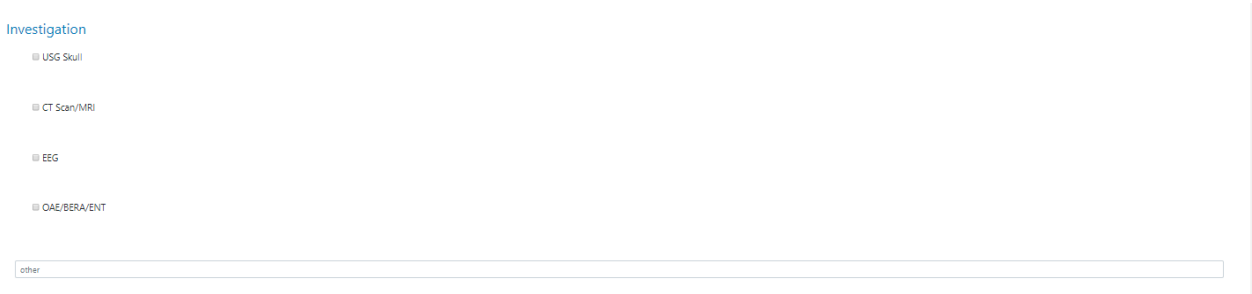
Morbidities are diagnosed and recorded.



The treatment provided for the morbidity and the duration for which it is provided is also recorded.

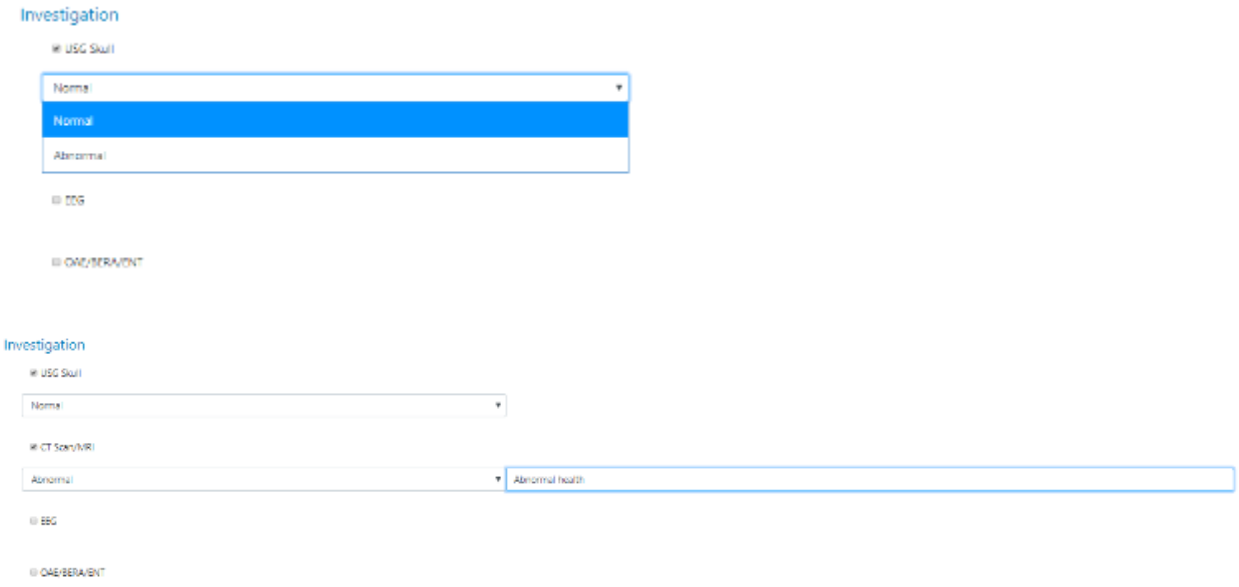


Risks are identified by the doctor and based on the risk selected in the highest category, the overall risk is set. For example if the risks selected are NICU admission, 33-36 weeks and Meningitis which belong to Mild, Moderate and High respectively then the overall risk will be set to High. If Meningitis were not selected the overall risk would be Moderate.



