Kalim Qureshi[1*], Ebtisam Alazeme[2], Paul Manual[3]

Intelligent Mobile Base Home Doctor Advisor for Babies

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Abstract*:** The healthcare system has adopted the usage of information technology, including mobile applications, due to its reliability, low cost, and time efficiency. Most people are now familiar with mobile applications, including health care organizations and patients. Secure Intelligent Home Doctor Adviser (SIHDA) ***mobile application for Babies is developed under the guidelines of the British Medical Association (BMA). The objective of SIHDA is to provide online support and guidance for mothers and infants at home. Unified Modeling Language (UML) has been used to provide design models for the proposed IS application. As a part of this research, we gather software requirements from various SIHDA stakeholders and define system architecture and models. We developed different models, such as Use Case diagram, Activity Diagram, System Sequence Diagram, Entity Relationship Diagram, User Interface, Interactive Diagram, and Class Diagram. The proposed system is secure and intelligent. The system monitors the babies at home. When the baby becomes uncomfortable, it proactively alerts the parents/guardians and advises for immediate action. In addition, the system can determine the vaccination date and type based on the child's age. The system also alarms ambulances from the nearest hospital in case of emergency. The usability of the design models of the developed system was evaluated by software engineers, and the acceptance rate was 84.8%.

***Keywords*:** Intelligent Health Adviser, Doctor Information System, Child Care System, Mobile-based Health Care Application, Secure Application Development.

I. INTRODUCTION

The usage of mobile applications has been growing rapidly recently in different fields [1-11]. Nurturing infants is always a challenge to parents [15]. If the infants are not properly cared for, needless to say that the consequences are severe. The counselors say that infants require proactive care. This online mobile application intends to minimize the expenditures spent for home doctors. This is a sensitive issue because no insurance covers the expenses of home doctors for infants [16].

In this research project, we decided to develop a mobile application that works as a family doctor or home advisor, helping families determine the possible cause of a symptom and what to do. The mobile based such system will save a significant amount of time while also increasing the likelihood of them receiving the medical advice they require at home. This would improve both their quality of work-life and their productivity. Knowing the child's problem would reduce the probability of its existence without any compelling or dangerous reason. Answering the questions in this application will help you to distinguish between minor problems and conditions that need immediate medical attention [17].

According to the British Medical Association (BMA), the Family Doctor Home Adviser guideline [18]. The developed system supports 10 health cases for one-year-old babies' routine health issues such as Sleeping problems, Excessive crying, Fever in babies, Rash with Fever, vomiting in babies, Diarrhea in babies, Feeding problems, slow weight gain, Skin problems, Eye problems.

II. MOTIVATION

Babies usually get sick frequently. Most families, especially those who have a child for the first time, don’t know how to deal with health issues. Some health issues are emergencies, and you must deal with them in a specific, step-by-step manner. Because babies are so sensitive to any changes, people feel scared to deal with baby health issues and prefer to have a guide or manual to direct them and help them. While vaccination is very important for children, families need to have a reminder about the vaccination dates for their kids. In urgent cases, people need to know the locations of health centers, clinics, and hospitals.

The application that we are developing provides the users with some services related to their baby’s or kid's health care. The application allows the family to view common health cases and what to do in that situation. Users can answer some questions related to the symptoms that the baby has, so the application will suggest a possible cause and action. The application can remind families of their children's vaccination dates. The application also allows users to view a list of the close health centers to help them in urgent cases.

The paper is organized as contains an introduction, motivation, and an organization of the paper part first. Secondly, gives an overview of the current related work that investigates the efforts of other researchers to develop an Intelligent Home Doctor Adviser Information System for newborn babies' application. Thirdly, we analyzed the proposed system and determined the system requirements. We provide a table of other related system features comparison to extract existing and innovative features. In addition to the intelligence of the system and functional requirements. Furthermore, contains Babies' Routine Health Issues. In this part, we follow the British Medical Association guidelines, to support 10 health cases for one-year-old babies with routine health issues. We provide several flowcharts for each case, but we will show and explain the flowchart of fever in babies. Moreover, we provide illustrative design models of the proposed IS application and we applied different models, such as analysis diagrams and design diagrams. Lastly but not least, we discussed the different types of tools that we have used in the system. In addition, the result of the implementation will include a screenshot of the result of the system implementation. Finally, the usability of the system will be discussed.

Table 1: Recent developed mobile applications in healthcare

Ref.	Author contribution	Remarks
[1]	Personalized mobile health for elderly home care	A systematic review
[2]	Smartphone App integrated into primary child health care to promote healthy diet and physical activity behaviors and prevent obesity in preschool-age children.	Smart App developed to monitor the diet and obesity of school children.
[3]	Hand Hygiene observation system	A free Mobile application improves the efficiency of hand hygiene observation collection.
[4]	Improve pediatric asthma care through asthma apps	The asthma app developed adheres to clinical practice guidelines for the management of asthma.
[5]	Remote blood pressure data collection and monitoring system for expectant mothers.	Apps development to monitor the expected mother blood pressure.
[6]	Health management of heart failure patients guiding cardiac rehabilitation	Developed an app for cardiac rehabilitation
[7]	Mobile Health technology in early detection and diagnosis of oral cancer	Apps development of oral cancer.
[8]	Nutrition-related mobile application for daily dietary self-monitoring	Apps are developed to compute calories for daily dietary self-monitoring systems.
[9]	Intelligent mobile patient health monitoring system	Embedded technology-based mobile patient health monitoring such as temperature, heartbeat, etc.
[10]	Mental Health Mobile Information System	Contraction of rural left-behind children’s mental health mobile information system based on IoT.
[11]	Mobile-based maternal healthcare management system	Develop pregnant women heath management system
[12]	Mobile-based system development to evaluate the physical fitness of students	Development of an APP to evaluate the physical fitness of students.

