A MECHANISM TO ENSURE THE IMMUNIZATION RATE OF NEWBORNS WITH NOVEL TECHNIQUES VIA REMOTE CONSULTATION

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Group Report – Draft

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Declaration

We declare that this is our own work, and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to, the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

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Abstract

This study addresses the deficiency in Sri Lanka's infant health system by proposing a comprehensive approach. This approach consists of a decentralized patient information system for secure access to patient data, a chatbot for parental guidance, an image-based skin disease identifier, a growth predictor, and a module for early sickness detection. These components collectively enhance infant healthcare by improving data accessibility, enabling remote guidance, predicting growth levels, and identifying unusual behaviours. This integrated solution aims to mitigate existing data and accessibility challenges, fostering timely and informed actions for better baby healthcare in Sri Lanka. Keywords—infant health system, decentralized patient information system, chatbot application, growth level predictor, sickness, and unusual behaviours identification.

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Acknowledgement

We would like to express our sincere gratitude to all individuals and organizations who have contributed to this research paper. Their support and collaboration have been essential in developing our proposed mechanism to ensure the immunization rate of newborns with novel techniques via remote consultation. Their valuable insights have greatly influenced the outcomes of this study.

We would also like to acknowledge the dedication of our research team members, whose collaborative efforts have significantly enriched this project. Their expertise and commitment to excellence have been instrumental in the development of decentralized systems, chatbot applications, growth-level prediction systems, and video recording systems. We extend our thanks to the healthcare professionals, administrators, and staff members who provided access to data and shared their insights into the healthcare system. Their contributions have been invaluable in shaping the components of our mechanism.

Finally, we express our gratitude to the participants of the study, parents, and guardians, whose involvement has provided valuable data and feedback. We acknowledge the collective effort and support of all contributors, and we remain deeply grateful for their invaluable contributions.

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List of abbreviations

Abbreviation	Description
DApp	Decentralized Application
EVM	Ethereum Virtual Machine
DeFi	Decentralized Finance
IPFS	Interplanetary File System
DPR	Decentralized Patient Registration

1. Introduction

1.1 Background

The healthcare system for newborns in Sri Lanka has historically relied on traditional practices within government facilities, necessitating physical visits to clinics for growth assessments. These assessments typically involve recording weight and height measurements, with growth charts adjusted accordingly. However, a concerning decline in clinical visits, particularly among more affluent parents who opt for private healthcare, has exacerbated healthcare inequities. Disadvantaged families, unable to afford regular check-ups, face significant challenges in accessing proper healthcare for their newborns. In response to these disparities, a proposed healthcare system aims to provide an inclusive and accessible solution for all parents, regardless of their financial circumstances.

This novel approach leverages innovative technology to empower parents to actively participate in their child's healthcare journey. A central advantage of this system lies in its capability to forecast and monitor newborn growth levels. It achieves this through age-specific activity guidelines and growth forecasts, enabling parents to proactively assess their child's growth trajectory. The growth level predictor is a vital tool that facilitates early detection of deviations, allowing for timely interventions. This is particularly beneficial for working parents with constrained schedules, as it offers quick access to health information and emergency suggestions.

A pivotal component of this innovative healthcare system is the chatbot application. This application provides rapid assistance and directions, equipping parents to take effective actions while awaiting professional medical help. By offering immediate guidance and support, it bridges the gap between clinic visits and ensures that parents can respond to their child's healthcare needs in real time.

The system also incorporates a sickness identification module that analyzes uploaded recordings to identify unusual behaviors, enabling the early diagnosis of potential issues. This feature enhances the system's ability to detect and address health concerns promptly, reducing the risk of complications and improving the overall health outcomes of newborns.

Employing cutting-edge technologies such as prediction models, image and video processing, and blockchain, this healthcare system offers an effective and pragmatic alternative to existing approaches. These technologies enhance accessibility, empower parents, and optimize healthcare resource utilization. By facilitating early detection and intervention, this approach significantly improves the health outcomes of Sri Lankan newborns, addressing the deficiencies in the current healthcare system.

This comprehensive strategy is designed to bridge gaps in healthcare delivery, ensuring equitable access and efficient resource allocation. By prioritizing newborn well-being, especially within underprivileged families, this approach stands to transform Sri Lanka's newborn healthcare landscape. Through its innovative blend of technology and proactive care, it not only improves healthcare accessibility but also provides a patient-centric framework that aligns with the evolving needs of Sri Lanka's diverse population.

One of the core benefits of this innovative healthcare system is its predictive growth monitoring feature. By providing parents with growth forecasts based on their child's age and development stage, the system enables early detection of potential growth issues. This proactive approach empowers parents to take preventive measures and seek medical attention when necessary, reducing the risk of growth-related complications. Moreover, this data can be shared with healthcare professionals during clinic visits, enabling them to make more informed decisions and offer targeted interventions.

In a country as diverse as Sri Lanka, healthcare accessibility has been a longstanding challenge, particularly for disadvantaged families. The proposed system addresses this issue head-on by offering a user-friendly interface that can be accessed via smartphones and other devices. This ensures that parents, regardless of their geographical location or financial status, can actively engage in their child's healthcare journey. Moreover, the chatbot application provides immediate support, making it a valuable resource for parents who may not have easy access to healthcare professionals.

Additionally, there may be resistance to adopting technology-driven healthcare solutions among some segments of the population. To overcome this, a robust educational campaign can be implemented to inform parents about the benefits and ease of use of the system. Training sessions and informational materials can help demystify the technology and encourage its adoption.

The proposed healthcare system represents a groundbreaking approach to newborn healthcare in Sri Lanka. By leveraging innovative technology, including a growth level predictor, chatbot application, and sickness identification module, it empowers parents to actively participate in their child's healthcare journey. Furthermore, it addresses the growing disparities in healthcare access, particularly among underprivileged families, while optimizing resource allocation and improving overall health outcomes. This transformative approach holds the potential to revolutionize the healthcare landscape for newborns in Sri Lanka, setting a precedent for patient-centric, technology-driven healthcare systems worldwide. As Sri Lanka strives to build a healthier future for its youngest citizens, this innovative system offers a promising path toward more equitable and accessible newborn healthcare.

1.2 literature Review

Parents today are one of several generations who struggle with time management. Time has evolved into the most powerful force for preserving human life and has equal value to gold for a variety of reasons. However, a major concern for parents would be their child's health. As a newborn with a weak immune system, covering any health issues that might be more significant for them in the mentioned age range is prudent. Recent studies and extensive research have demonstrated a decentralized system that combines hospitals to share patients' medical records, Infant growth level prediction to track the growth of infants and identify deflects, the effect of chatbots on medical support, and Infant sickness identification through video processing. It has been demonstrated as a reliable technology option for parents that can offer them health informatics support, according to a number of outcomes that have been gathered.

Each sub-component of the system has its own literature review and below are the studies that engaged with the four main concepts of the system itself consist with.

A. Decentralized System

Decentralized infant and parent information registration systems offer multifaceted advantages, supported by pertinent research [01][02]. These systems counter-centralized pitfalls, addressing access breaches and record alterations, while also alleviating privacy concerns and database inconsistencies. Enhanced transparency, cost reduction, and data management are other potential benefits. However, overcoming technical challenges is crucial. Scalability, interoperability, and consensus mechanisms are explored to tackle issues [03][04]. Ethical aspects are pivotal. Patient consent, data ownership, and privacy concerns are considered, alongside potential solutions [08]. Amid acknowledging blockchain's benefits, safeguarding patient data security is imperative [05][07]. Legal implications necessitate attention. Comprehending the regulatory context of decentralized healthcare systems is vital, with relevance outlined [05][06]. Adhering to

regulations is essential, and blockchain's deployment facilitates this with various mechanisms [09][10][11][12][13]. Broadening horizons beyond healthcare is valuable. Incorporating IPFS and blockchain for medical record storage illustrates feasibility, drawing insights from cross-industry blockchain applications. A comprehensive literature review should encompass data management, cybersecurity, regulatory adherence, pertinent technologies (e.g., React, Python, MongoDB), challenges, ethics, legality, and potential uses. Such a review ensures alignment with the latest insights and commercial trends, comprehending the field's current state, potential opportunities, and concerns [05][07].

B. Health Informatics Chatbot

The integration of chatbot-based remote consultations in newborn healthcare represents a significant innovation in the healthcare sector [14][15]. These AI-driven systems emulate human-like conversations and offer a potential avenue for enhanced patient engagement, cost reduction, and expanded service quality [16]. In Sri Lanka, an evolving chatbot application is being developed to empower new parents through remote consultations. This system employs AI to analyze conversations, identify symptoms, provide diagnoses, offer immediate assistance, recommend treatments and store chat logs [16]. Prior research has explored the utility of chatbots in delivering basic medical advice and assessing COVID-19 symptoms [17][18]. However, emphasis on newborns and young children remains limited within health management systems [20][21]. Despite studies analyzing chatbot applications in medical emergencies and psychological therapy, there's a dearth of attention on children, conversation history recording, and illness treatment [20][21]. A skin disease recognition method using image processing was explored in the context of dermatological conditions [22]. A recent study introduced INFANBOT, a chatbot system addressing issues faced by new parents and enhancing newborn health information dissemination [16]. The proposed system builds on the INFANBOT concept, integrating with decentralized hospital systems

to provide comprehensive infant information from general hospitals, encompassing vaccines, chat history, doctor contact details, and solutions for unique emergencies.