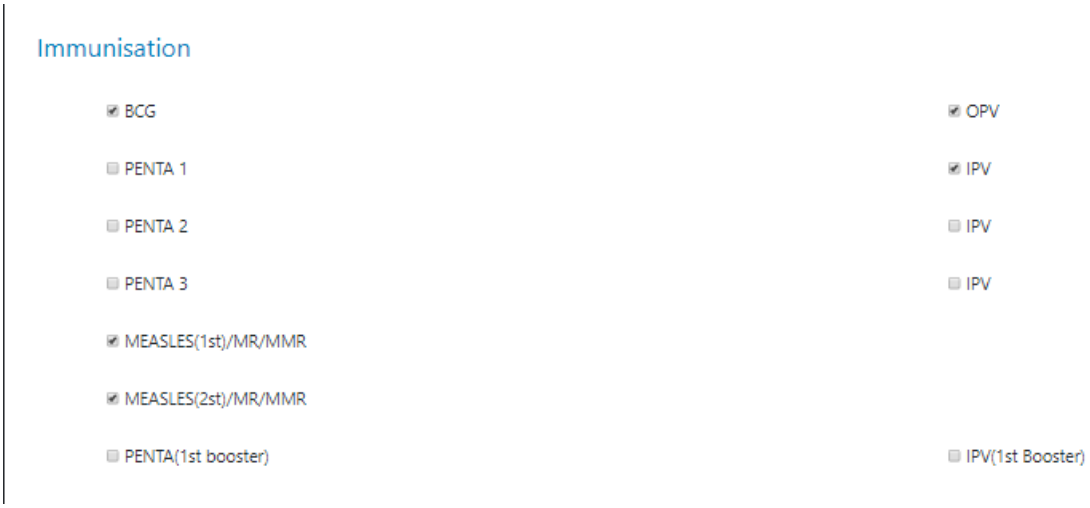
In order to have a detailed understanding of the newborn's health, few investigations are suggested. Check the completed investigations for the newborn.

Choose the appropriate result for the chosen Investigation type.

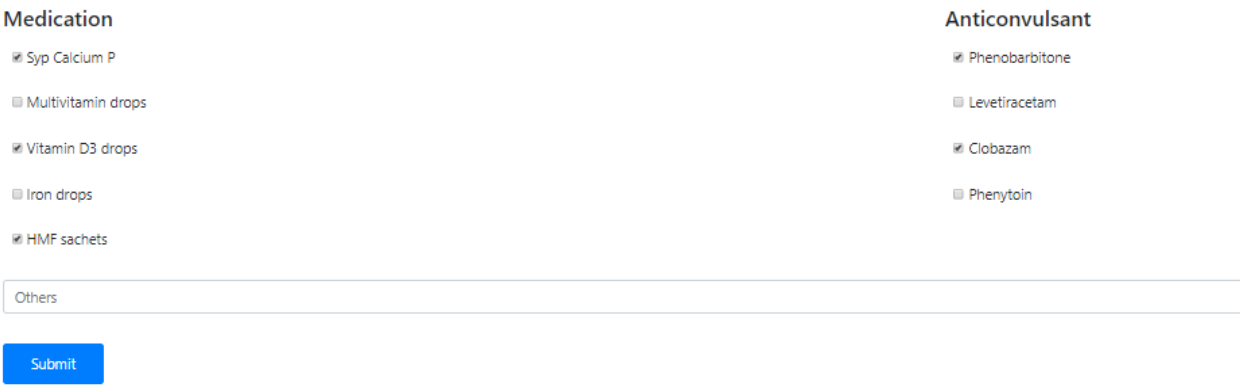


Against the investigation, Write the anomalies that are present.

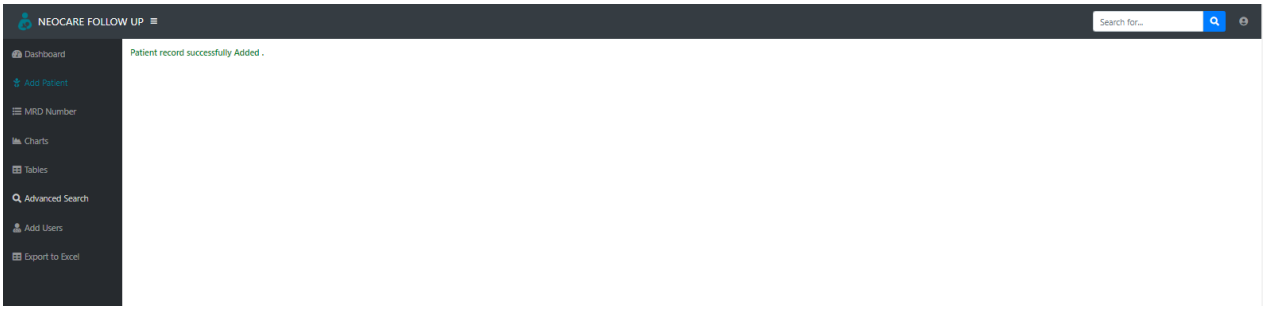
The doctor keeps a record of the immunizations given to the newborn. The type of immunization given is selected from the list and the mode through which the immunization is given is also recorded. These modes include IPV (inactivated polio vaccine) and the OPV (oral polio vaccine).