III. LITERATURE REVIEW

In this part, we investigate the efforts of other researchers to develop similar nature systems. Recent references were chosen, and a brief comparison was made. In addition to providing two tables, one of them indicates a set of references and authors' major contributions and our remarks. The other tables show the features supported by the developed system of same nature. The feature also cross list with our proposed system to justify the innovativeness of the system. Mobile technology has been used for many health care applications developments, as shown in Table 1 applications [1-12]. But there is not enough effort to develop a home care information system for baby.

In [19] discuss the situation before the COVID-19 pandemic and that there were few visits to health care providers. Telehealth is a solution that has increased dramatically during the pandemic. Nowadays, healthcare systems have begun to seriously think about financial solvency after the occurrence of the pandemic.

Author developed mobile healthcare applications [22] has been noticed to be an essential part of innovation that could assist patients with their daily life healthcare management. It is proved that these mobile applications increase the effectiveness of the whole process and reduce the costs of healthcare delivery. It also prevents illness through behavior change and awareness among patients. This study adopted an Object-Oriented Analysis development methodology for Android platforms to design the application proposed for the same issue.

The demand for people's health increased [21] due to the material living standards improvement. Anyways, the hospitalization traffic has not been resolved yet and this made hospitals a heavy space causing an overload on the hospital entities. A family doctor app has been developed by the authors to resolve this problem. This app is designed to act as a medical health service with the integration of new technologies such as the Internet of Things (IoT).

Author [29] express child health and maternal indicators have been the international targets set by the UN in several developing countries. This was a part of the Millennium or Sustainable Development Goals. This is due to the fact there is a lack of information and non-standardized maternal health record that has a negative effect on the quality of data. The main aim of this study is to design and develop a standard and compliant data access model for maintaining this challenge and to enable an effective data exchange for the healthcare system.

Thompson [23] describes children-in-Care is known for being at a higher risk of not having the sufficient health needs that should be met than the general pediatric population. For that, a study has been conducted to reveal the evidence of the same challenge and it was found that health information is essentially needed for an initial assessment for children-in-care. The methods and frameworks used in this research are useful for foster parents, medical care providers, and social workers.

The study [24] introduces a friendly-user web app known as the Doctor Advisor that allows users to search for different doctors in developing countries in a matter of seconds. It shows usefulness in hospitals, clinics, consultancy about patients, doctor agencies etc. To create an appointment, patients can directly do that through the website and have a patient ID after signing up. The patient will finally get the appointment letter to be brought to the doctor or only bring the Patient ID.

The book [25] focuses on major research within the biomedicine field and explores the various information and knowledge developed for strategies about consultation systems. It particularly focuses on the medical consultation challenges and how to overcome them. Furthermore, it focuses on the formulation of new schemes known as EXPERT and the application of these schemes in building more models related to the same field. It also shows the essential role of AI in the field of medicine.

The main objective of this study [26] is to evaluate a mobile health application. This application assists in employing the various elements of social game design that could praise medical care for unresolved challenges and symptoms. The study included two phases and the results of them showed satisfaction and feasibility intervention.

Table 2 : Other related systems features comparison

Features	Ref. [23]	Ref. [24]	Ref. [25]	Ref. [26]	Proposed SIHDA IS
Medical advisors	✓	✓	✓		✓
Medical assessment	✓	✓			✓
Health management systems			✓		✓
Family doctor app			✓		✓
Video calls				✓	✓
DB management systems	✓	✓	✓		✓
Resolve cases for newborn babies					✓
Vaccination Reminder					✓
Detect the closest hospitals					✓
Secure					✓
Total features out of 10	3	3	4	1	10

It was concluded that mobile apps could greatly promote the health management system among teenagers that have unresolved concussion symptoms. There has been an explosion in health promotion apps and technologies related to them in the form of smartphone applications that support health behavior change [27]. There have been many innovative and new approaches that support childhood weight management specifically. Anyways, the current industry research and studies revealed a lack of basic behavior change in apps theory and evidence. This study came to address the gaps, design and develop new evidence and theories through user-centered healthy eating apps that target patients for childhood weight management. The related work gave an insight into the recent developments in this field. It was noticed that there was no past work that was encountered speaking about giving assistance to new-born babies. This generated the main objective of this project, which is to design a new app that can be described as a family advisor for the common diseases that new-born babies might encounter and provide the proper guidance on how to deal with these diseases or common symptoms for a healthier family. Table 2 shows the cross list the features and with proposed SIHDA information system.

IV. SIHDA SYSTEM DEVELOPMENT METHODOLOGY IN STEPS

1. The British Medical Association guideline “Family doctor home advisor” is used to build the system. We selected ten important cases for newborn babies from the guidelines.
2. From the related work, we extract the features of similar existing systems and compare these features with those of the SIHDA system.
3. From the related work, we identify the function requirements of the SIHDA system and add the nonfunctional requirement (security).
4. Before building the system, we developed UML diagrams such as the Use case, activity, and system sequence of the SIHDA system.
5. After completing the building and testing phase of the SIHDA system, it is evaluated using standard usability test matrices.