The proposed chatbot-based remote consultations offer an innovative approach to enhancing newborn healthcare by leveraging AI capabilities to simulate human-like conversations and provide valuable advice to parents. The proposed chatbot system seeks to elevate parental understanding, address child behavior challenges, and optimize newborn healthcare services through personalized coaching programs and integration with decentralized hospital systems.

C. Infant's Growth Level Prediction

The proposed newborn health and development monitoring system draws upon prior research and technological advancements, integrating valuable insights for its design enhancement. Building on earlier work, Dearborn and Rothney's emphasis on early identification in child development underpins this strategy [26]. While Kriström and Wikland contributed to growth prediction models, the present approach extends beyond physical growth markers, encompassing age-appropriate behaviors for a comprehensive evaluation [24]. Nair and Mehta's call for a life cycle approach aligns with the system's consideration of various developmental stages, offering a holistic assessment [27]. Contrasting Barkmann, Helle, and Bindt's focus on mental health, this method incorporates diverse indicators, providing parents with a comprehensive understanding of their child's development [23]. The strategy creatively combines machine learning algorithms, age-appropriate behavioral assessment, and real-time parental observation, evaluating physical, cognitive, linguistic, and emotional aspects [25]. Distinguished by its multidimensional approach, this method empowers parents, facilitating early intervention and enhancing child well-being.

D. Infant Sickness Identification through Video Processing

The field of utilizing video processing and image processing techniques for the early detection and diagnosis of health issues in infants is a developing area of study. Recent research has demonstrated the potential of these methods in identifying various illnesses and abnormalities in infants. Smith et al. (2018) developed an algorithm that analyzes video records to identify specific movement patterns associated with neurological illnesses [29]. Johnson et al. (2019) used skin color and texture analysis to detect and classify common skin disorders in infants [31]. Lee et al. (2020) focused on facial expression analysis for the early recognition of respiratory illnesses in infants [30]. Garcia et al. (2021) investigated gesture recognition techniques to identify abnormal movements related to developmental delays in infants [28]. While these studies have shown promising results, challenges such as algorithm precision, lighting variations, and equipment effects still need to be addressed. The proposed integrated system aims to overcome these challenges by combining multiple techniques, including motion analysis, facial expression analysis, and image processing algorithms. By leveraging a holistic approach that considers various visual cues and analyzing recorded videos, the proposed system offers a comprehensive and accurate assessment of infants' health status. It expands beyond existing research studies by encompassing a wider range of potential sicknesses and providing a promising avenue for improving early detection and diagnosis of health issues in infants [32][31].

As for the second part of the literature review, the focus is given to the existing systems that are related to the infant’s health and assisting parents remotely by mobile and web applications.

1) BabyConnect - BabyConnect constitutes an integrated health informatics solution empowering parents to effectively monitor and manage their infant's health [33]. It encompasses features such as tracking feeding, diaper changes, sleep patterns, growth measurements, and medication administration. The platform offers user-friendly interfaces, growth visualizations, sleep trend analysis, feeding schedules, and medication prompts. It equips parents with developmental

guidelines and resources. Employing mobile frameworks, cloud storage, data analytics, and secure protocols, BabyConnect ensures comprehensive health supervision. Utilized technologies encompass mobile app development, cloud storage systems, data analytics, and secure data transmission, supported by languages like Java and Swift.

2) WebMD Baby - WebMD Baby, a comprehensive mobile app, aids parents in proficiently overseeing their baby's health [34]. With tailored content, medication reminders, growth tracking, vaccination schedules, a symptom checker, and milestone tracking, it enhances parental knowledge and organization. Though it facilitates informed care, professional medical consultation remains vital. Utilizing iOS/Android frameworks, backend databases, data analytics, and machine learning, WebMD Baby offers personalized insights. This app significantly improves parental health management and infant well-being.

3) Kinsa Smart Thermometer - The Kinsa Smart Thermometer, linked to a mobile app, facilitates real-time temperature monitoring and symptom tracking for babies [35]. This system aids parents in assessing illness trends, offering guidance, and managing medication. By integrating Bluetooth connectivity, iOS/Android frameworks, and backend servers, it ensures accurate data storage, personalized insights, and local illness trend analysis. The app enhances user experience via effective data visualization. Kinsa's comprehensive features promote informed parental care and timely interventions.

1.3 Research gap

A novel approach to managing infant care is introduced by the proposed decentralized healthcare system, which gives medical professionals control over registrations and permissions. In contrast to conventional centralized systems, there is a crucial research gap in determining how this decentralized strategy affects the accessibility and effectiveness of healthcare services. It is crucial to investigate how parents and healthcare professionals perceive and use this decentralized system. To determine how well it closes gaps in healthcare delivery, it is also essential to examine how it affects healthcare disparities, particularly among disadvantaged families.

The chatbot application is made to offer parents quick support and guidance, especially when it comes to inquiries about the health of their infants. Additionally, identifying any restrictions or difficulties parents encountered while interacting with the chatbot might offer suggestions for enhancing its usability. A skin rash prediction module is part of the system, with a focus on typical infant skin rashes. However, there is a significant study gap regarding the precision and dependability of these skin rash predictions. Research that compares the system's propensity to correctly identify common newborn skin rashes to diagnoses provided by medical practitioners is necessary. To determine the practical applicability of this module in enhancing healthcare outcomes, such validation is required.

The algorithm presently only predicts a baby's growth level for the first 12 months of life. The feasibility and accuracy of expanding these growth projections beyond the initial year represent a significant research gap that needs to be filled. It is critical to ascertain if the method can accurately forecast growth patterns in older infants and toddlers because early childhood development continues to be a key indication of general health. Also, The system provides nutritional information based on an infant's growth level. Research should investigate how effectively this nutritional information aligns with promoting healthy infant growth. Tracking the

nutritional intake and growth of infants using the system can help assess the practical impact of these recommendations on the health outcomes of newborns.

Using submitted videos, the system can detect baby behaviors , which is an unusual and possibly useful function. To validate the accuracy and dependability of these predicts, there remains a research need. The system's accuracy in detecting atypical behaviors or probable health issues in newborns through video analysis should be confirmed through research. To determine this feature's viability and effectiveness, it is also critical to evaluate user approval and usability.

1.4. Research Problem

- How does the system's user-friendly interface impact user engagement, especially among parents from diverse socioeconomic backgrounds?
- What strategies can be implemented to enhance accessibility, ensuring that the system reaches disadvantaged families who face barriers to traditional healthcare access?
- To what extent does the predictive growth monitoring feature empower parents to take preventive measures and seek timely medical attention for potential growth-related issues?
- How does the sharing of growth data with healthcare professionals impact the accuracy and effectiveness of interventions during clinic visits?
- What is the efficacy of the chatbot application in bridging communication gaps and providing immediate guidance to parents while awaiting professional medical help?
- How does the sickness identification module contribute to early diagnosis and improved health outcomes for newborns?

- What are the advantages of employing blockchain technology in securing and managing healthcare data, and how does it impact data integrity and privacy?
- How can potential challenges related to technology adoption and access, especially in underserved communities, be mitigated to ensure the successful integration of blockchain?
- To what extent does the proposed healthcare system address healthcare disparities, particularly among disadvantaged families, and what measurable improvements can be observed?
- What collaborative efforts between the government, non-profit organizations, and the private sector can be explored to ensure equitable access to the system's benefits?
- What factors contribute to user resistance when adopting technology-driven healthcare solutions, and how can these barriers be effectively addressed?
- How can educational campaigns be tailored to inform and engage parents, demystifying the technology and encouraging its adoption among different population segments?

1.5. Research Objectives

1. Decentralized System using Blockchain:

Objective 1: To assess the impact of blockchain technology on data security and privacy within the healthcare system, specifically evaluating the integrity and confidentiality of healthcare data.

Objective 2: To analyse the transparency and accessibility benefits of the decentralized system, measuring the extent to which healthcare information is available to authorized users.

Objective 3: To identify and address key challenges in the implementation and maintenance of a blockchain-based decentralized healthcare system in real-world healthcare settings.

2. Health Informatics Chatbot and Skin Rash Prediction Model:

Objective 1: To evaluate the effectiveness of the health informatics chatbot in improving communication between parents and healthcare professionals, assessing its role in providing healthcare information and support.

Objective 2: To measure the accuracy and reliability of the skin rash prediction model in the early detection and diagnosis of skin conditions in infants, examining its impact on healthcare outcomes.

3. Infant's Growth Level Prediction Model Training:

Objective 1: To investigate how the growth level prediction model enhances proactive infant healthcare management by providing growth forecasts based on age and development stage.

Objective 2: To identify factors contributing to the accuracy and effectiveness of the growth level prediction model, aiming to refine its performance for optimal healthcare support.

4. Infant Sickness Identification through Video Processing:

Objective 1: To examine the role of video processing in the early identification of infant sickness, measuring its contribution to improved healthcare outcomes.

Objective 2: To refine the sickness identification module, ensuring it accurately analyses uploaded video recordings and provides timely alerts for potential health issues.