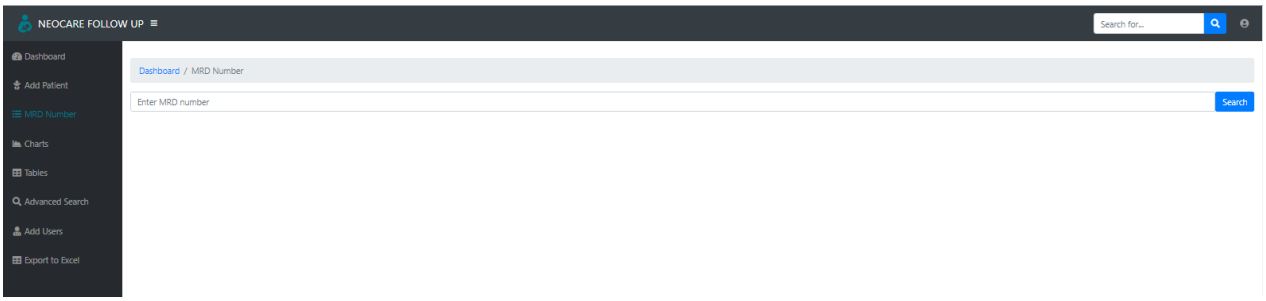
After examination the doctor will advice and prescribe some medication accordingly. These medications and anticonvulsants (if any) are recorded in the system.



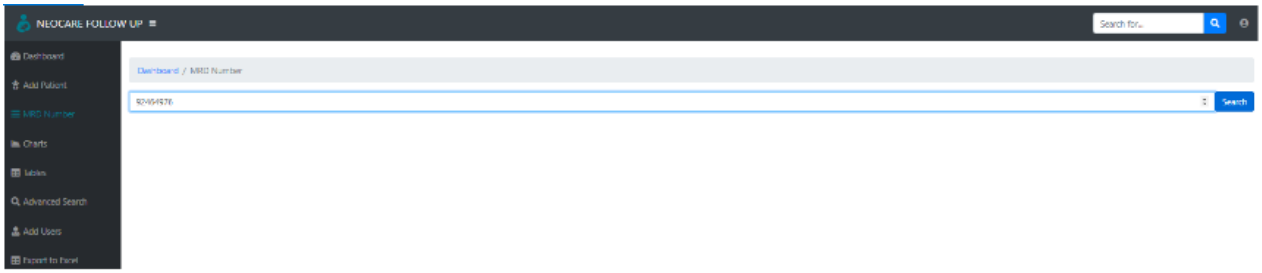
On entering all this data the Submit button is clicked and a record is saved.