IV.I. SECURE MOBILE APPLICATION

An increased adoption of mobile health and ubiquitous health systems in increasing. However, mobile application in health systems face significant challenges related to data security and privacy that must be addressed while designing the system [13]. The mobile application has the following security issues [14]:

- Improper platform usage and poor code quality
- Insecure data storage, communication, authentication, cryptography, authorization. Mobile health care application requires the following essential security components [4]:
- Identify the system's users and their access rights
- Maintain an operating environment for authorized users and the processing system by protecting the system from different attacks. Protect the information in the systems' database and during transmission in internal and external networks.

IV.II. PROPOSED SIHDA MOBILE APPLICATION

We applied 10 cases related to babies less than one-year-old. We follow the British Medical Association guideline to support 10 health cases issues such as:

- Babies' sleep problems
- Excessive crying in babies
- Fever in babies
- Rash with Fever
- Vomiting in babies
- Diarrhea in babies
- Feeding problems in babies
- Slow weight gain in babies
- Skin problems in babies
- Eye problems in babies

We developed the flow charts of diagnosis of individual cases, but here we can show the diagnosis flow chart of fever for babies in Figure 1 as a sample.

Table 3. : Existing and innovation features

Existing features from other researchers' work	**Innovative / Indigenous features**
• Providing medical care • Family doctor app • Children-in-care • DB management systems • Deep Learning	• Resolve cases for newborn babies. • Provide 10 cases with their solutions. • 'Reminder' for an upcoming vaccination. • It can locate the closest hospitals/clinics. • Intelligent

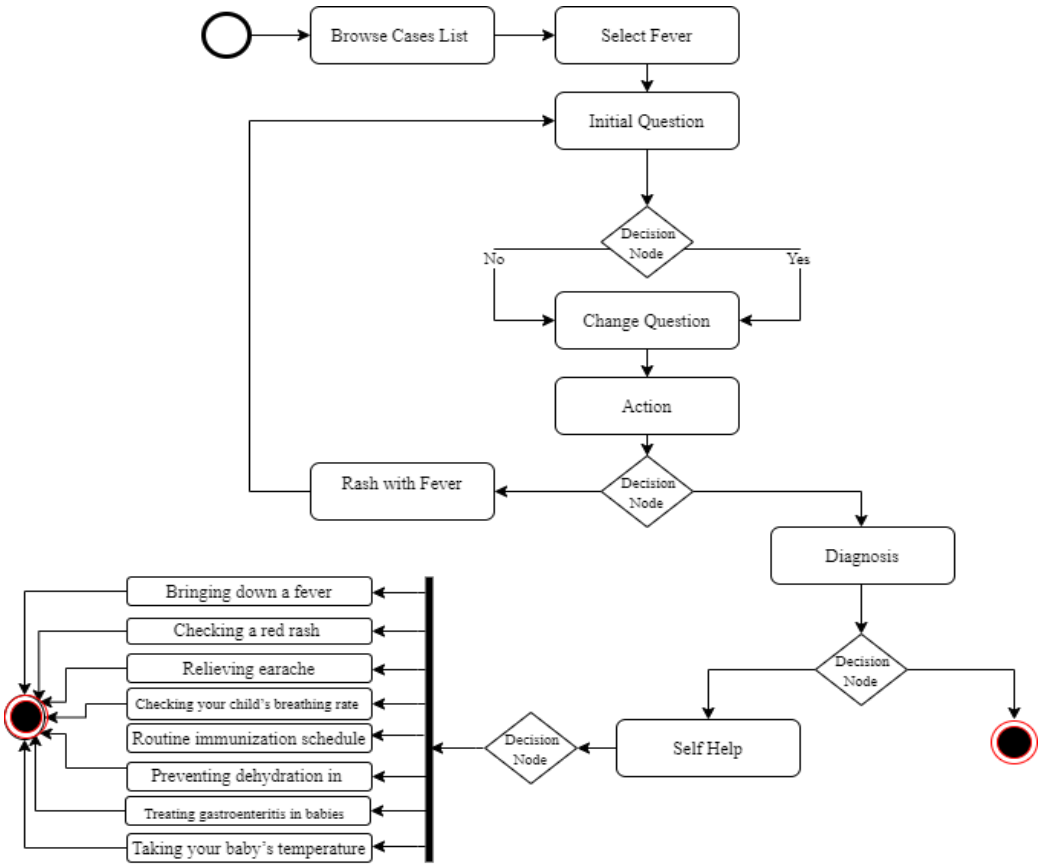

Figure 1: Diagnosis Flow Chart of Fever for Babies

The intelligence of the system in the Fever of babies is shown in Figure 1:

1. The system will start asking the User multiple questions about the child's health condition,
2. The system can move from one question in one case, to another question in another case.
3. The system can move from one case to another case if there is no complete solution. for example, Moving from an existing case (Fever) to a new case (Rash with Fever).
4. The intelligent system provides self-help for specific diagnoses dependent on each action, such as: bringing down a fever, checking a red rash, relieving earache, checking your child's breathing rate, preventing dehydration in babies, treating gastroenteritis in babies, taking your baby's temperature, routine immunization schedule or fever after immunization.
5. The system can determine the vaccination date and type based on the child's age.
6. The system can display hospitals in order of proximity to the user.

