HealthWatch: ICU Monitoring and Cloud Integration

Mukta Manoj Bahulekar
Department of Computer Engineering
Sinhgad College of Engineering
Pune,India
bahulekarmukta@gmail.com

Chitrarth Purushottam kadel
Department of Computer Engineering
Sinhgad College of Engineering
Pune,India
chitrarth.kadel2003@gmail.com

Sahil Phule
Department of Computer Engineering
Sinhgad College of Engineering
Pune,India
sahilphule0710@gmail.com

Swayam Sanjay Sonar
Department of Computer Engineering
Sinhgad College of Engineering
Pune,India
swayam.yvupw21@sinhgad.edu

***Abstract*— The advancement of technology has reached all sectors, profoundly transforming industries and enhancing capabilities. In healthcare, particularly in Intensive Care Units (ICUs), these advancements have the potential to significantly improve patient outcomes and streamline critical workflows. HealthWatch is a cloud-integrated web-based system that serves to revolutionize the care of ICU by way of point-of-care monitoring of vital signs in real-time, safe data storage, customizable alerts, and solid analytics. HealthWatch lets health professionals access up-to-date information about their patients from any location, thereby improving response times and patient outcomes. Integration of HealthWatch with ICU monitors captures all key data points from a patient, for example, heart rate, ECG, blood pressure, temperature, and securely stores it in the cloud. The staff will receive an overview on a centralized dashboard, allowing them to monitor more than one patient at once. Customizable alerts allow for automatic notifications to medical staff when vital signs exceed or fall below threshold values, so they can intervene quickly. Data analytics and machine learning capabilities offer predictive insights to aid in better decision-making and proactive care. Healthwatch, therefore, will optimize intensive care unit procedures, increasing productivity, and reduce the workload of staff in the hospital, cutting down on human error in the end resulting in high patient satisfaction and quality care.**

Keywords—healthcare, patient monitoring, data storage, analytics, alert management, cloud.

I. INTRODUCTION

Healthcare is an essential industry that profoundly impacts the quality of life for every individual. The state of a country's healthcare system reflects its overall well-being, with better healthcare facilities leading to healthier, more productive citizens. The rapid advancement of technology has brought transformative changes to healthcare, making it more precise and effective. One of the most critical areas within hospitals is the Intensive Care Unit (ICU), which provides continuous, high-level medical care to patients in severe condition.

In the ICU, constant monitoring of vital signs, frequent health assessments, and immediate doctor interventions are fundamental, as even minor delays or inaccuracies can have serious consequences. However, many hospitals rely on manual, chart-based systems for recording and tracking patient data. This reliance increases the workload for nurses, contributes to fatigue, and raises the risk of human error, which can lead to delays in treatment and adverse outcomes.

Digitization and automation can significantly improve ICU operations. By streamlining patient monitoring with advanced digital solutions, healthcare teams can achieve greater precision, reduce manual effort, and minimise the potential for errors. Automated data collection and alerting mechanisms enable healthcare professionals to focus on direct patient care, improve response times, and make more informed decisions.

To meet these demands, we introduce HealthWatch, an innovative platform designed to revolutionize ICU operations. HealthWatch automates the monitoring and documentation process, offering real-time tracking of patient vitals, integrated data analytics, and customizable alert systems to enhance patient safety. By digitizing these processes, HealthWatch aims to reduce the burden on healthcare staff, improve data accuracy, and ensure timely, data-driven decision-making, ultimately leading to more efficient and effective patient care in the ICU.

II. LITERATURE SURVEY

A. 'I-Doc – A Cloud Based Data Management System For Health Care'[1]

This paper describes a system for cloud management of patient data, that matches our scope of integrating cloud storage in the monitoring of ICU patients. The benefits of using a cloud-based EMR [18] system are presented here, offering insight into how to produce a scalable and efficient cloud infrastructure. It uses the Bootstrap and Electron frameworks in the user interface, which enable adapting user-friendly experience to the needs of health professionals. It presents the shift of systems from in-house data centers of the hospital premises to cloud solutions that eventually reduce maintenance costs and improve scalability. These are factors HealthWatch needs. The use of advanced techniques of encryption and access protocols is achievable through cloud integration to encrypt the patient data.
The paper is purely on managing health records rather than monitoring real time data. Our system would need to depend more on collecting and analyzing real-time data since, in the ICU environment, urgent responses to patients are always

required due to shifting patient conditions. It does not scale the patient data across facilities.