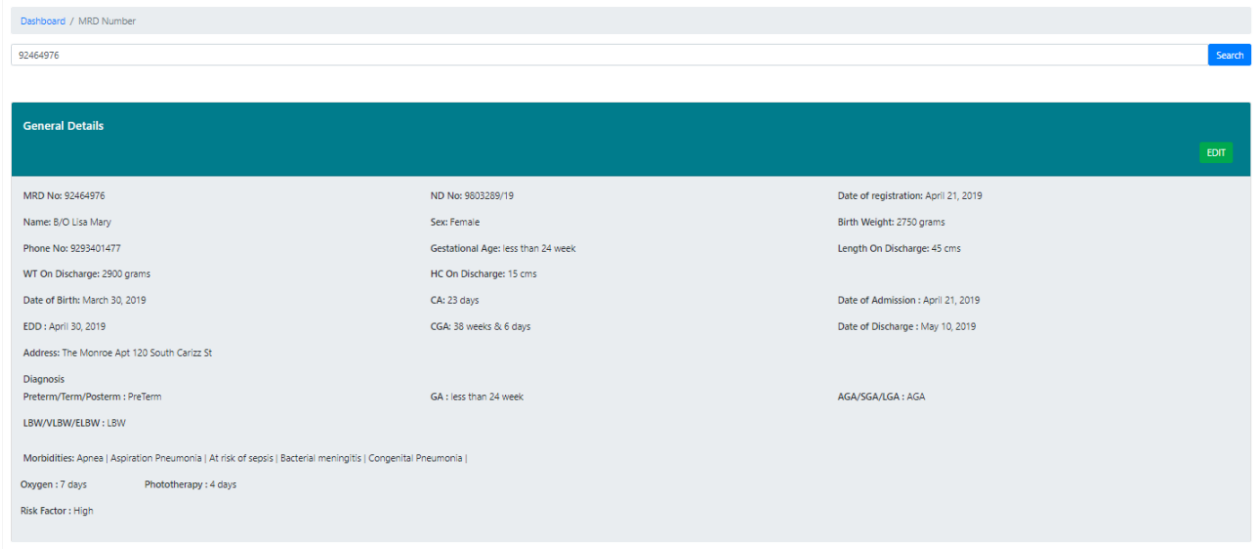
If the record is saved successfully a successful message is displayed, else an appropriate error message is displayed.



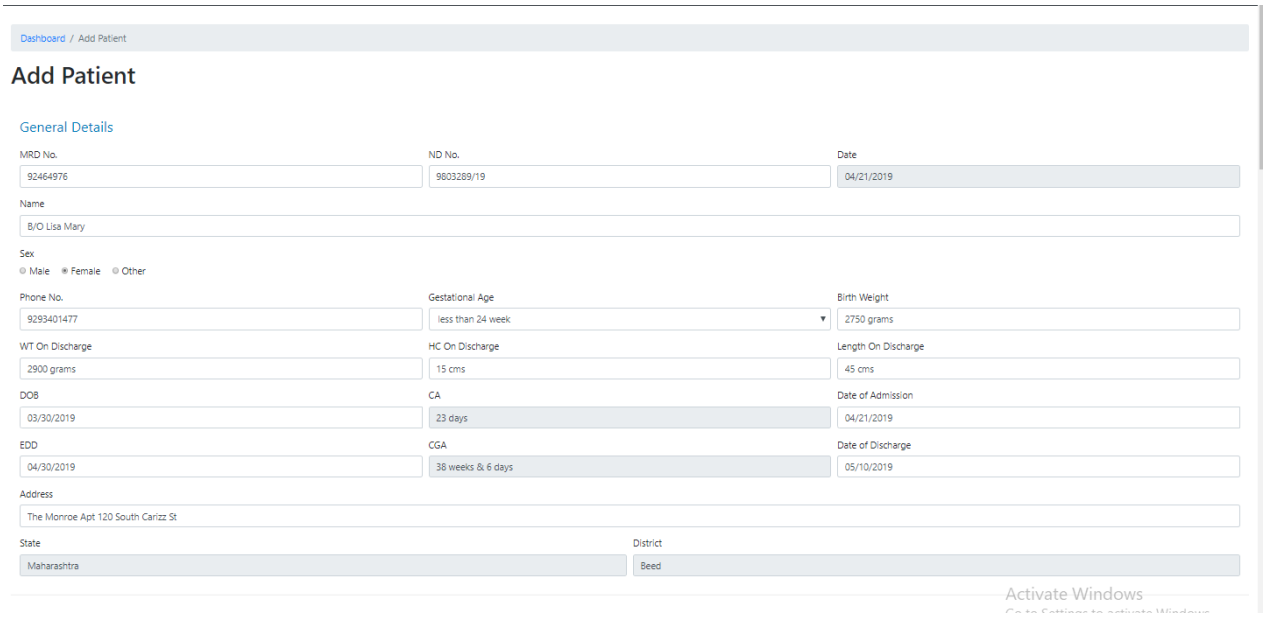
There's also an option of checking and editing the newborn's details by searching with MRD Number. From the left pane, select 'MRD Number'.