The proposed system consists of two major components, which are, i) some existing features from other researcher work and ii) a few innovative features. The list of components is shown in Table 3. Below is the list of SIHDA functional intelligence requirements.

IV.III. FUNCTIONAL REQUIREMENTS OF SIHDA MOBILE APPLICATION

1. The system should allow the user to create new accounts
2. The system should allow the user to login into their accounts using their identity (Username & Password)
3. The system should allow the users to create more than one profile
4. Users will be able to view a list of the main cases.

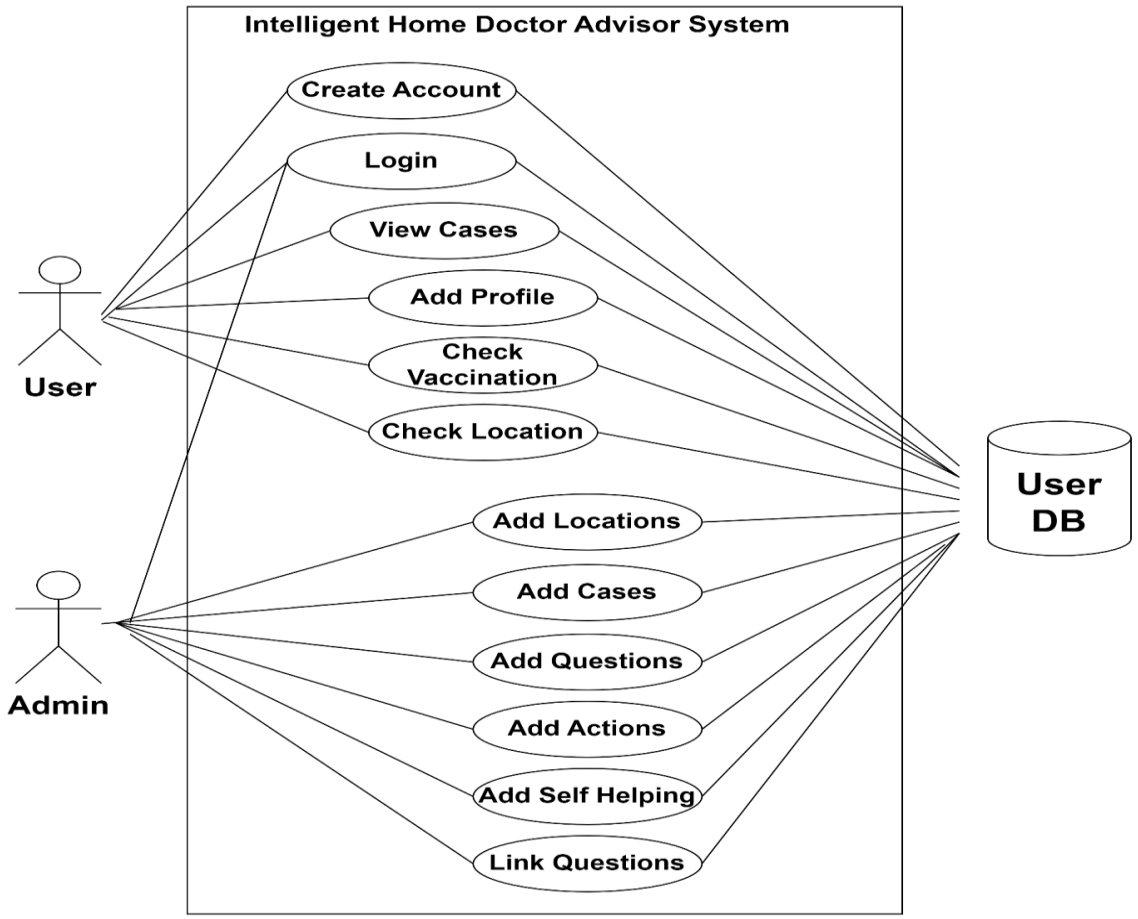

Figure 2: SIHDA Use Case Diagram

5. The system should be able to solve under 1-year cases
6. The system should allow the users to start questions to figure out the solutions
7. The users should be to see the result of the online diagnostics

The admin should be able to enter new cases, questions, self-helping, and actions for the user

8. The admin should be able to enter a new case's solution
9. Reminder for any upcoming vaccination
10. Determine the closest hospitals and clinics
11. The system can store all user's data in the User Database

IV.IV. THE INTELLIGENCE OF THE SIHDA MOBILE APPLICATION

1. The system can switch from one case to another case if there is no complete solution.
2. The system can switch from one question in one case, to another question in another case.
3. If necessary, the system can provide self-help.
4. The system can determine the vaccination date and type based on the child's age.
5. The system can display hospitals in order of proximity to the user.

IV.V. ANALYSIS AND DESIGN MODELS OF SIHDA

In this section, we provide illustrative analysis and design models of the proposed system. Analysis Diagrams include Use Case, Sequence Diagrams, Activity Diagram, and Entity-Relationship diagrams (ERD). On other hand, the Design Diagrams include User Interface (Prototype), Interactive Diagrams, Class Diagrams, and

Context diagrams. But in this paper, we will explain only the Use Case Diagram**,** General Activity Diagram of View Case Option, and Sequence Diagrams for View cases.