B. *'Iot Based Icu Patient Monitoring Smart System'[2]*

The paper describes an IoT-based system that provides real-time monitoring to ICU patients by using various sensors for temperature, ECG, and respiratory rates. The sensor integrated into the ESP8266 microcontroller, showing a better understanding of sensor calibration and protocol of wireless data transmission. The paper uses AWS [10] services, such as DynamoDB [11], MQTT [12], and SNS [13], to provide a framework of cloud-based architecture for storing and analyzing patient data. Upon using these sensor-based data from patients, the machine learning model can predict a patient's health but majorly emphasizes alert systems rather than in-depth predictive analysis. Customization by the users or professionals is not flexible as per requirement; it provides basic alerts based on patient vitals.

C. *'Prediction of ICU Patients' Deterioration Using Machine Learning Techniques'[3]*

This paper evaluates the use of ML models (Gradient Boosting [13], KNN [14], SVM [15], etc.) to predict ICU patient deterioration based on vital signs such as blood pressure, heart rate, respiratory rate, and oxygen saturation. It uses static models on historical data for deterioration prediction. It gives insight into monitoring ICU patients and predicting deterioration using real-time vital signs, comparing performances on model selection for early ICU deterioration warnings.

D. *'Cardio Monitoring and Cardiac disease prediction using Machine Learning' [4]*

This paper focuses on integrating sensors (ECG, heart rate, temperature, glucose) with IoT platforms to monitor patient vitals and predict cardiac disease using ML models (KNN [14] and SVM [15]). Provides a roadmap on how to gather vital signs from sensors and transmit them to the cloud for processing. Using SVM and KNN to predict heart disease aligns with the goal of integrating cardiac monitoring in ICU patients.

It explores data preparation, training, and validation approaches, but lacks real-time adaptive prediction. The cardiac monitoring paper uses traditional ML models (SVM, KNN) with a relatively small dataset.

E. *'Onsite Survey and Practical Observations'*

We conducted an onsite survey at Smt. Kashibai Navale Medical College and General Hospital, Pune to gain practical insights into the current state of ICU monitoring. This survey was conducted in various hospital wards to understand the overall workflow and monitoring practices, the patterns were identified in addition to interviews with doctors and nursing staff regarding problems and limitations. It was observed that most of the ICUs still utilize chart-based systems for recording patient vitals without much dependency on automatic systems. These systems require nurses to document data regularly; hence, their workload is taken to the next level with the risk of human error. Medical staff aired the fact that this manual process would often lead to delays in updating patient information, so response times are compromised when it really matters-most notably during emergencies. This result also shows that even though there are some hospitals that use digital monitoring equipment, the data they collect is often decentralized or imperfectly integrated with a comprehensive system. This incomplete integration makes it difficult to monitor several patients simultaneously or get an overview of patient histories and current vitals in real-time. They led to a need for a solution that would not only automate the collection of data but also centralize the patient information for attaining an at-a-glance view of the status of the ICU.

These first-hand observations confirmed the findings in literature, through an emphasis on the need for an efficient, automated system that would simplify monitoring patients and reduce the possibility of manual errors. From these onsite surveys, insights have provided a good clarity to develop HealthWatch as a product which will enhance the current ICU monitoring through real-time integration, customizable alerts, and predictive analytics.

III. PROPOSED SOLUTION

The proposed system is designed as a comprehensive platform integrating four main functionalities: Vitals Monitoring, Alert Management, Data Analytics, Patient & Doctor Registry. This system will leverage IoT technology, artificial intelligence, machine learning, and cloud computing to create a unified, patient-cantered ecosystem. The functionalities are given as follows:

A. *Vitals Monitoring*

1. Overview

Vitals monitoring is a foundational aspect of patient care, requiring real-time data acquisition to quickly detect changes in a patient's condition. Traditional methods often rely on periodic manual checks, which can lead to delays and data gaps. This system aims to improve vitals monitoring by implementing continuous, automated data capture through connected IoT devices.

2. Technology and Approach:

- Vitals Measuring Devices: The devices are attached to patients that continuously monitor vital signs, such as heart rate, blood pressure, oxygen saturation, temperature, and respiratory rate. These devices are equipped with sensors that collect data in real time and transmit it securely to the central system.
- Monitoring Equipment: For in-patient care, smart central monitors will be deployed to capture vitals from stationary or critical patients, particularly in high-dependency areas like ICUs. These devices will integrate seamlessly with the system, ensuring all collected data flows into the centralized database.
- Data Aggregation and Analysis: The data from IoT devices is aggregated and stored in the cloud for analysis, creating a continuous, comprehensive record of patient vitals.