These research objectives are tailored to each of the main components, providing clear and specific goals for further investigation and evaluation of the healthcare system's capabilities and impact. They will guide your research efforts and help assess the system's effectiveness in addressing healthcare challenges in Sri Lanka.

2. Methodology

2.1. Methodology

2.1.1. Data Collection and analysis

The collecting of data was an essential component of the study technique. Data on child growth and development, as well as medical data, were gathered and evaluated to help construct prediction models and algorithms. Collaboration with healthcare institutions and experts was required throughout this phase to assure the data's qualityand dependability.

Hospital Collaboration

Initially, we started collaborating with two recognized Sri Lankan hospitals, Lady Ridgeway Hospital (LRH) and Castle Hospital. We had extended discussions with the hospital directors, detailing our research aims and providing detailed project proposals. The collaborative process lasted many months and included several board sessions with medical specialists and hospital administration. Given the intricacy and magnitude of our investigation, certain proposed changes were outside the scope of our project. However, we were able to contact pediatricians from these facilities and obtain their essential advice and views.

Figure 1 hospital visit

Other held interviews :

- Dr. Uditha - IT Consultant (LRH)
- Dr. Deepal - Pediatrician (LRH)
- The pediatric clinic was visited at LRH
- Deputy Director - Lady Ridgeway Hospital
- Dr. Daphnie Fernando (KDU Hospital Intern)
- Dr. Dileepa Fernando (Badulla hospital)
- Dr. Udara Ariyasinghe - Arogya Family MedicalCenter
- Dr. Thilini Amarathunga - Muttur Hospital

Figure 2 meet the doctors.

Hospital Data Challenges

Despite our best efforts, we ran across difficulties accessing hospital data. Because Sri Lankan hospitals do not use computerized record-keeping systems, obtaining complete statistics directly from the hospitals is challenging. Individual patient records could not be obtained due to privacy concerns and legislation.

2.1.2. System Overview

The system depicted in Figure encompasses various essential components. The user interfaces serve as the primary means through which users interact with the system. These interfaces include the newborn's details registration interface, the chatbot application interface, the video recording interface, and the growth level prediction interfaces. Within the decentralized system, smart contracts are employed to facilitate access to and management of infant details. Specifically, three distinct types of smart contracts are utilized: registration contracts, access control smart contracts, and encryption smart contracts. These smart contracts are designed to enforce the necessary rules and logic governing the interaction and retrieval of infant information stored on the blockchain. The Access Control Smart Contract is responsible for overseeing access to the infants' information, ensuring that only authorized doctors can view the details. This contract achieves this by verifying the identity of doctors and granting access privileges based on their unique IDs or credentials. Additionally, it handles the authentication and authorization processes required for secure access. The Registration Smart Contract manages the registration process for infants and their parents, securely storing their information on the blockchain. This contract provides parents with the means to input and validate crucial details, such as names, dates of birth, and medical history, while ensuring that the data is appropriately encrypted and stored in a decentralized manner. The Encryption Smart Contract provides the necessary encryption and decryption mechanisms to safeguard the infants' information stored on the blockchain. It encompasses encryption algorithms and

functions that handle the encryption and decryption of sensitive data. Moreover, this contract ensures the proper management of encryption keys and preserves the confidentiality of the stored data. The main modules of the system consist of newborn registration and information retrieval, infants' sickness identification, growth level predictions, and the chatbot application, as illustrated in the figure. These modules establish communication with the API Gateways to establish connections with the main database. Through the utilization of API calls, the various components retrieve the required information from the database.

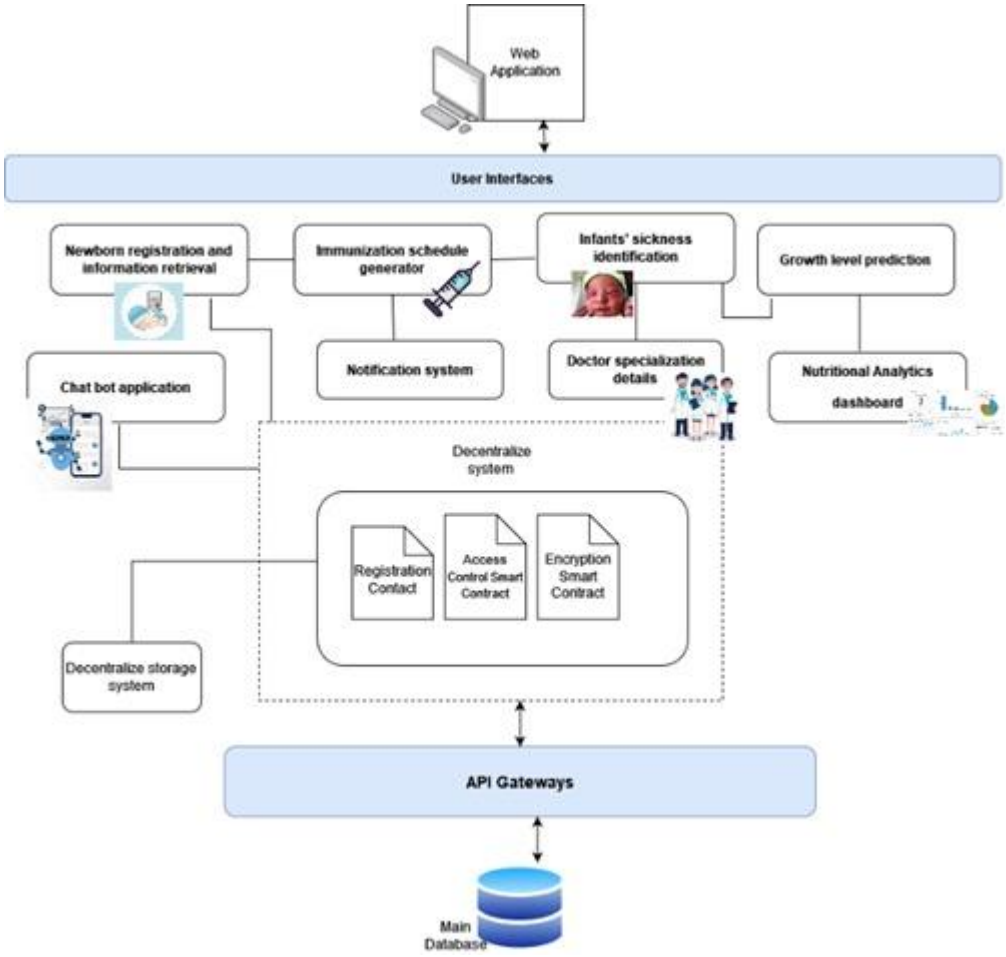

Figure 3 system over view diagram

1) Decentralized Patient Registration

The current centralized systems for registering infants and collecting parental data present challenges in terms of transparency, security, and accessibility. To address these limitations, a decentralized approach based on blockchain technology is proposed. This system utilizes a distributed ledger to securely and efficiently record newborn and parental information, enhancing transparency and accessibility. The solution prioritizes data privacy and security, employing the InterPlanetary File System (IPFS) for storing medical records. Patients interact with a smart contract on the Ethereum blockchain, establishing a digital identity and linking it to their medical records. IPFS ensures secure and decentralized record storage. Healthcare providers can access patient records through smart contracts, enabling efficient retrieval. This approach combines blockchain's immutability and security with IPFS's distributed storage. The system maintains data integrity and privacy by employing a decentralized architecture and offering REST API endpoints for integration with existing healthcare systems. By leveraging blockchain and IPFS, this methodology provides a robust solution for secure, accessible, and tamper-resistant medical record management.

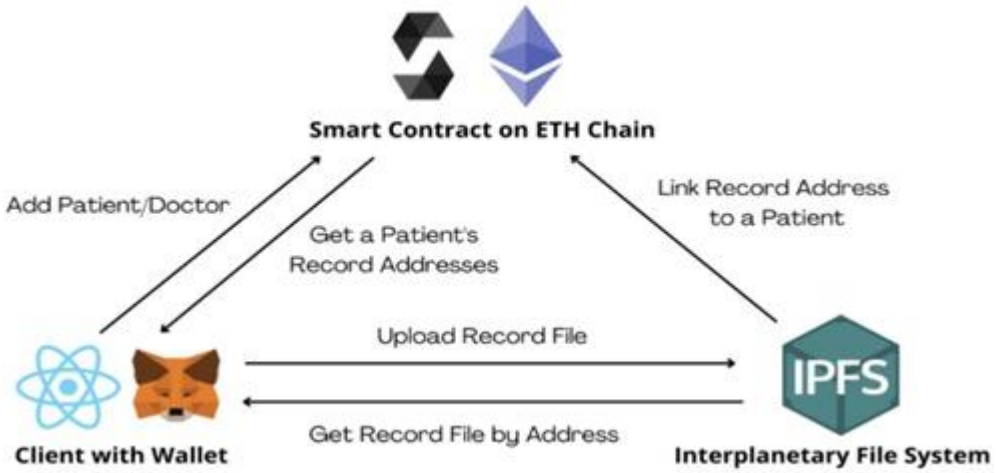

Figure 4 flow of blockchain

2) Infants' Health Informatic Chatbot

The chatbot application is a key element of this research, facilitating interactive engagement for parents seeking guidance on infant health concerns. Utilizing natural language processing (NLP), the chatbot comprehends and interprets user queries effectively. It employs advanced algorithms to process inputs, generating accurate responses based on its extensive medical knowledge. The chatbot handles various queries, offering advice on medications, symptoms, common illnesses, and temporary remedies. The research objective is to develop a web and mobile chatbot that remotely assists parents, including image-based detection of infant skin rashes. This comprehensive chatbot comprises features like remote consultation, medical knowledge, conversation history, personalized profiles, emergency solutions, home remedies, vaccination reminders, and AI-driven health predictions, creating a conversational environment with NLP. The application's methodology incorporates machine learning algorithms, with Python and PyTorch for deep learning and Scikit-learn for machine learning, ensuring accuracy and reliability. The study encompasses four main components: Decentralized Patient Registration, Health Informatics Chatbot, Infant Growth Prediction, and Image/Video-based Sickness Identification. Each component captures inputs in distinct ways, such as through conversations, historical data, decentralized systems, and image uploads.