IV.VI. USE CASE DIAGRAM

The Use Case diagram of SIHDA system is shown in Figure 2. We have focused on the main actors of our system, which are Users and System Administrators. On the other hand, we have one database responsible for storing all the data. Use Case diagram identify how users interact with the system.

General Activity Diagram of View Case Option: In Figure 3, when the user enters the system successfully, the user will be able to see a list of cases. In each listed case, the system will provide 10 cases related to babies' problems. Then the user will choose one of them. After that, the system will start asking the user some questions. The user, in this case, must answer the questions by clicking on "yes" or "no answer." If there is no solution, the system will ask the user to move on to another case, depending on the user's answers. Finally, the user can get the final action or diagnosis of a specific case.

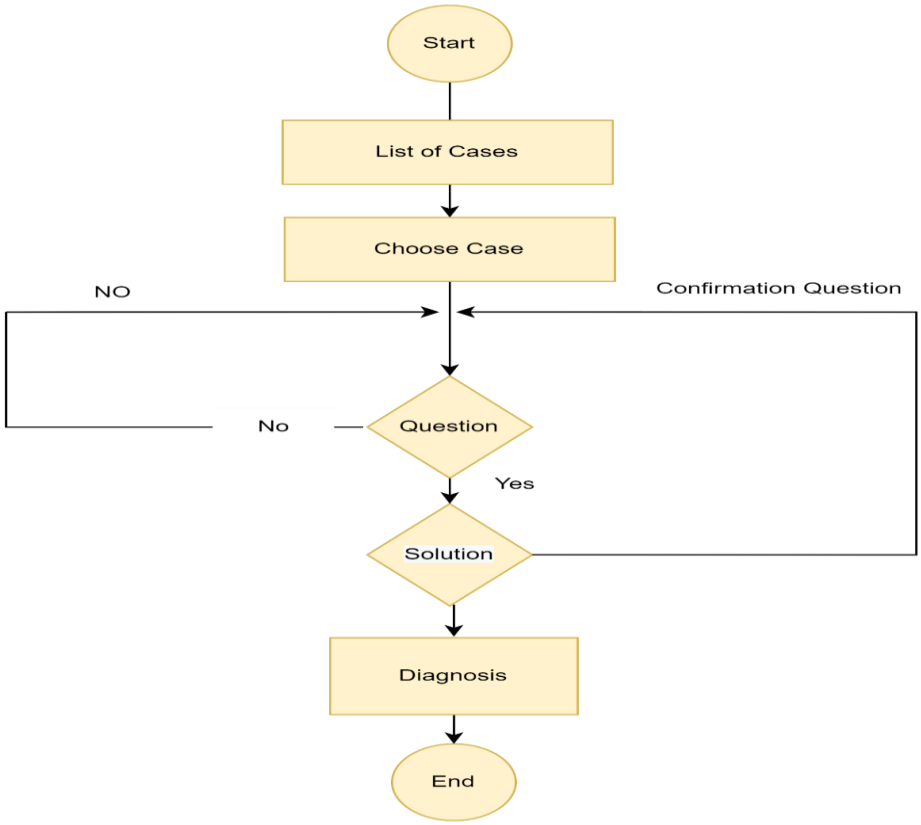

Figure 3: General Activity Diagram of View Cases

Table 4: Security mechanisms used in the SIHDA system

Security Mechanisms	**Brief Discretion**
User Identification	Identifying the users that our system is targeting is the first step in the development of access controls
User Registration	To obtain access to the system, users must complete the registration process by providing their identification information.

Identity Proofing	After receiving a complete registration request, the system checks the new account requests against existing ones to avoid duplications.
User Authentication	After proofing eligible users' identities, the system generates users' IDs. The system requests those users to provide authentication information.
Access Control List	Depending on the role of a user and the object that is to be accessed, we define the access mode. Access modes include, but are not limited to, read, write, delete, create, and modify.
Encryption	Encryption, or in other words cryptography, is one of the strongest defense mechanisms in computer systems. With encryption, data in the diabetes system will be stored in a cipher form.
Backup and Recovery	Planning for database backup and recovery are adequate safeguards against data loss and software errors.
Data Transmission Security	Data in transmission levels targets many threats such as interrupting communication, sending extra signals to block the base station, spying, and networking traffic. As in database security, the most effective solution is to encrypt information during transmission to preserve confidentiality.

IV.VII. SEQUENCE DIAGRAMS FOR VIEW CASES

The system sequence diagram of SIHDA system is shown in Figure 4. The user will log in to the system to have the privilege of seeing all the cases. First, the system will show all the options that are included in the system. Second, the user will select View Cases and will be able to read the case list. After that, the system will request the case from the database and retrieve it for the user. Then the user will select a case. The system will now start to display all the questions related to this case for the user. Finally, the user must answer all the Yes and No questions to get the final action (diagnosis). Security components in the SIHDA application are shown in Table 4.

VI.VIII USABILITY EVALUATION OF SIHDA APPLICATION

The SIHDA application was developed by Android Studio. The Hostinger website is used for online server hosting and the application uses online hosting for database storage. IBM has given a list of indicators to evaluate the usability satisfaction of an application [20].

The list of 10 indicators is listed below:

U1. The system is user-friendly.
U2. It is easy to navigate through the system and come up with a solution for the different cases.
U3. It was easy to learn and get used to the system.
U4. Learning about the system did not take too much time.
U5. The system showed bugs and errors during usage.
U6. The information provided within the system was easy to understand.
U7. The ‘Help’ facilitates the use of the system.
U8. The design and interface of the system are relaxing and make it easy to use.
U9. The functions of the system are useful.
U10. Overall, it is satisfactory to use the system.