3. Benefits:

- Continuous Monitoring: Provides healthcare providers with an uninterrupted stream of data, reducing the reliance on manual checks.
- Informed Decision-Making: Gives a detailed view of patient health, facilitating timely interventions when patterns indicating deterioration are detected.
- Remote Patient Management: Enables remote monitoring for patients outside hospital settings, reducing the need for frequent in-person visits and helping manage chronic conditions.

B. Alert Management

1. Overview:

Alert management is critical for managing emergencies and ensuring patient safety. In this system, alerts are based on real-time data analysis, generating notifications for healthcare providers when a patient's vitals reach critical thresholds or when abnormal patterns are detected.

2. Technology and Approach:

- AI and Machine Learning Algorithms: HealthWatch will use AI models trained on historical patient data to predict adverse health events. For instance, a sudden drop in blood oxygen levels or an unusually high heart rate would automatically trigger an alert.
- Customized Alert Thresholds: Different patients have unique health baselines. The system will allow for customized threshold settings based on individual patient profiles, which helps reduce false alarms and ensures alerts are meaningful.
- Mobile Alert System: Healthcare providers receive alerts on mobile devices through email or WhatsApp messaging, enabling rapid response even when they are not at the patient's bedside. For example, nurses and doctors can receive real-time push notifications for any abnormal events, complete with patient details and recommended actions.
- Escalation Protocols: If the initial responder does not acknowledge an alert within a certain timeframe, the system escalates it to other team members or shifts it to a higher priority level.

3. Benefits:

- Proactive Response: Allows healthcare staff to intervene before conditions become critical, significantly improving patient outcomes.
- Reduced Alarm Fatigue: Customizable alerts reduce unnecessary notifications, helping clinicians focus on high-priority cases.
- Enhanced Workflow: Streamlines and prioritizes tasks, improving overall staff efficiency and response times.

C. Data Analytics

1. Overview:

The data analytics component of the HealthWatch is essential for gaining insights from the vast amount of health data generated. By applying analytics to patient data, healthcare providers can identify trends, predict patient outcomes, and tailor treatments to individual needs.

2. Technology and Approach:

- Descriptive Analytics: Generates reports and dashboards showing key metrics like average heart rate trends, frequency of alerts, and overall patient status. This information is accessible in real time for clinicians to monitor and compare against historical data.
- Predictive Analytics: Uses machine learning to predict future health events, such as risk of heart failure or likelihood of ICU admission. For example, the system can analyse a patient's vitals and alert clinicians to potential deterioration over the coming hours.
- Prescriptive Analytics: Recommends specific actions based on data analysis, such as adjusting medication dosages or suggesting specific interventions for high-risk patients. By integrating clinical guidelines, prescriptive analytics aids clinicians in making decisions aligned with best practices.

3. Benefits:

- Enhanced Clinical Insights: Provides clinicians with data-driven insights, making it easier to customize patient care.
- Preventive Care: Identifies patterns that can predict potential health issues, allowing for early intervention.
- Improved Resource Allocation: Supports planning for high-risk patients, optimizing staff resources, and better inventory management (e.g., oxygen supplies or medications).

D. Patient Registry

1. Overview:

Patient Registry is critical for continuity of care, providing healthcare professionals with comprehensive access to a patient's health history. Fragmented health records often lead to incomplete diagnoses and unnecessary tests. This system integrates all patient history into a centralized electronic health record (EHR) [16], accessible to all authorized staff.

2. Technology and Approach:

- Electronic Health Records (EHR) System: All patient records, including medical history, diagnostic results, treatment plans, and medication records, are consolidated in an EHR [16]. This ensures complete and consistent patient profiles, which can be accessed securely by authorized personnel.
- Interoperability and Data Sharing: The system will support integration with other healthcare systems, enabling data exchange with external healthcare facilities, labs, pharmacies, and imaging centers.
- Data Access Controls: Role-based access control (RBAC) [17] ensures that only authorized individuals can view or edit specific data fields.

3. Benefits:

- Seamless Continuity of Care: With a comprehensive, accessible patient history, clinicians can make informed decisions based on a full understanding of each patient's medical background.

- Reduced Redundant Testing: Access to prior test results and treatment histories minimizes repetitive testing, reducing costs and patient discomfort.

