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

***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 behaviors. This integrated solution aims to mitigate existing data and accessibility challenges, fostering timely and informed actions for better baby healthcare in Sri Lanka.**

Keywords*— *chatbot application, decentralized patient information system, growth level predictor, infant health system, sickness, unusual behavior identification.

I. INTRODUCTION

The newborn healthcare system in Sri Lanka predominantly relies on traditional practices within government facilities, necessitating physical visits to clinics for growth assessments. Weight and height measurements are recorded, and growth charts are adjusted accordingly. However, a noticeable decline in clinical visits, particularly among more affluent parents who opt for private healthcare, exacerbates healthcare inequities. Disadvantaged families, unable to afford regular check-ups, face challenges in accessing proper healthcare. To address these disparities, this proposed healthcare system aims to provide an inclusive and accessible solution for all parents, irrespective of their financial circumstances.

This novel approach leverages innovative technology to empower parents to actively participate in their child's healthcare journey. [13] A central advantage lies in the system's capability to forecast and monitor newborn growth levels. Through age-specific activity guidelines and forecasts, parents can proactively assess their child's growth trajectory. [14] The growth level predictor facilitates early detection of deviations, enabling timely interventions. This proves particularly beneficial for working parents with constrained schedules, offering quick access to health information and emergency suggestions [07]. A pivotal component is the chatbot application, which provides rapid assistance and directions, equipping parents to act effectively while awaiting professional medical help [08]. The system also incorporates a sickness identification module that analyzes uploaded recordings to identify unusual behaviors, enabling early diagnosis of potential issues [19].

Employing cutting-edge technologies like prediction models [20] image and video processing and blockchain [03] this system offers a practical and pragmatic alternative to existing approaches [09] [10]. It enhances accessibility, empowers parents, and optimizes healthcare resource utilization. By facilitating early detection and intervention, the approach significantly improves the health outcomes of Sri Lankan newborns, addressing the deficiencies in the current system.

This comprehensive strategy bridges gaps in healthcare delivery, ensuring equitable access and efficient resource allocation [12]. 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 [07].

II. 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.

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 [05]. Amid acknowledging blockchain's benefits, safeguarding patient data security is imperative. Legal implications necessitate attention. Comprehending the regulatory context of decentralized healthcare systems is vital, with relevance outlined. Adhering to regulations is essential, and blockchain's deployment facilitates this with various mechanisms [06]. 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.

B. Health Informatics Chatbot

The integration of chatbot-based remote consultations in newborn healthcare represents a significant innovation in the healthcare sector [07]. These AI-driven systems emulate human-like conversations and offer a potential avenue for enhanced patient engagement, cost reduction, and expanded service quality. 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 [08]. Prior research has explored the utility of chatbots in delivering basic medical advice and assessing COVID-19 symptoms [09]. However, emphasis on newborns and young children remains limited within health management systems. 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 [10]. A skin disease recognition method using image processing was explored in the context of dermatological conditions A recent study introduced INFANBOT, a chatbot system addressing issues faced by new parents and enhancing newborn health information dissemination.[11] 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,[12] 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 [13]. 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 [14]. Nair and Mehta's call for a life cycle approach align with the system's consideration of various developmental stages, offering a holistic assessment [15]. 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 [16]. The strategy creatively combines machine learning algorithms, age-appropriate behavioral assessment, and real-time parental observation, evaluating physical, cognitive, linguistic, and emotional aspects. 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. developed an algorithm that analyzes video records to identify specific movement patterns associated with neurological illnesses [17]. Johnson et al. used skin color and texture analysis to detect and classify common skin disorders in infants. Lee et al. focused on facial expression analysis for the early recognition of respiratory illnesses in infants [18]. Garcia et al. investigated gesture recognition techniques to identify abnormal movements related to developmental delays in infants [20]. 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 [21]

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 is a comprehensive health monitoring solution for parents, enabling tracking of various aspects of infant care [19]. It offers user-friendly interfaces, growth tracking, sleep analysis, and medication reminders. Employing mobile and cloud technologies, it ensures robust health supervision with Java and Swift support.