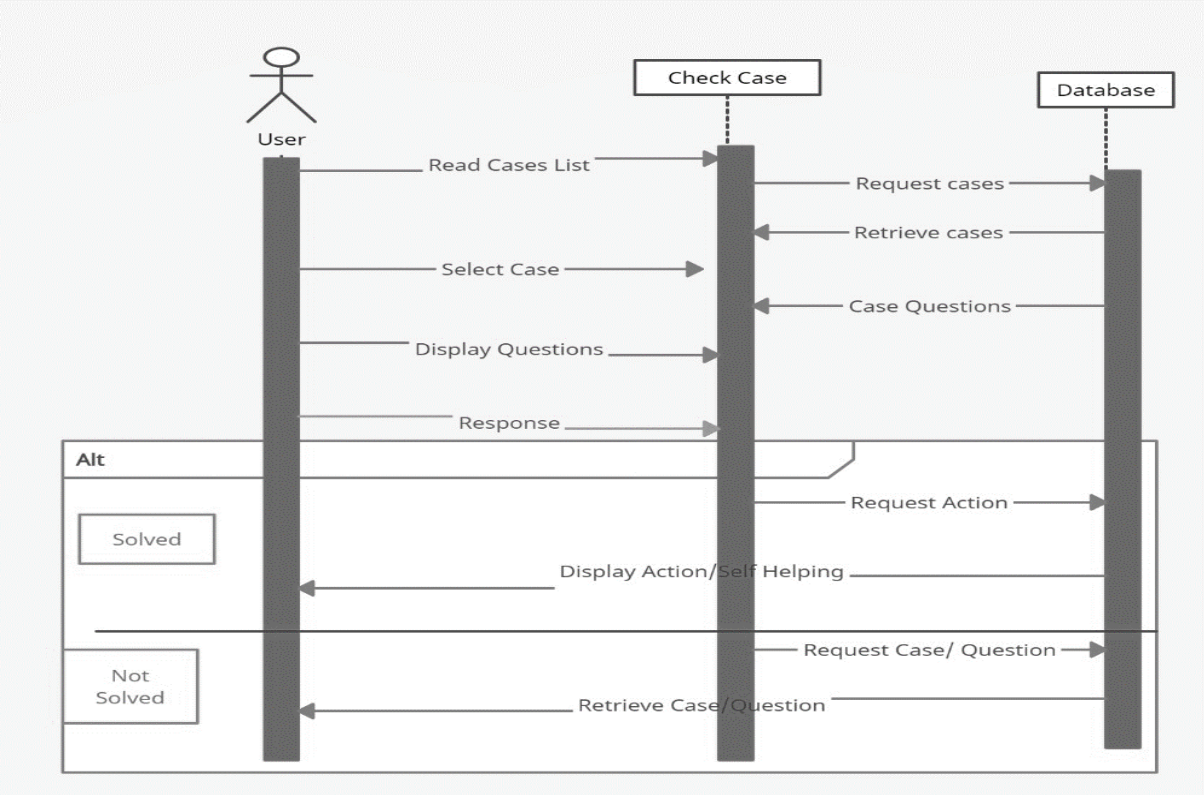

Figure 4: Sequence diagram for View Cases

To evaluate the usability satisfaction of developed mobile SIHDA application, a research survey was conducted. The survey used the IBM Computer Usability Satisfaction Questionnaires (Lewis 1995). In the survey, 55 experts participated. The respondents include software engineers, health providers, and health receivers.

Figure 5 displays the Sunburst Chart of Usability Evaluation of SIHDA application and Figure 6 displays the usability acceptance of SIHDA application. The overall acceptance rate of the SIHDA application is 84.8%.