E. Doctor Registry

1. Overview:

The Doctor Database is a centralized, real-time repository within the HealthWatch that stores essential information on each doctor's availability, specialties, current patient assignments, and schedules. This database facilitates efficient doctor allocation by matching patient needs with the most suitable available doctors and enabling healthcare providers to check doctor availability instantly.

2. Key Features of the Doctor Database:

- Doctor Profile Management: Detailed Doctor Profiles: Each doctor's profile contains comprehensive information such as medical specialty, current role, and departmental affiliations. Profiles also include preferred work shifts, typical caseloads, and past patient interactions.
- Doctor Availability Check and Scheduling: Calendar and Shift Integration: Synchronizes doctor availability with shift schedules, planned leave, and any planned on-call rotations. This integration ensures that only available doctors are listed during specific times and helps avoid scheduling conflicts.
- Patient-Doctor Matching and Allocation: Manual Allocation Options: The system provides manual selection options, allowing healthcare administrators or the triage team to allocate doctors to patients in real time or schedule visits in advance.
- Caseload Balancing: Ensures an even distribution of patients across doctors, considering each doctor's existing caseload and availability. This feature helps avoid overloading individual doctors, improving care quality and maintaining a balanced workload.

3. Benefits:

- Improved Patient Care and Reduced Wait Times: Patients are quickly matched with available doctors who have the right expertise, minimizing delays and improving patient satisfaction.
- Optimized Resource Utilization: Ensures doctors are allocated efficiently based on current demand and availability, reducing bottlenecks and maximizing staff productivity.
- Better Staff Management and Reduced Burnout: Caseload balancing prevents doctor overload and allows administrators to allocate cases fairly, improving work-life balance and reducing burnout risk.
- Seamless Care Coordination: Doctor availability and activity tracking ensure that all team members have access to accurate information, enabling a smoother flow of care across departments.

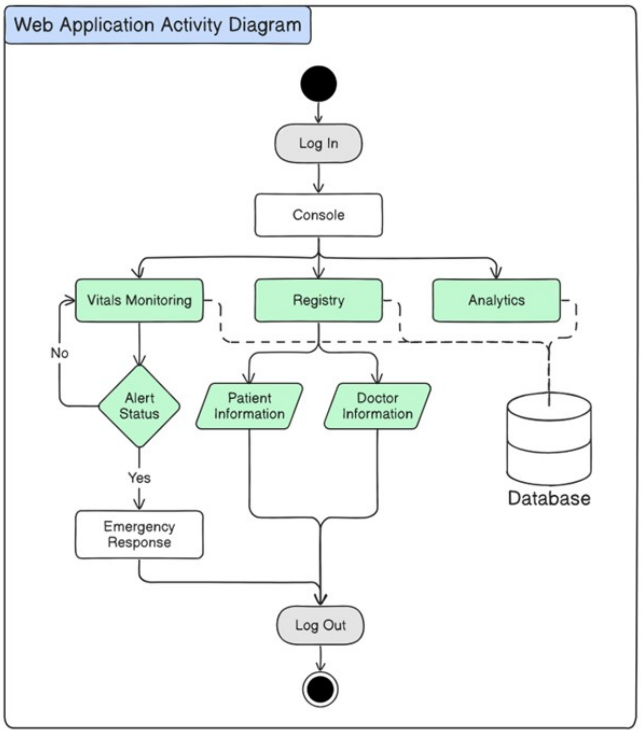

Fig. 1. Web Application Activity Diagram

IV. PROPOSED SYSTEM ARCHITECTURE

The architecture of the HealthWatch system is designed to efficiently handle real-time patient data monitoring, cloud integration, and data analytics. The system architecture can be divided into three key sections: Data Extraction, Web Application, and Cloud Computing. Each part of the architecture uses specific technologies to ensure smooth data collection, processing, storage, and display. Additionally, we will be implementing a microservice architecture to enhance the system's modularity, scalability, and flexibility. This approach allows for independent deployment and scaling of different services, improving system performance, ease of maintenance, and future integration with additional healthcare tools. The microservice design also supports better fault isolation and faster deployment of updates.

1. Data Extraction

The Data Extraction section focuses on gathering patient data from ICU monitors, which is the foundation of the HealthWatch system. The ICU monitors, such as Draeger devices, capture vital patient metrics, including ECG, heart rate, SpO2, and respiratory rate. These devices generate both analog and digital data. To facilitate seamless extraction of data, ESP32 microcontrollers are employed as intermediaries. These microcontrollers are equipped with built-in Analog-to-Digital Converters (ADC) that convert analog signals from ICU devices into digital values.