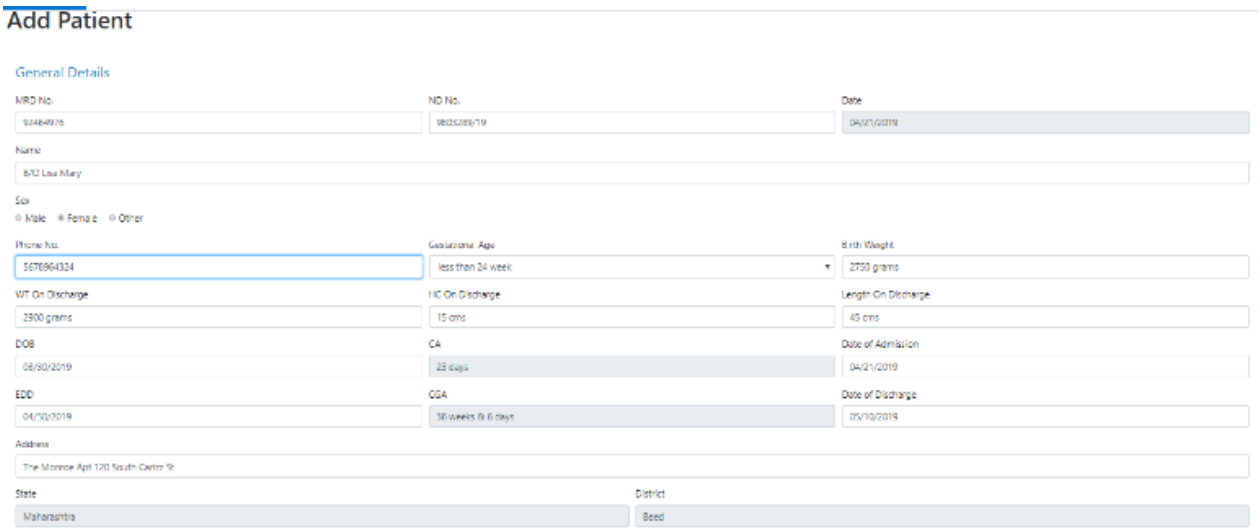
Search by typing the appropriate MRD Number of the newborn.



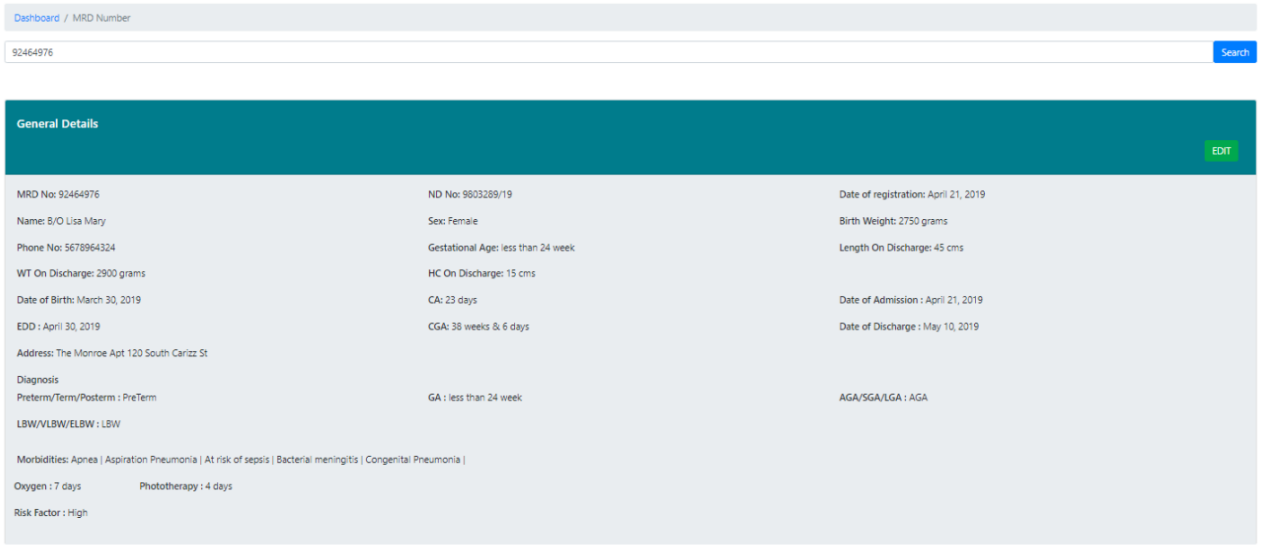
After typing the MRD Number and clicking on Search, the details of the newborn will be displayed. The user will be given an option to edit the details of the newborn if necessary.