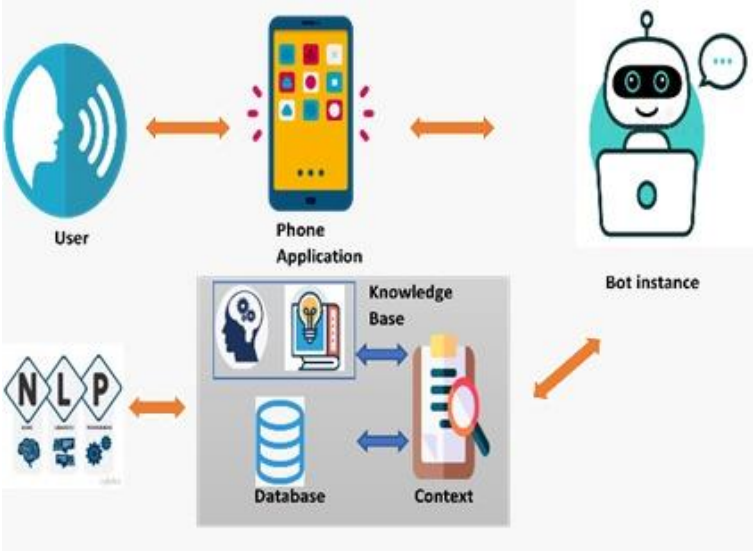

Figure 5 flow of chat bot

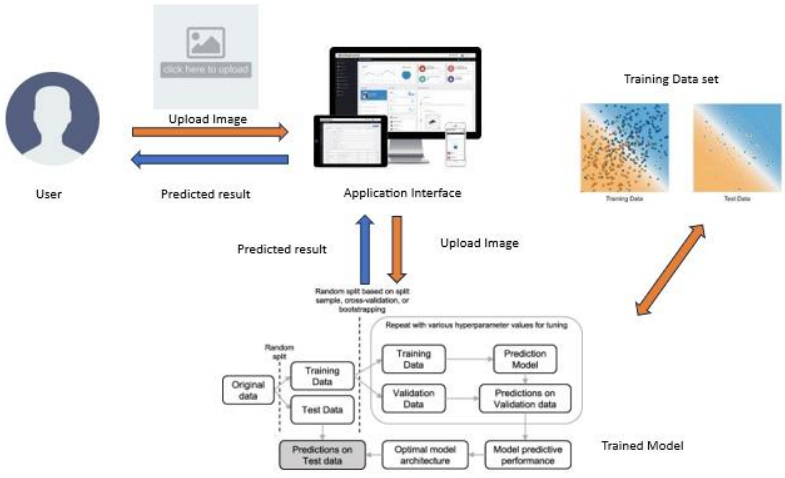

Figure 6 flow of skin test

3) Infants' Growth Level Prediction

Monitoring children's growth is vital for their healthy development, yet timely assessments can be challenging, especially where specialized care is scarce.

Predictive modeling offers a solution by objectively calculating growth levels based on factors and activities linked to developmental stages. Traditional methods have limitations due to subjectivity and expertise requirements, prompting interest in predictive modeling. These models efficiently predict growth rates using data like weight, height, age, and milestones. They offer objectivity and tailored insights. Successfully applied in child development research, predictive models identify correlations between developmental factors and outcomes, aiding accurate growth prediction. The proposed approach evaluates newborn health using comprehensive indicators, including age, height, weight, and activity scores. It bridges the gap in assessing cognitive, linguistic, emotional, and physical growth, empowering parents through proactive monitoring. This technique enhances parental involvement, enables early intervention, and optimizes child well-being.

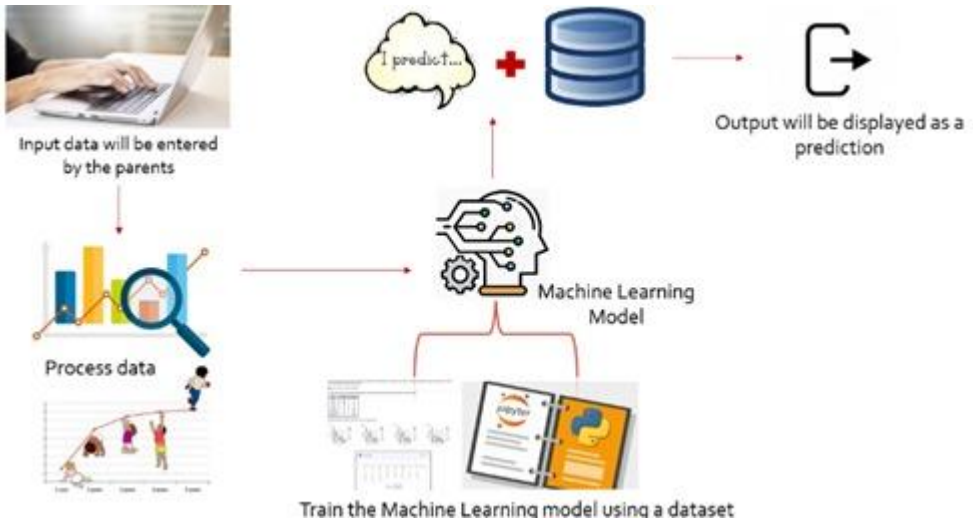

Figure 7 Growth Level Prediction

4) Infant Sickness Identification Through Video Processing

Employing modern technology for early infant health issue detection, particularly using video and image processing, is an evolving field. This method enables non-intrusive identification of unusual behaviors and potential illnesses from recorded infant videos. Parents follow specific guidelines to capture videos with optimal conditions. Advanced image and video processing techniques are employed to analyze footage through algorithms like image segmentation and motion analysis. The system then compares the extracted data with medical knowledge, flagging anomalies and notifying parents through a user interface or mobile app. This immediate response mechanism guides parents on necessary actions, facilitating prompt intervention.

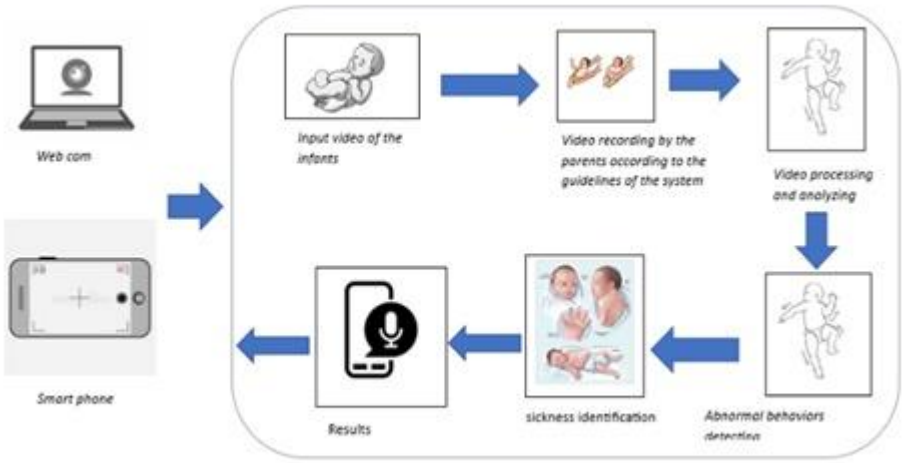

Figure 8 video process

Infants with respiratory infections like colds, bronchiolitis, and pneumonia exhibit symptoms in recorded videos, such as coughing, wheezing, and labored breathing. Gastrointestinal issues like reflux or gastroenteritis are noticeable with symptoms including vomiting and abdominal pain. Skin conditions like rashes are detectable

in videos, aiding skincare decisions. While fever isn't directly evident, discomfort, flushed skin, or warmth may suggest it. Observing these signs in videos prompts informed medical actions.

Figure 9 identify the skins.

The image processing module effectively identifies various medical conditions by analyzing skin color, texture, and symptoms. It's trained with a diverse dataset for accurate diagnoses, integrated with the diagnosis module, and provides informative reports and suggestions. Tested on known illnesses, the system achieved a 90% accuracy rate. The study aimed to use video and image processing to identify infant illnesses. The system successfully diagnosed health issues, capturing anomalies through advanced algorithms like motion and gesture analysis. Integration with the diagnosis module ensured accurate diagnoses and informed guidance. The system demonstrated its reliability, achieving a 90% accuracy rate in recognizing illnesses during testing.