The data extraction process involves the following steps:

- ICU monitors send data either in analog (ECG) or digital (pulse) formats.
- The ESP32 microcontroller collects and filters this data, converting analog signals to digital values.

- The microcontroller then transmits the processed data to the Master System, either through wired (cable) or wireless (Wi-Fi) connections.
- Node-RED is used as middleware to enable communication between the ICU monitors and the web-based system, transforming and forwarding the data for further processing.

The use of Node-RED ensures that the data can be collected from multiple ICU monitors and transmitted to the cloud in real-time. This setup helps maintain an efficient data pipeline, ensuring that patient vitals are continuously updated and processed.

2. Web Application:

The Web section of the architecture deals with the user interface (UI) and how healthcare providers interact with the system. The web application interface will be designed to be intuitive, ensuring seamless navigation for healthcare providers with minimal training. Its user-friendly dashboard will provide quick access to critical functions, such as real-time vitals monitoring, patient records, and alert management. Additionally, its responsive design will ensure accessibility across devices, enabling remote monitoring and decision-making. The web-based application must be responsive, user-friendly, and capable of handling large amounts of data with minimal latency. To meet these requirements, the frontend is developed using HTML5, CSS3, and JavaScript frameworks such as React [20].

Key components of the web-based system include:

- Main Console: After logging in, healthcare providers are directed to a central dashboard displaying real-time vitals of all patients in the ICU. The interface is intuitive, providing easy navigation to key features such as Vitals Monitoring, Analytics, Registry, and Alert Management.
- Vitals Monitoring Dashboard: This dashboard shows real-time patient vitals (heart rate, blood pressure, ECG, SpO2, etc.) and updates continuously without manual refresh. Clicking on a Bed ID opens detailed patient data, enabling staff to monitor specific patients more closely.
- Alert Management Interface: Doctors and nurses can manage alerts triggered when a patient's vitals exceed predefined thresholds. Alerts are displayed in a clear, actionable format, and notifications are sent through Email or WhatsApp.
- Data Analytics Dashboard: This feature provides graphical visualizations and reports based on historical patient data. Using graphs and charts, healthcare providers can analyze patient trends and derive predictive insights.
- Doctor and Patient Registry:
  This feature enables comprehensive management of patient and doctor information within the system. It facilitates the registration and updating of details, allowing healthcare providers to maintain an accurate and organized repository of records. The registry supports secure and role-based access to ensure data integrity and confidentiality. By integrating this module, the system improves patient-doctor engagement, allowing for better coordination and continuity of care.

The backend of the web system is developed using Node.js and Express.js, which provide a lightweight and scalable environment to handle requests, manage sessions, and interact with the database. RESTful APIs are used for seamless communication between the backend and the frontend, ensuring data retrieval, user management, and alert configuration are performed efficiently. Node.js is selected specifically because of its ability to handle real-time data management, ensuring strong and robust performance.

3. Cloud Computing:

The Cloud infrastructure is critical for storing, processing, and managing large volumes of patient data. The HealthWatch system uses Amazon Web Services (AWS) to leverage its scalable, secure, and reliable cloud services. The following key technologies are employed in the cloud architecture[9]:

- AWS Virtual Private Cloud (VPC): The VPC ensures that the system's infrastructure remains secure and private. This is critical for compliance with healthcare regulations, as sensitive patient data must be protected from unauthorized access.
- AWS Elastic Compute Cloud (EC2) and Elastic Container Service (ECS): EC2 instances will be utilized for the development and testing phases of the application, while ECS will be deployed for production purposes. ECS leverages containerization technology, ensuring that all application dependencies are packaged together, which minimizes the risk of failures. Additionally, ECS supports features like auto-scaling and load balancing, enabling effective management and distribution of incoming traffic.
- AWS Relational Database Service (RDS): Patient data, including real-time vitals and historical records, are securely stored in MySQL databases. This service provides a managed, scalable database solution, offering backup, recovery, and high availability. Data can be queried in real-time or archived for historical analysis.
- Amazon Simple Storage Service (S3): S3 buckets are used to store application files, patient records, and large datasets. The system's data storage needs are met by providing secure, scalable storage that is easy to integrate with other cloud services.
- AWS CloudWatch and Analytics Tools: AWS services, such as CloudWatch, are used for monitoring system performance, tracking application logs, and ensuring that all components of the system are functioning correctly. Additionally, AWS Analytics tools provide the capability to analyze large datasets and generate predictive insights, which are critical for healthcare providers to make informed decisions based on real-time and historical patient data.