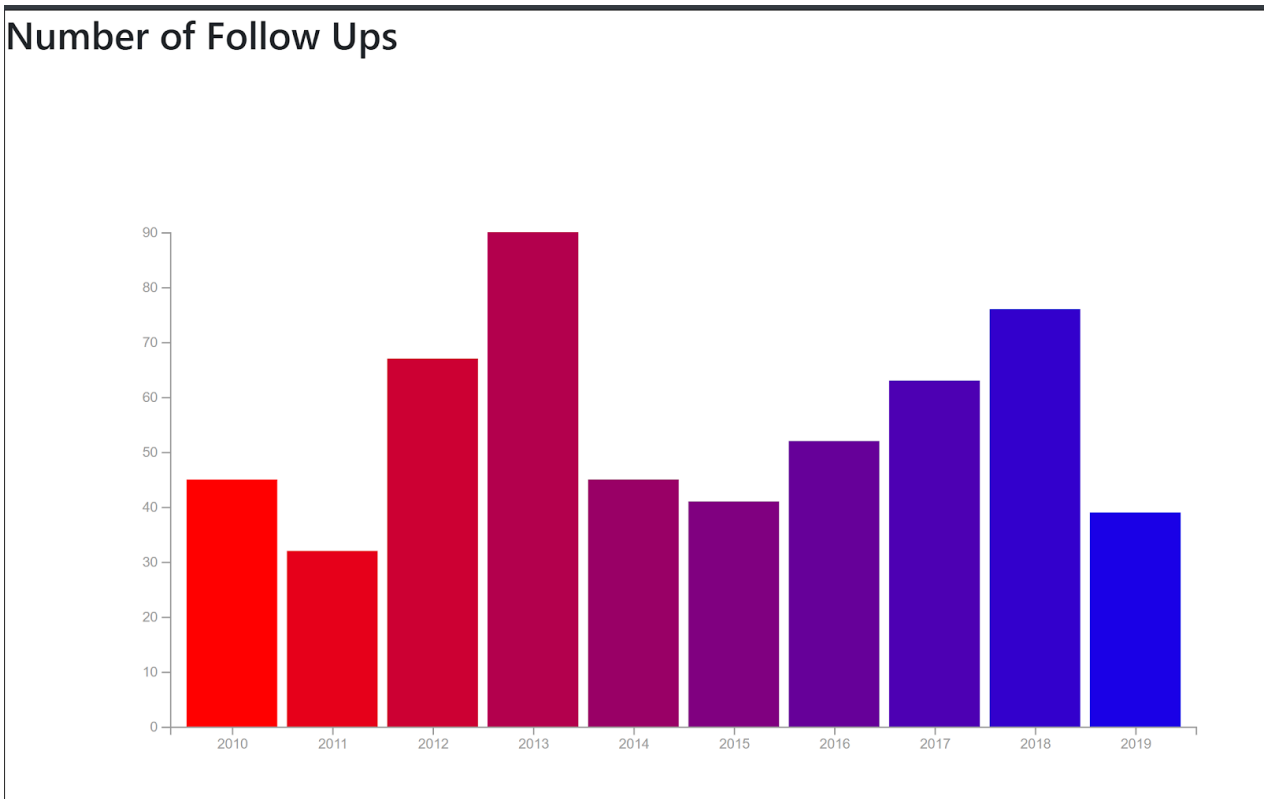
After clicking on the ‘EDIT’ button, the details of the particular newborn will be displayed.



Choose the required field to edit and click on submit. Here, we have chosen the Phone number and updated it with the new number.