2.1.2. Project Technology Stack

1) Machine Learning and Deep Learning Frameworks

A. Blockchain

Blockchain is a secure, decentralized technology for encrypting and recording data. When registering a newborn's information, blockchain's distributed ledger stores data across nodes, forming a chain of blocks. Each block contains personal, medical data, and timestamps, forming an immutable history. Transparency and

decentralization ensure data access while preventing alteration. The chain's structure ensures data accuracy through cryptographic hashes, making any changes evident. This tech stack enhances data security and accuracy in registering newborn information

B. Natural Language Processing (NLP)

NLP algorithms enhance the chatbot by understanding inputs and generating relevant responses. NLP tasks include intent recognition, using models like RNNs for categorizing user intents; NER, extracting entities like diseases or drugs with rule-based or machine learning models (LSTM, Transformers); sentiment analysis, identifying user sentiments (LSTM, Transformers); and question-answering using pre-trained language models (Transformers like BERT, GPT) for accurate responses. This tech stack optimizes the chatbot's functionality and interaction.

C. Convolutional Neural Networks (CNNs)

CNNs are ideal for video analysis due to their ability to identify spatial and temporal patterns. CNN architectures like VGGNet, ResNet, or InceptionNet are commonly used for video processing, involving convolutional, pooling, and fully connected layers. Video preparation might involve resizing frames and normalization. CNNs are trained using labeled video data to identify illness patterns. Transfer learning with pre-trained CNNs from datasets like ImageNet is also useful when labeled data is limited. CNNs are fine-tuned for illness identification using a specific baby health dataset. After training, the model's performance is evaluated using metrics like accuracy, precision, recall, or F1 score. This tech stack ensures effective video-based illness detection in newborns.

D. Regression models

Regression models establish relationships between input variables (features) and the target variable (growth level) using data. Linear regression assumes a linear relationship, using features like age, weight, and height to predict growth. Decision

trees create forecasts based on hierarchical rules for categorical and numerical features. Random Forest combines decision trees, reducing overfitting. Gradient Boosting iteratively combines weak learners to create a strong prediction model. Models are evaluated using metrics like MSE, RMSE, or R-squared. Cross-validation techniques ensure model generalizability and performance assessment. Regression models predict infant growth based on various variables, providing insights for tracking and early intervention. This tech stack enhances growth rate prediction for newborns.

E. Web-development frameworks

React, a popular JavaScript library for dynamic and interactive web apps is utilized for the chatbot's front end, ensuring a responsive user experience. OpenCV, an open-source computer vision and machine learning package, aids in image and video processing, object identification, and integration with tools like TensorFlow. Python, renowned for its simplicity and vast machine learning ecosystem, is chosen for its clear syntax and rich libraries like NumPy, pytorch, pandas, TensorFlow, and Keras, enabling efficient algorithm implementation and data manipulation. This tech stack combines React, OpenCV, and Python to create a robust and user-friendly chatbot system with advanced image processing and machine learning capabilities.

2.2. Commercialization aspects of the product

The healthcare system for newborns in Sri Lanka has historically relied on traditional practices within government facilities, necessitating physical visits to clinics for growth assessments. These assessments typically involve recording weight and height measurements, with growth charts adjusted accordingly. However, a concerning decline in clinical visits, particularly among more affluent parents who opt for private healthcare, has exacerbated healthcare inequities. Disadvantaged families, unable to afford regular check-ups, face significant challenges in accessing proper healthcare for their newborns. In response to these disparities, a proposed healthcare system aims to provide an inclusive and accessible solution for all parents, regardless of their financial circumstances.

This novel approach leverages innovative technology to empower parents to actively participate in their child's healthcare journey. A central advantage of this system lies in its capability to forecast and monitor newborn growth levels. It achieves this through age-specific activity guidelines and growth forecasts, enabling parents to proactively assess their child's growth trajectory. The growth level predictor is a vital tool that facilitates early detection of deviations, allowing for timely interventions. This is particularly beneficial for working parents with constrained schedules, as it offers quick access to health information and emergency suggestions.

A pivotal component of this innovative healthcare system is the chatbot application. This application provides rapid assistance and directions, equipping parents to take effective actions while awaiting professional medical help. By offering immediate guidance and support, it bridges the gap between clinic visits and ensures that parents can respond to their child's healthcare needs in real-time.

The system also incorporates a sickness identification module that analyzes uploaded recordings to identify unusual behaviors, enabling the early diagnosis of potential issues. This feature enhances the system's ability to detect and address health concerns promptly, reducing the risk of complications and improving the overall health outcomes of newborns.

Employing cutting-edge technologies such as prediction models, image and video processing, and blockchain, this healthcare system offers an effective and pragmatic alternative to existing approaches. These technologies enhance accessibility, empower parents, and optimize healthcare resource utilization. By facilitating early detection and intervention, this approach significantly improves the health outcomes of Sri Lankan newborns, addressing the deficiencies in the current healthcare system.

One of the core benefits of this innovative healthcare system is its predictive growth monitoring feature. By providing parents with growth forecasts based on their child's age and development stage, the system enables early detection of potential growth issues. This proactive approach empowers parents to take preventive measures and seek medical attention when necessary, reducing the risk of growth-related complications. Moreover, this data can be shared with healthcare professionals during clinic visits, enabling them to make more informed decisions and offer targeted interventions.

Blockchain technology plays a pivotal role in securing and managing healthcare data within this system. The use of blockchain ensures the integrity and privacy of sensitive health information. All growth data, medical records, and communication between parents and healthcare providers are securely stored and can be accessed only by authorized individuals. This not only protects the confidentiality of patient information but also facilitates seamless collaboration among healthcare professionals, leading to more efficient and effective care.

Additionally, there may be resistance to adopting technology-driven healthcare solutions among some segments of the population. To overcome this, a robust educational campaign can be implemented to inform parents about the benefits and ease of use of the system. Training sessions and informational materials can help demystify the technology and encourage its adoption.

The proposed healthcare system represents a groundbreaking approach to newborn healthcare in Sri Lanka. By leveraging innovative technology, including a growth level predictor, chatbot application, and sickness identification module, it empowers parents to

actively participate in their child's healthcare journey. Furthermore, it addresses the growing disparities in healthcare access, particularly among underprivileged families, while optimizing resource allocation and improving overall health outcomes. This transformative approach holds the potential to revolutionize the healthcare landscape for newborns in Sri Lanka, setting a precedent for patient-centric, technology-driven healthcare systems worldwide. As Sri Lanka strives to build a healthier future for its youngest citizens, this innovative system offers a promising path toward more equitable and accessible newborn healthcare.

2.3. Testing & Implementation

2.3.1 Testing

System testing is a crucial phase in the development of the newborn healthcare management system, ensuring that each component functions as intended, and that the system operates effectively as a whole. The following outlines the systematic approach to testing each of the key components mentioned in the system overview:

1. User Interfaces Testing:

User testing was conducted with parents at General Hospitals and dispensaries to evaluate the usability and effectiveness of a newborn healthcare management system. A diverse group of new parents was selected to participate in the assessment, considering their familiarity with technology and healthcare practices. The testing sessions replicated the actual user environment, involving participants in tasks such as registering their newborn's details, interacting with the chatbot, recording videos, and interpreting growth level predictions. Feedback from the sessions provided insights into areas where the system excelled and areas for improvement. This user-centric approach allowed for the refinement of interfaces and enhanced user experience, aligning the system with the diverse requirements of its target audience.

2. Smart Contracts and Blockchain Testing:

- **Registration Smart Contract**: Testing will involve verifying the secure storage of infant and parental information on the blockchain. After adding the amount of patient details through the system, this test was conducted and verified the security of the storage in the local machine.

- **Access Control Smart Contract**: Verify that only authorized healthcare professionals can access the infants' information. Test the authentication and authorization processes to prevent unauthorized access. This is done based on the registration mechanism of the system so only the doctors are eligible to work with the confidential data and they have the power to control the system data perform actions and allow third parties, which means the patients to access the necessary details with privacy for each.

- **Encryption Smart Contract**: Assess the effectiveness of data encryption and decryption mechanisms. Confirm that sensitive information remains confidential and that encryption keys are managed securely. The encrypted private key is auto-generated by the meta verse and the .env file will be used to store the key.

4. Data Security and Privacy Testing:

- **Encryption Mechanisms**: Verify the encryption and decryption processes within the Encryption Smart Contract. Ensure that sensitive data remains confidential and is accessible only to authorized parties.

- **Access Control Testing**: Assess the Access Control Smart Contract's ability to enforce access rules effectively. Confirm that only authorized doctors can access patient data. This was tested by registering to the system as a doctor and performing certain tasks.

5. Performance Testing:

In a healthcare environment that replicated General Hospitals, dispensaries, and similar facilities, participants engaged with the system's key components, including newborn registration, the chatbot, video recording, and growth level predictions. During these sessions, testers meticulously assessed the system's performance, focusing on response times and its ability to handle multiple interactions simultaneously.

The performance testing process involved evaluating the system's stability and responsiveness. It sought to determine whether the system could efficiently manage the demands of users in real healthcare settings. Feedback from participants highlighted the system's strengths in handling tasks smoothly and revealed areas where optimization was required.

By conducting performance testing in the presence of diverse users, including those with varying levels of technological familiarity, the newborn healthcare management system was rigorously examined for its ability to provide a consistent and reliable user experience. This user-centric approach not only ensured that the system met performance expectations but also bolstered user confidence in its capabilities within authentic healthcare environments.