2) WebMD Baby - WebMD Baby, a mobile app, aids parents in overseeing their baby's health [20]. With tailored content, medication reminders, growth tracking, and vaccination schedules, it enhances parental knowledge and

organization. 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 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.

III. METHODOLOGY

A. System Overview

Key components of the system shown in Figure 1 are accessed largely through user interfaces. These interfaces include those for filming videos, predicting growth levels, and registering newborns. Three different forms of smart contracts—access control, encryption, and registration—are used by the decentralized system to manage baby data. Access Management By authenticating users and allowing access to data based on credentials, smart contracts guarantee that only authorized doctors have access to it. Parent and child information is safely entered and verified by registration smart contracts and stored on the blockchain. Data encryption and decryption are handled via encryption smart contracts, maintaining secrecy.

The main components of the system are the chatbot application, which communicates with API Gateways to connect to databases, and the modules that track newborns, diagnose illnesses, anticipate growth, and monitor growth. Data retrieval from the main database is made possible using API calls.

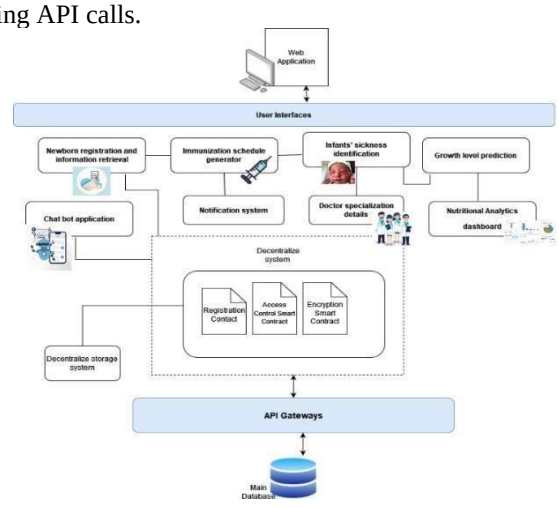

Figure 1: High-level diagram for the system

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 record newborn and parental information securely and efficiently, enhancing transparency and accessibility. The solution prioritizes data privacy and security, employing the Inter Planetary File System (IPFS) for storing medical records.[05] 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.[06] 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.

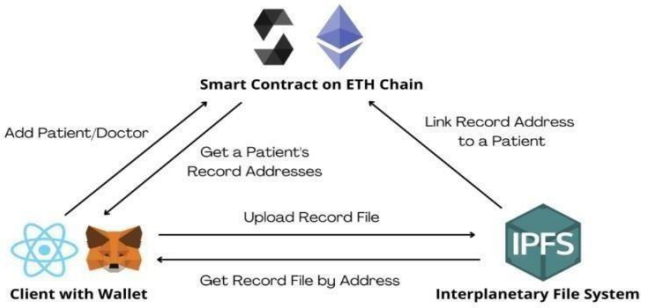

Figure 2: Component diagram for the decentralized system

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), [08] the chatbot comprehends and interprets user queries effectively. The chatbot handles various queries, offering advice on medications, symptoms, common illnesses, and temporary remedies. 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.[10] 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.[12]

Figure 3: Component diagram for the chatbot application

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.[14] 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.[15] [16] This technique enhances parental involvement, enables early intervention, and optimizes childwell-being.

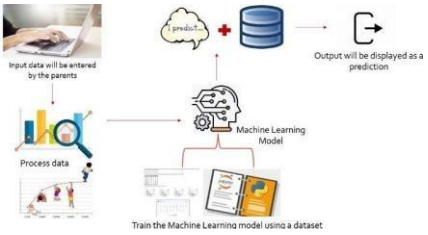

Figure 4: Component diagram for the growth level prediction

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 [18].