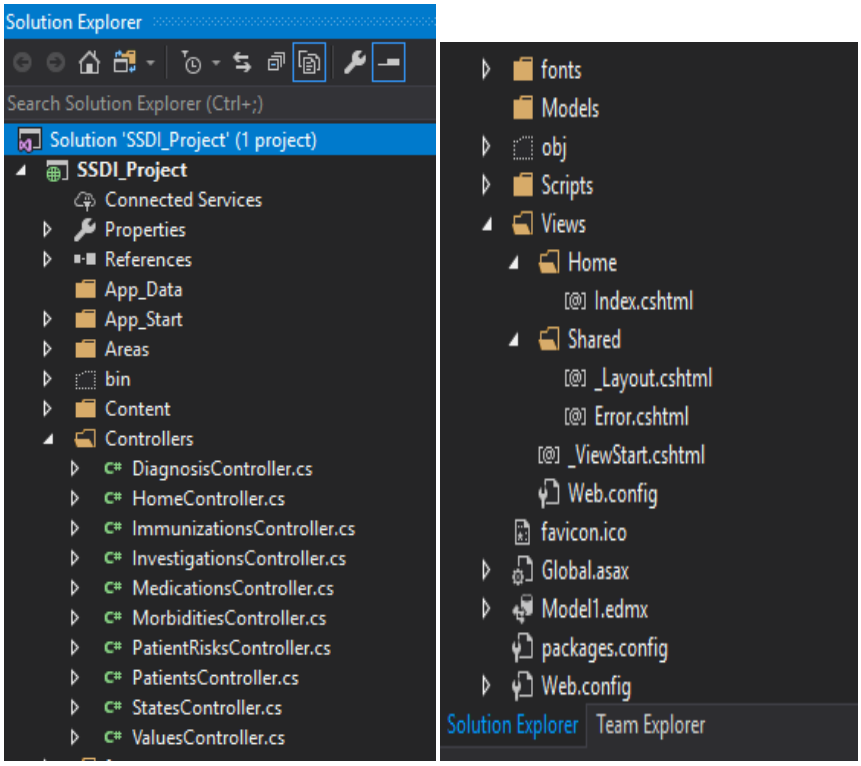


The screen is displayed with the updated information and upon clicking the submit button, an appropriate message will be displayed saying that the patient information is successfully updated.



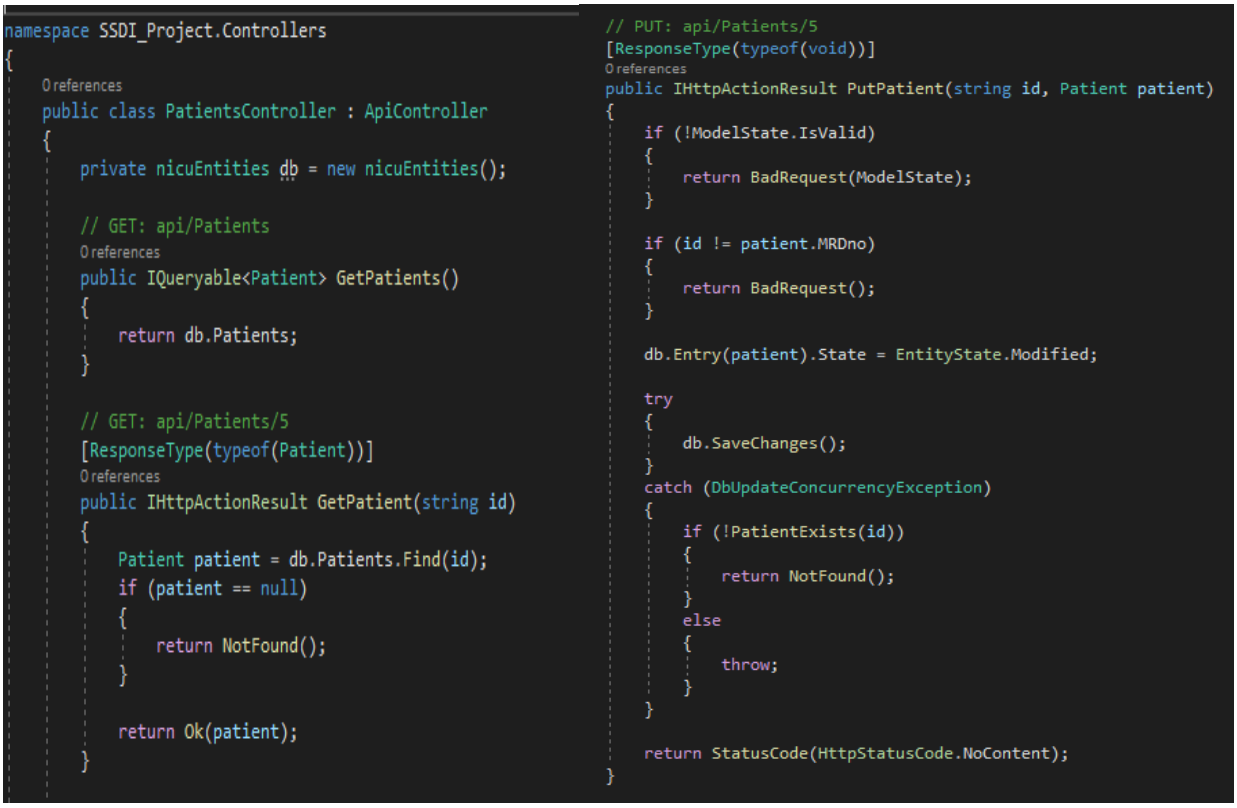
This is a graph displayed on the landing page which shows the number of follow up visits and the Year.