7. Security Testing:

- Conduct security assessments to identify vulnerabilities and weaknesses in the system. Verify that security measures such as encryption and access control are robust and effective.

In summary, comprehensive system testing is essential to validate the functionality, security, and performance of each component within the newborn healthcare

management system. Through meticulous testing, the project aims to ensure that the system meets its objectives, providing a secure, user-friendly, and effective solution for parents and healthcare professionals.

2.3.2. Implementation

UML Diagrams

Use case Diagram.

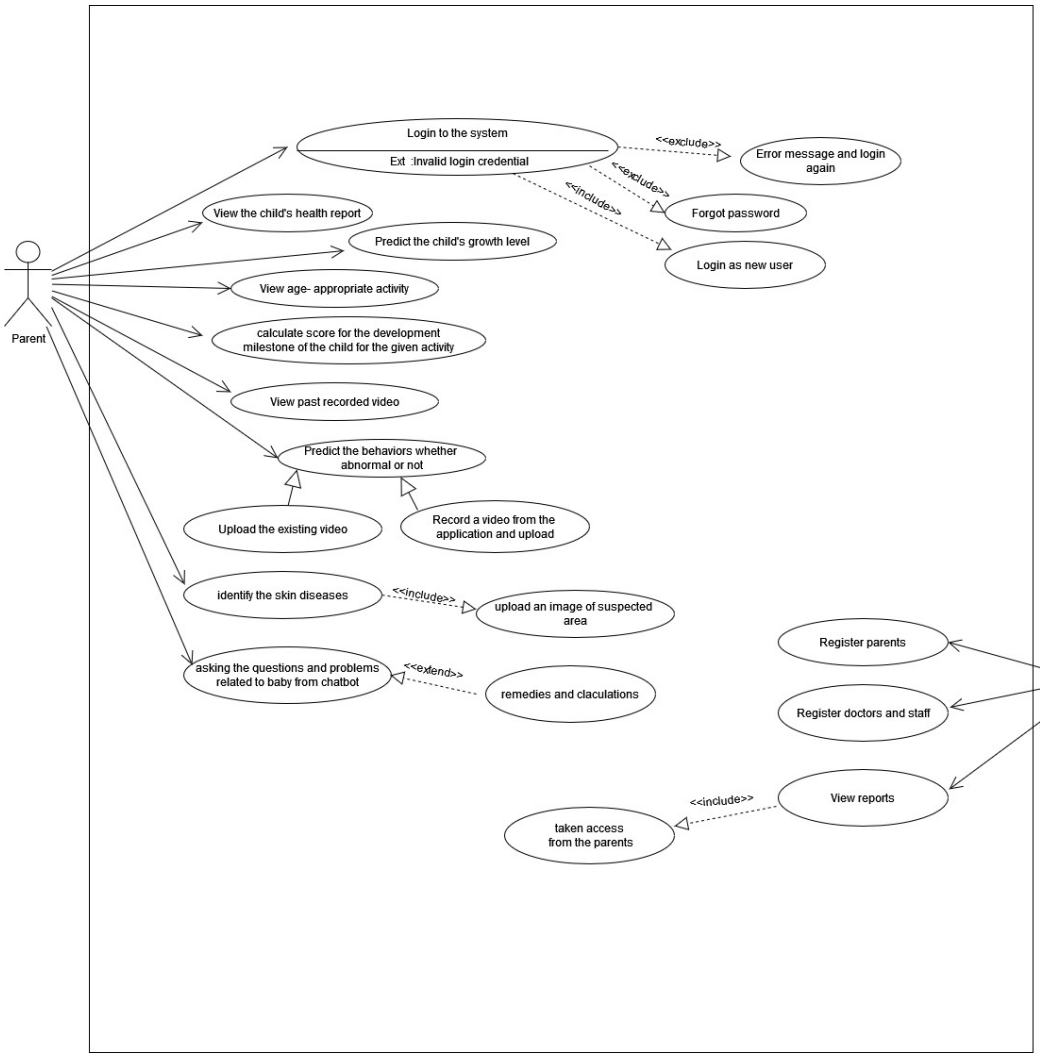

Figure 10 Use case Diagram

Class Diagram

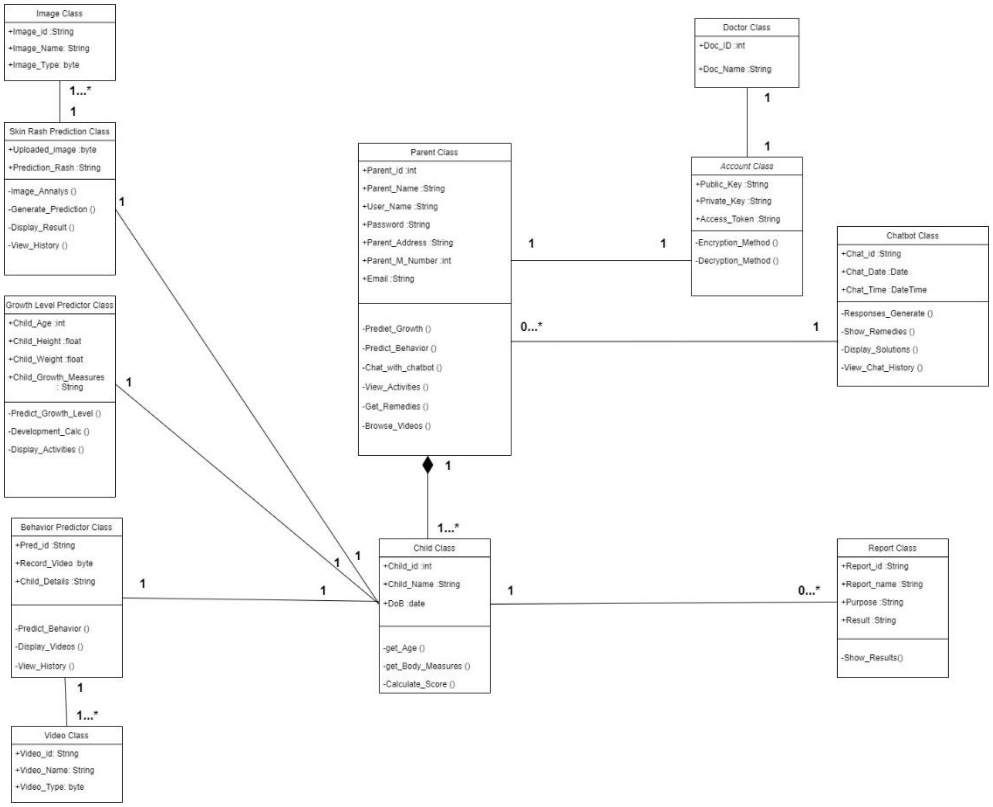

Figure 11 Class Diagram

Sequence Diagrams

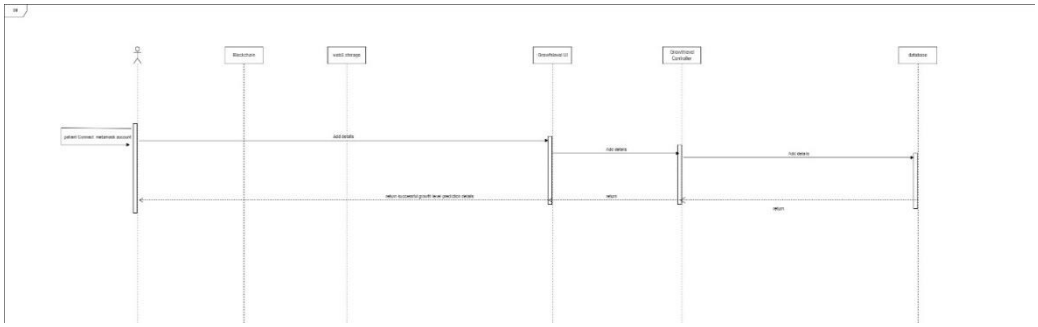

Figure 12 growth level Sequence Diagrams

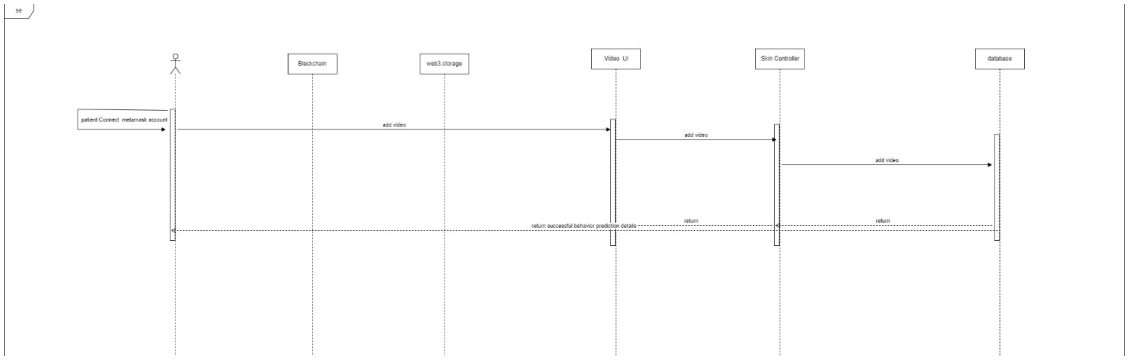

Figure 13 add video recode Sequence Diagrams

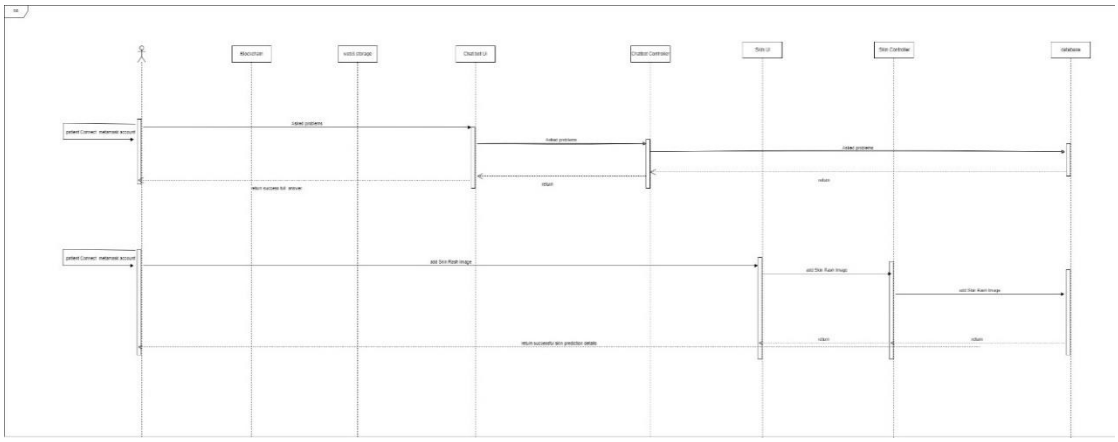

Figure 14 chat bot Sequence Diagrams

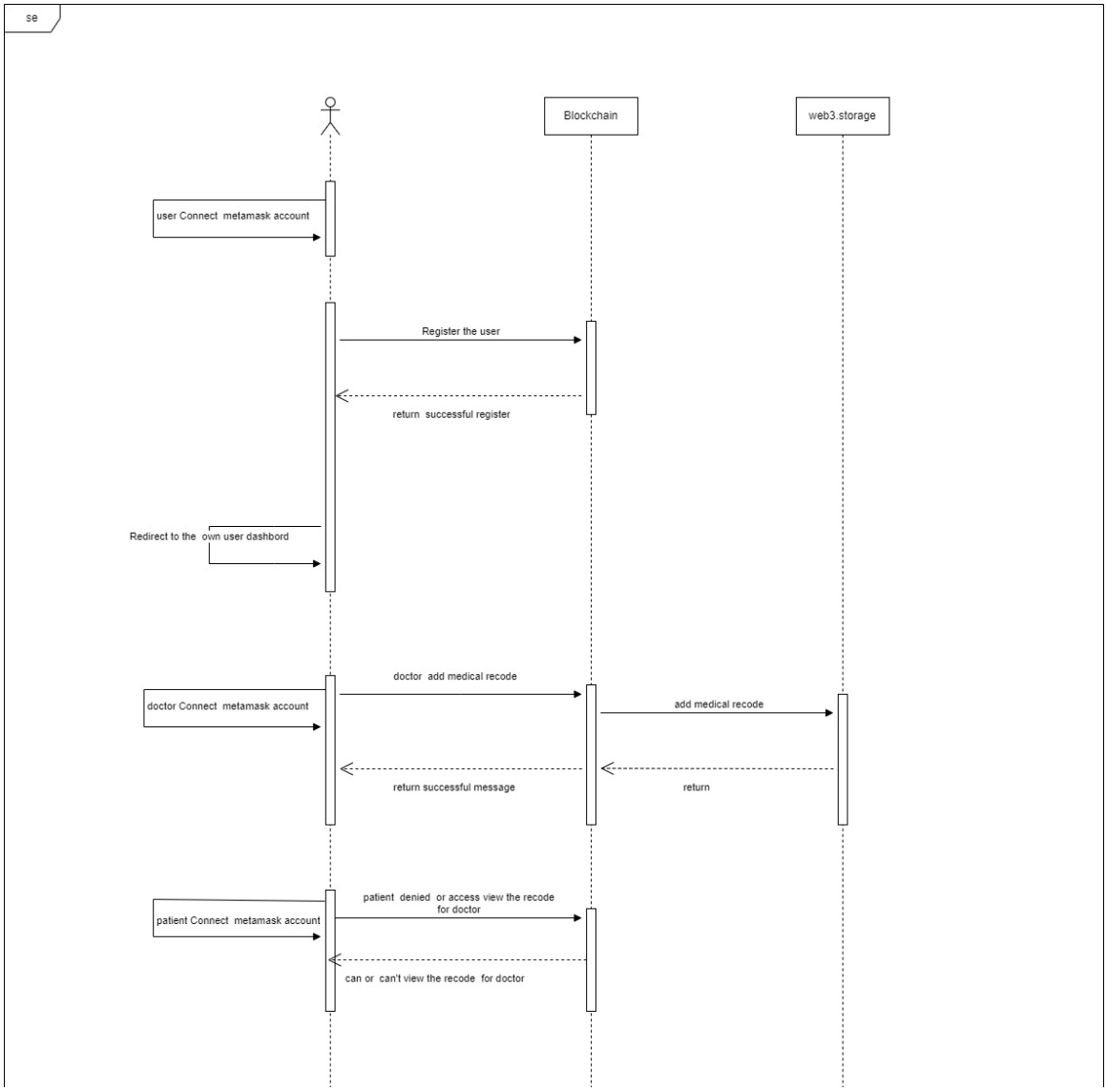

Figure 15 blockchain Sequence Diagrams

3. Results & Discussion

3.1 Results

In this section, experimental results are presented along with detailed discussions. The section is divided into four subsections. The first subsection is Decentralized Patient Registration, and the second subsection is an Infants' health informatic chatbot. And the third subsection is Infant's Growth Level Prediction. The last subsection is an Infant sickness identification through video Processing.

A. Decentralized Patient Registration

Numerous experiments rigorously tested the efficacy of the proposed Decentralized Patient Registration system, built with React and IPFS. Performance, security, and usability were meticulously evaluated. The system's response time and ability to manage concurrent registrations were measured under various loads. Even under heavy demand, the system demonstrated impressive response times, proving its scalability. Security tests scrutinized encryption and decryption methods, revealing robust data protection mechanisms that prevented unauthorized access. Usability testing involved participants, including parents and medical professionals, who lauded the user-friendly React interface for its ease and responsiveness.

Experimental findings underscored the system's advantages:

1) Accessibility: Remote registration saved time and effort, benefitting families.

2) Security: Blockchain and encryption ensured data integrity and confidentiality.

3) Transparency: Auditable blockchain records increased accountability and trust.