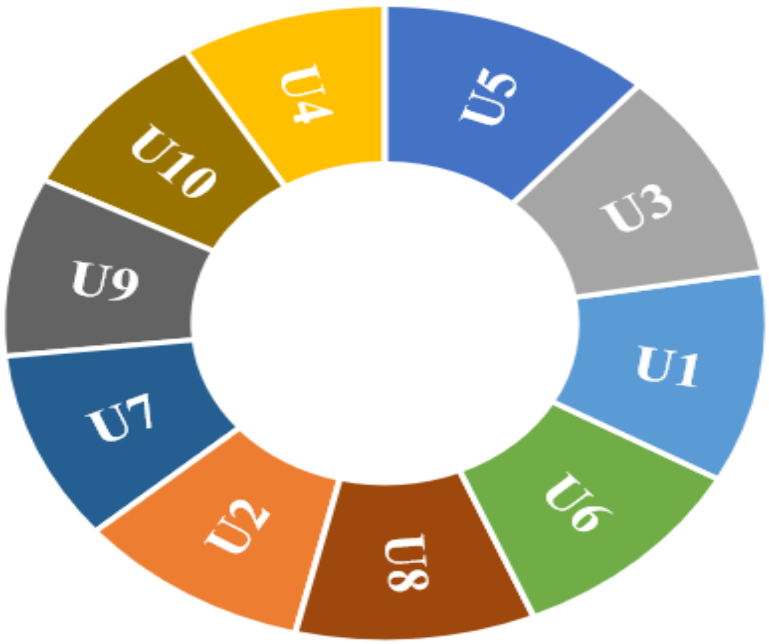

Figure 5: Sunburst Chart of Usability Evaluation of SIHDA application

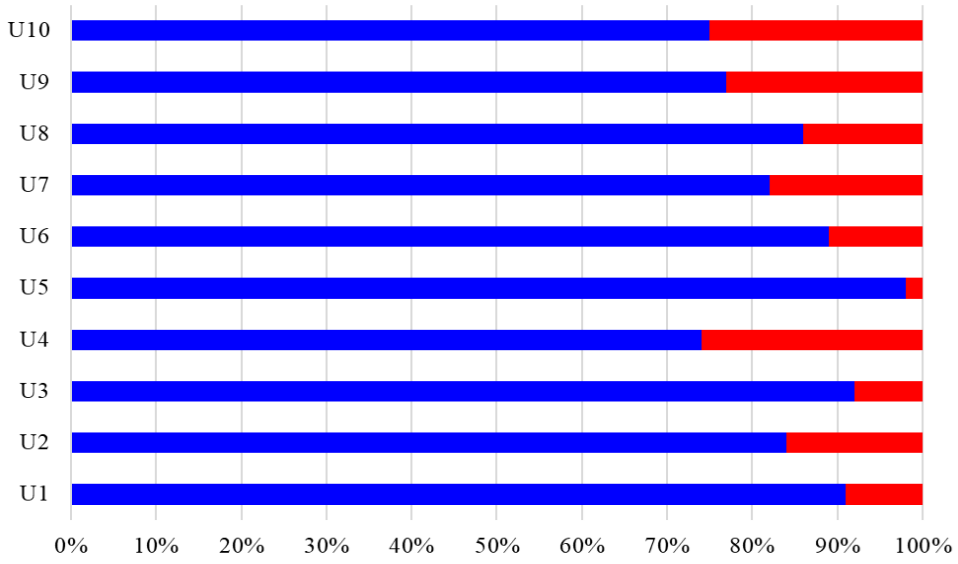

Figure 6: The usability acceptance of SIHDA application. The blue color represents a positive response.

VII. BUILD SYSTEM SCREENSHOTS

The screen shorts of the developed SIHDA system are shown in Figure 7-11.