7. **Backend Solution Structure:**



Sample code of the Patient Controller file for reference:

GET and PUT Methods:



```
namespace SSDI_Project.Controllers
{
    0 references
    public class PatientsController : ApiController
    {
        private nicuEntities db = new nicuEntities();

        // GET: api/Patients
        0 references
        public IQueryable<Patient> GetPatients()
        {
            return db.Patients;
        }

        // GET: api/Patients/5
        [ResponseType(typeof(Patient))]
        0 references
        public IHttpActionResult GetPatient(string id)
        {
            Patient patient = db.Patients.Find(id);
            if (patient == null)
            {
                return NotFound();
            }

            return Ok(patient);
        }
```

```
        // PUT: api/Patients/5
        [ResponseType(typeof(void))]
        0 references
        public IHttpActionResult PutPatient(string id, Patient patient)
        {
            if (!ModelState.IsValid)
            {
                return BadRequest(ModelState);
            }

            if (id != patient.MRDno)
            {
                return BadRequest();
            }

            db.Entry(patient).State = EntityState.Modified;

            try
            {
                db.SaveChanges();
            }
            catch (DbUpdateConcurrencyException)
            {
                if (!PatientExists(id))
                {
                    return NotFound();
                }
                else
                {
                    throw;
                }
            }

            return StatusCode(HttpStatusCode.NoContent);
        }
```

POST and DELETE Methods:

```
// POST: api/Patients
[ResponseType(typeof(Patient))]
0 references
public IHttpActionResult PostPatient(Patient patient)
{
    if (!ModelState.IsValid)
    {
        return BadRequest(ModelState);
    }

    db.Patients.Add(patient);

    try
    {
        db.SaveChanges();
    }
    catch (DbUpdateException)
    {
        if (PatientExists(patient.MRDno))
        {
            return Conflict();
        }
        else
        {
            throw;
        }
    }

    return CreatedAtRoute("DefaultApi", new { id = patient.MRDno }, patient);
}
```

```
// DELETE: api/Patients/5
[ResponseType(typeof(Patient))]
0 references
public IHttpActionResult DeletePatient(string id)
{
    Patient patient = db.Patients.Find(id);
    if (patient == null)
    {
        return NotFound();
    }

    db.Patients.Remove(patient);
    db.SaveChanges();

    return Ok(patient);
}

7 references
protected override void Dispose(bool disposing)
{
    if (disposing)
    {
        db.Dispose();
    }
    base.Dispose(disposing);
}

2 references
private bool PatientExists(string id)
{
    return db.Patients.Count(e => e.MRDno == id) > 0;
}
}
}
```

15.FUTURE UPGRADES

The current system helps the doctor to track the health and other medical conditions of the baby. Depending on all the patient's details and information that is present in the database, graphs will be generated where in the doctor can have a vivid idea of the patient's health in general. Number of graphs will be generated that gives information about the patient's medical condition, vaccinations received by them, overall growth from the date of birth till the last visit or the date of discharge, Investigations, Immunizations etc. Through these graphs, the doctor will be able to know the types of diseases the newborns are more prone to. They can also know the highest and moderate risk factors of the patients depending on their age growth. As

the graphs give details of all the patients in general, it helps the doctors to be more careful in case of the diseases and other risk factors of the newborns.

16. **CONCLUSION**

As mentioned above, we have thus created an application which maintains complete history of a child right from birth to the age of 5 years. The application maintains information right from health complications from birth, risks, diagnosis, immunization records and medications given. There are graphs provided for easy analysis of the growth and statistics of follow-ups.

17.REFERENCES

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