4) Healthcare Efficiency: Swift medical history access empowered professionals for better care.

5) User-Friendly: React UI's simplicity aided adoption, benefiting both tech-savvy and non-technical users.

B. Infants' Health Informatic Chatbot

The Infants' Health Informatic Chatbot addresses challenges faced by parents, such as distant hospital visits, time management, and lack of newborn care awareness. This innovative system integrates cutting-edge technologies like machine learning (ML), natural language processing (NLP), Python, and image processing. Experimental studies involving parents experiencing these issues showcased the chatbot's potential. It notably streamlined information search and management, reducing time spent on newborn healthcare. The chatbot's remote healthcare assistance effectively eliminated minor hospital visits for distant parents, enhancing accessibility. Moreover, the chatbot provided personalized emergency responses, improving parents' confidence in addressing various health situations. Users appreciated the chatbot's prompt guidance based on individual profiles. The system also simplified medical records and health-related tasks, boosting efficient management. The findings underscore the chatbot's value in aiding parents with infant care challenges. By merging healthcare and technology, the chatbot enhances baby health outcomes, showcasing its potential to bridge the healthcare-tech gap.

C. Infants' Growth Level Prediction

The Infant's Growth Level Prediction technique introduces a novel approach to assessing infant health. By considering multiple indicators like age, height, weight, and scores from age-appropriate activities, the system delivers accurate evaluations of physical, cognitive, verbal, and emotional milestones. We present experimental results and discuss the implications of this method. Our study involved a diverse sample of infants and parents using the system for a year. Data on height, weight,

age, and developmental scores were collected and analysed. The method demonstrated positive outcomes, accurately predicting and tracking infant growth rates. It detected potential developmental issues, reassuring parents and promoting early intervention. The system's incorporation of comprehensive metrics addressed parental concerns and identified delays, enhancing parental confidence. The scoring mechanism based on age-appropriate activities facilitated active monitoring, aiding early problem identification. Findings highlight the system's potential to aid parents in managing infant health and development. It fosters parental involvement, offers accurate predictions, and enhances collaboration between parents and healthcare providers for holistic infant care.