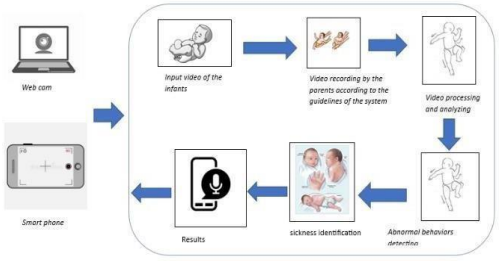

Figure 5: Component diagram for the infant's sickness identification

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 observed in videos like in figure 6, aiding skincare decisions.[19] [20] But this system predicts the

abnormality of the child's behavior and suggested some actions can be taken.

Figure 6: discharge, flushed skin, and redness

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 [21]. Tested on known illnesses, the system achieved a 90% accuracy rate. The study aimed to use video and image processing to identify infant behaviors. 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 behaviors during testing.

B. Project Technology Stack

1) Machine Learning and Deep Learning Frameworks

A. Blockchain

Blockchain is a secure, decentralized technology for encrypting and recording data [8]. When registering a newborn's information, the 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);[08] [09]and question-answering using pre-trained language models (Transformers

like BERT, and GPT) for accurate responses. This tech stackoptimizes 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. Transferring learning with pre-trained CNNs from datasets like ImageNet is also useful when labeled data is limited.[19] [20] 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, orF1 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 [16]. 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.

2). 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.

IV. Results and Discussion

A. Decentralized system

Table 1 – patient registration performance metrics

Metrics	Value
Data Security	High
Data Accessibility	Efficient
Transparency	Improved
Data Integrity	Guaranteed

B. Health informatic chatbot results

Table 2: Chatbot Performance Metrics

Metrics	Value
User Engagement	High
Medical Knowledge	Comprehensive
Symptom Prediction	Accurate
Emergency Response	Rapid

C. Skin rash prediction model results

Table 3: Skin Rash Prediction Model Metrics

Metrics	Value
Rash Identification Accuracy	70%- 75%
Skin Condition Recognition	Comprehensive
Prompt Identification	Achieved
Symptom-Based Prediction	Effective

D. Infant growth level prediction results

Table 4: Growth Level Prediction Metrics

Metrics	Value
Growth Prediction Accuracy	Above 80%
Early Detection Capability	High
Parental Involvement	Enhanced
Comprehensive Assessment	Achieved

E. Infant sickness identification through video processing results

Table 5: Sickness Identification Performance Metrics

Metrics	Value
Illness Identification Rate	Above 80%
Prompt Intervention	Facilitated
Comprehensive Assessment	Achieved

The proposed infant health system combines cutting-edge components to address healthcare gaps in Sri Lanka. These include a chatbot app, growth predictor, skin disease identifier, early disease detection, and decentralized patient information system. The decentralized system enhances data security, accessibility, accuracy, and confidentiality. The chatbot empowers parents with remote guidance, and future improvements involve NLP advancements and multilingual support. The growth predictor boosts parental involvement in infant health, with potential enhancements in prediction models and mobile compatibility. Video-based illness identification offers preventative healthcare, with improvements like machine learning techniques and expanded data sources. This system democratizes

healthcare access, ensuring fairness and raising patient care standards. Future refinements aim to comprehensively address Sri Lanka's healthcare challenges.

V. CONCLUSION

The particular infant healthcare issues in Sri Lanka are intended to be addressed by this integrated healthcare system. It improves data accessibility, facilitates early problem diagnosis, gives parents more control, and leads to better outcomes for baby healthcare in general. Particularly at government clinics, traditional methods, characterized by lengthy wait periods and restricted accessibility, can impede prompt intervention. Healthcare practitioners can access the proposed system securely from a distance thanks to a decentralized patient information system. A chatbot application provides accurate information and speedy evaluations, including the identification of skin disorders. Early impairment detection is aided by the illness identification module, and active child development monitoring is made possible by the growth level predictor. This approach makes the best use of available medical resources, lessens long-term problems, and incorporates parents in their child's medical treatment. Future research will validate its efficacy, benefiting Sri Lankan newborns and collaborating on healthcare challenges.

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