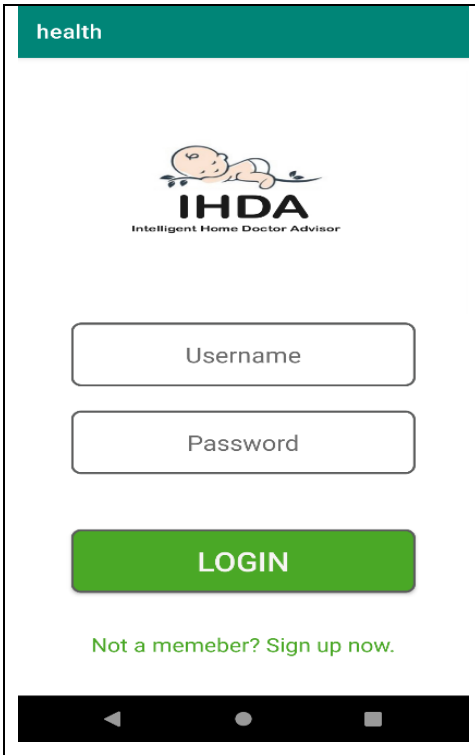

Figure 7: Login page

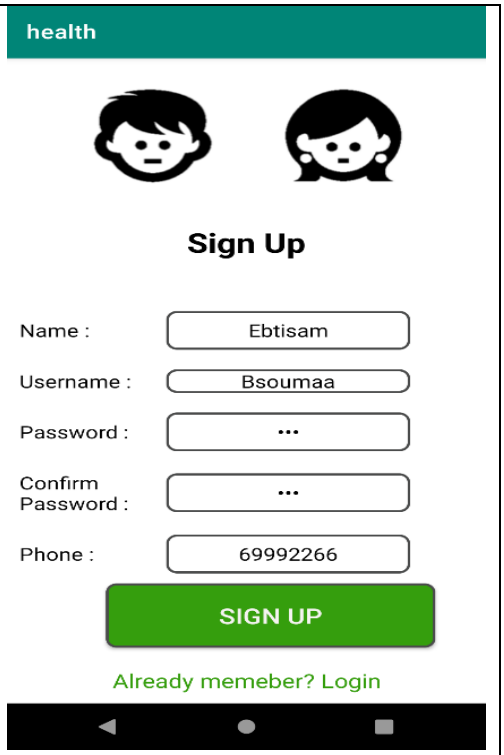

Figure 8: Sign-up page

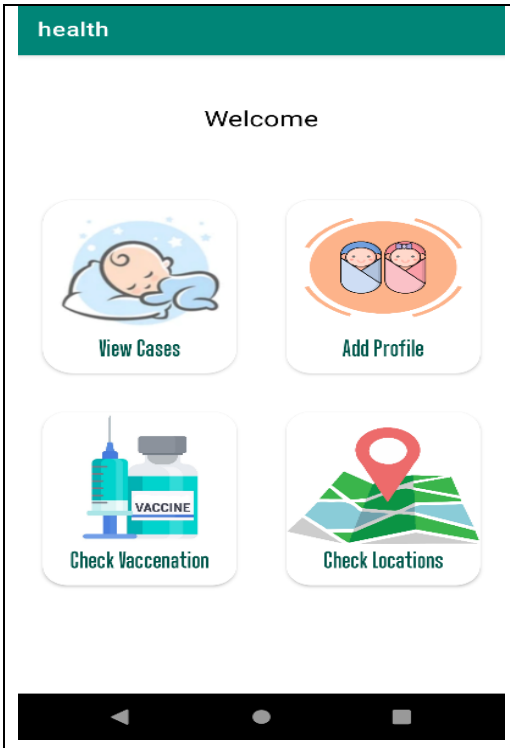

Figure 9: Main Page

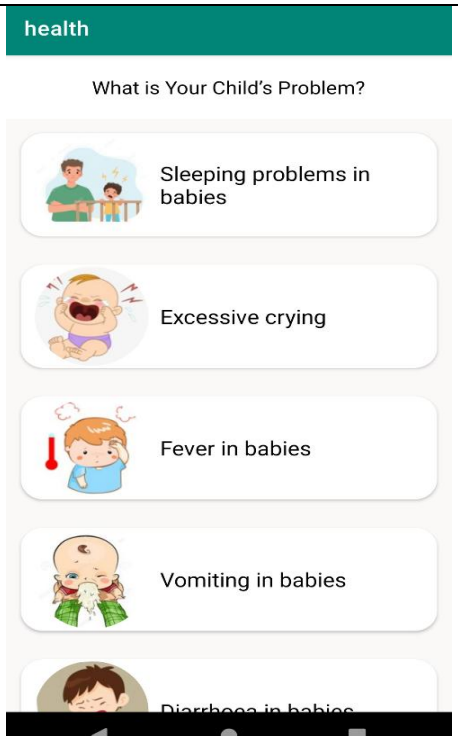

Figure 10: Cases Page

Figure 11: Add a profile

VII.I SHORT DESCRIPTION FOR EACH PAGE

1. **Login page:** The user must create an account to log in to the system. The user and admin can log in by entering the correct Username and Password as shown in Figure 7.
2. **Sign-up page:** If the user does not have an account, then he should sign up by filling out the form. The form contains Name, Username, Password, and Phone Number, as shown in Figure 8.
3. **Main Page:** This is the main page of the system which contains 4 parts: View cases, Add profile, Check vaccination, and Check location, as shown in Figure 9.

4. **Cases Page:** When the user selects the View Cases option, the system will provide 10 cases related to the babies' issues such as Babies' sleep problems, Excessive crying in babies, Fever in babies. Rash with Fever, Vomiting in babies, Diarrhea in babies. Feeding problems in babies, Slow weight gain in babies, Skin problems in babies, and Eye problems in babies. After selecting one of the cases the system will ask the user multiple questions and the user must answer them with Yes or No questions to get the diagnosis and self-helping if needed, as shown in Figure 10.
5. **add a profile:** This feature allows the user to create a Profile for their children to get notifications about the vaccinations. That will require the Name of the baby and Date of birth, as shown in Figure 11.
6. **Vaccination Page**: This page will give the user access to check their children's date and type of vaccination. If they have more than one baby, they need to select the baby's name then the data will display, as shown in Figure 8.

VII. CONCLUSIONS

In conclusion, technology plays a vital part in improving the wellness and quality of life of people. The Secure, Intelligent Home Doctor Adviser IS for Babies SIHDA mobile application is developed under the guidelines of the British Medicine Association (BMA). The proposed system is intelligent in advising and diagnosing health cases, such as Sleeping problems, Excessive crying, Fever in babies, Rash with Fever, vomiting in babies, Diarrhea in babies, Feeding problems, Slow weight gain, Skin problems, and Eye problems. The overall acceptance rate of the SIHDA application is 84.8%. In addition, the system will be beneficial for new mothers because the system supports 10 health issues. In the future, we have a plan to add more BMA supported cases and also make the system to more intelligent & secure. Usability-measured results are shown in Figure 6.

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BIOGRAPHY OF AUTHORS

Dr. Kalim Qureshi is currently an Associate Professor in the Information Science Department at Kuwait University, located in Kuwait. His research interests are focused on network parallel distributed computing, thread programming, concurrent algorithms designing, task scheduling, performance measurement and medical imaging. Dr. Qureshi obtained his Ph.D. and MS degrees from Muroran Institute of Technology located in Hokkaido, Japan, in the year 2000 and 1997, respectively. He has published over 50 research papers in reputable journals.

Ebtisam Alazeme completed her Master's in Computing Information Systems in 2024. She works for the Ministry of Education in Kuwait.

Prof. Paul D. Manuel is Professor in Information Science at Kuwait University. He received his M.S in Computer Science from the University of Saskatchewan, Canada in 1992. He obtained his Ph. D in Computer Science from the University of Newcastle, Australia in 1996. He got his first PhD in computing from Indian Institute of Technology, India in 1986.

His current research interests are in Information Systems, Graph Algorithms and Computational Complexity. According to Google Scholar, his publications have been cited more than 2567 times. The h-index is 28 and i10-index is 65. He has published more than over 100 scientific papers in peer-reviewed journals with a total impact factor exceeding 70. He was listed in the ' World's Top 2% Scientist 2022' as one of the world's most influential scientists, which was released by Stanford University and Elsevier Foundation.