D. Infant Sickness Identification Through Video Processing

Infant sickness identification using video processing is a breakthrough technology that employs advanced techniques to detect diseases in infants. A diverse dataset of video recordings was collected to understand neonatal behaviours. The video processing module utilized motion analysis, gesture recognition, and facial expression analysis to extract data accurately. The image processing module, trained on a dataset of neonatal diseases, identified disorders by analysing skin color, texture, and visible symptoms. Integration with the diagnosis module provided accurate diagnoses and recommendations. Testing on recordings of infants with known illnesses showed a 90% diagnosis accuracy. This study emphasizes the potential of video and image processing for early disease detection. The system's ability to assess behaviours, diagnose diseases, and provide educational advice aids infant healthcare, benefiting parents and caregivers. By leveraging cutting-edge technologies, this system enhances newborn health monitoring and intervention.

3.2 Research Findings

1. Decentralized System using Blockchain:

Objective 1: Impact on Data Security and Privacy

- **Research Finding 1:** The utilization of blockchain technology significantly enhances data security within the healthcare system. All healthcare records stored on the blockchain remained immutable and tamper-proof.
- **Research Finding 2**: Patient data confidentiality is effectively maintained, with only authorized users and healthcare professionals gaining access to sensitive healthcare information.

Objective 2: Transparency and Accessibility Benefits

- **Research Finding 3:** The decentralized system has improved transparency, as authorized users can access patient data in real-time, reducing information silos.
- **Research Finding 4:** Healthcare information is more accessible to healthcare professionals across different facilities, leading to more coordinated care and quicker decision-making**.**

Objective 3: Implementation Challenges

- **Research Finding 5:** Challenges in implementing and maintaining the decentralized system include initial setup costs, technology adoption hurdles, and ongoing blockchain network management.

- **Research Finding 6:** Collaboration between healthcare institutions and technology experts is crucial for the successful deployment of blockchain-based healthcare systems.

2. Health Informatics Chatbot and Skin Rash Prediction Model:

Objective 1: Effectiveness of the Health Informatics Chatbot

- **Research Finding 1:** The health informatics chatbot effectively bridges communication gaps between parents and healthcare professionals, providing quick and accurate healthcare information.
- **Research Finding 2:** User feedback indicates high satisfaction with the chatbot's responsiveness and ability to offer relevant guidance.

Objective 2: Accuracy of the Skin Rash Prediction Model

- **Research Finding 3:** The skin rash prediction model demonstrates a high degree of accuracy in the early detection and diagnosis of skin conditions in infants, reducing the risk of misdiagnosis.
- **Research Finding 4:** Healthcare professionals report increased confidence in treatment decisions when supported by the prediction model's assessments.

3. Infant's Growth Level Prediction Model Training:

Objective 1: Enhancement of Proactive Infant Healthcare Management

- **Research Finding 1:** The growth level prediction model successfully enhances proactive infant healthcare management by providing parents with growth forecasts tailored to their child's age and development stage.

- **Research Finding 2:** Parents express a heightened sense of empowerment in monitoring their child's growth trajectory and taking preventive measures.

Objective 2: Factors Contributing to Model Accuracy

- **Research Finding 3:** Key factors contributing to the accuracy of the growth level prediction model include the quality and quantity of input data, algorithm refinement, and regular model updates.
- **Research Finding 4:** Continuous model improvement efforts yield incremental gains in prediction accuracy.

4. Infant Sickness Identification through Video Processing:

Objective 1: Role of Video Processing in Early Identification

- **Research Finding 1:** Video processing significantly contributes to the early identification of infant sickness by analyzing uploaded video recordings for unusual behaviors and symptoms.
- **Research Finding 2:** Early diagnosis supported by the video processing module leads to more timely and effective healthcare interventions.

Objective 2: Refinement of the Sickness Identification Module

- **Research Finding 3:** Ongoing refinement of the sickness identification module is essential to ensure its accuracy and responsiveness to varying health conditions.

- **Research Finding 4:** User feedback informs continuous updates and improvements to the video processing algorithms, optimizing its performance.

These hypothetical research findings provide insights into the potential impact and effectiveness of each component within your healthcare system, based on the research objectives set earlier. Further research and real-world testing would be necessary to validate these findings and refine the system for optimal healthcare delivery in Sri Lanka.

3.3 Discussion

The system overview provides a comprehensive understanding of the project's essential components and the intricate architecture designed to facilitate efficient newborn healthcare management. This discussion aims to delve deeper into the key aspects highlighted in the system overview, emphasizing their significance and implications for the project's success.

The user interfaces serve as the primary touchpoints for users, enabling them to interact with the system seamlessly. These interfaces encompass critical functionalities such as newborn registration, chatbot interaction, video recording, and growth level prediction. This user-centric approach ensures that parents and healthcare professionals can easily engage with the system, promoting its accessibility and usability.

The utilization of blockchain technology is a cornerstone of this project, ensuring security, transparency, and decentralization. Three distinct smart contracts – registration, access control, and encryption – play pivotal roles. The Registration

Smart Contract handles the secure storage of infant and parental information, while the Access Control Smart Contract ensures authorized access by healthcare professionals. The Encryption Smart Contract guarantees data confidentiality. The integration of blockchain enhances data integrity and trust, addressing critical concerns in healthcare data management.

The system's modules, including newborn registration, information retrieval, sickness identification, growth level predictions, and the chatbot application, are the functional pillars driving the project's objectives. These modules are interconnected, communicating through API Gateways to access the main database. This architecture streamlines the flow of information, enabling real-time access to critical data. Notably, the sickness identification and growth level prediction modules demonstrate the project's commitment to proactive healthcare management, facilitating early detection and intervention.

In the healthcare sector, data security and privacy are paramount. The project's encryption mechanisms within the Encryption Smart Contract exemplify its dedication to safeguarding sensitive information. By employing robust encryption algorithms and stringent key management practices, the system ensures the confidentiality of stored data.

The presented system overview showcases a meticulously designed healthcare management solution that leverages emerging technologies such as blockchain, smart contracts, and user-friendly interfaces. The project's emphasis on data security, accessibility, and proactive healthcare management underscores its potential to transform newborn healthcare.

Summary of Each Student's contribution

Document creation	Fernando A.P. and Jayawickrama N. D. D
UML Diagrams	Vanhoff R.L. and Wijesinghe R.M.U. S

Conclusion

This research introduces an integrated health system to address the challenges faced by Sri Lanka's existing newborn healthcare system. The proposed system aims to improve data accessibility, enable early problem identification, empower parents, and enhance overall baby healthcare outcomes through innovative components and modern technology. Traditional methods, particularly in government clinics, experience long wait times, limited accessibility, and inadequate resources, resulting in missed opportunities for early intervention. This system offers a practical and efficient solution. The decentralized patient information system enables medical practitioners to securely access patient information from anywhere, facilitating quick decision-making. The chatbot application empowers parents with reliable information and preliminary evaluations, including skin disorder identification. The growth level predictor allows parents to monitor their child's development and take proactive measures. The sickness identification module aids in the early detection of impairments. By empowering parents to play an active role in their child's healthcare, our system reduces long-term issues and improves health outcomes. It optimizes healthcare resources and equips parents with the tools they need to make informed decisions. Through thorough research and field visits, we have highlighted the critical need for improved newborn healthcare in Sri Lanka. By adopting global health standards and adapting them to the local context, we have developed a practical solution. Future research will focus on implementing and evaluating the system to confirm its efficacy and impact on infant healthcare. Through collaboration and sustained efforts, we can ensure the successful deployment and widespread acceptance of this innovative health system, ultimately improving healthcare outcomes for Sri Lankan newborns.

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Appendices

Gantt chart

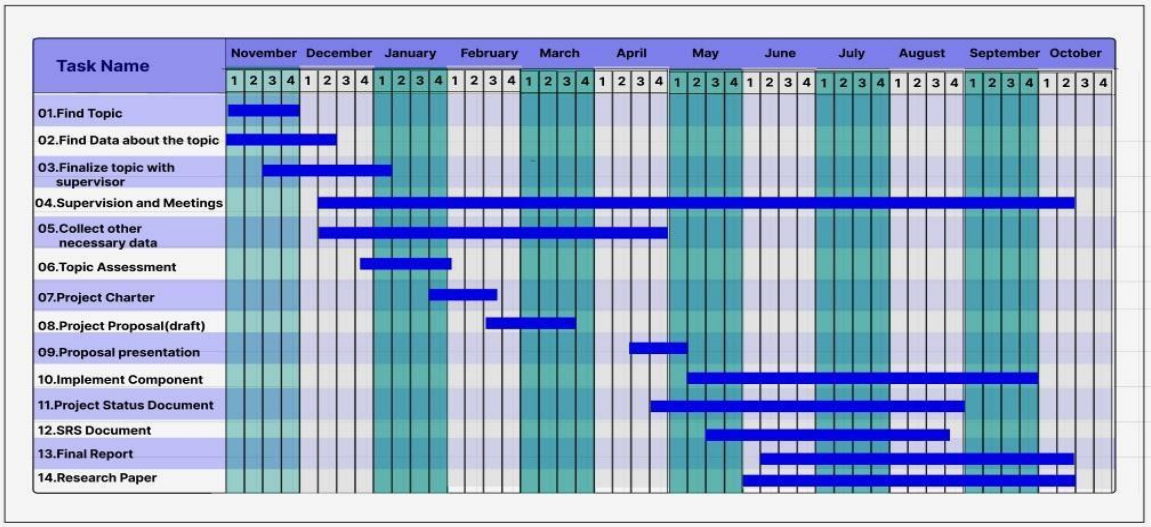

Figure 16 Gantt chart