The cloud infrastructure provides flexibility and scalability to the system. It enables easy integration with machine learning models and predictive algorithms, which can be added to enhance data analysis and provide advanced insights. By using cloud services, the HealthWatch system ensures that patient data is securely stored and processed, while maintaining high availability and performance.

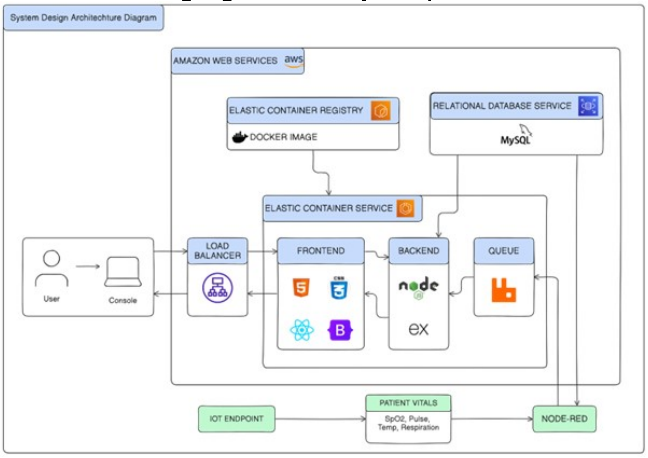

Fig. 2. Proposed System Architecture Diagram

V. FUTURE SCOPE

1. While HealthWatch is designed with ICU monitoring as its primary focus, its infrastructure is adaptable for use in other hospital departments, such as general wards, emergency rooms, and specialized units like pediatric and neonatal ICUs. By scaling the system, hospitals can create a unified monitoring platform across multiple departments, ensuring seamless patient data flow and consistent monitoring standards throughout the facility. This scalability enables better communication among departments, improved patient transfers, and comprehensive care continuity.
2. To enhance accessibility and improve response times, HealthWatch can be expanded to include mobile and app-based access for healthcare professionals. Mobile applications would allow doctors, nurses, and caregivers to view patient data, receive alerts, and make informed decisions even when they are not physically present in the hospital. This feature would be especially beneficial for on-call physicians, enabling them to monitor critical cases remotely and provide timely input. The app would be designed with secure login protocols and data encryption to ensure patient information remains confidential and protected. Features such as push notifications for critical alerts, access to historical data trends, and teleconsultation support would empower healthcare providers to maintain high standards of patient care from anywhere, improving overall efficiency and responsiveness.
3. With advancements in data analytics and machine learning, HealthWatch can incorporate personalized treatment plan suggestions. By analyzing a patient's continuous vital data, medical history, and responses to previous treatments, the system can identify patterns and predict potential outcomes. Using this data, HealthWatch can suggest tailored treatment plans or modifications to existing care protocols, supporting doctors in making data-driven decisions.

VI. CONCLUSION

A visible lack of records on health and vitals exists in even modern hospitals today, systems that do exists in hospitals are expensive, difficult, time consuming and unreliable, making them practically and literally unusable. Many hospitals do manual monitoring on soft records (paper, files) which is prone to accidental destruction or hazards. However, it can be easily solved by creating a centralized platform that can integrate itself with various available vitality sensors and equipment's which should be easy to use, navigate, access, customize per patient, and track information with. Our proposed systems aims to do this by creating a no code interface for ease of integration of various sensors, and their management, monitoring, event management, and AI /ML processing for predictive results of patients health, possible complications and vital expectations. As our proposed system stores data on cloud, it would be reliable and easy to access through our website for the doctors making it suitable for daily use and eliminating the need to mark vitals manually. A Dashboard will contain every little detail of each bed on the hospital with easy to modify options such as parameters of vitals to alert for, patient discharge and new entry, live vitals and a separate records section for various patient history.

In conclusion, our proposed centralized health monitoring platform is designed to revolutionize patient care in hospitals by streamlining data collection, monitoring, and predictive analysis. By integrating seamlessly with various vital sensors and offering an intuitive, no-code interface, this system will significantly reduce the burden on healthcare providers, minimize human error, and ensure secure, cloud-based storage of critical health information. With accessible dashboards and automated alerts, doctors can focus more on patient care while having the confidence of reliable, real-time data at their fingertips. This platform is not only a step toward a more efficient healthcare system but also a foundation for improved patient outcomes and proactive healthcare management.

REFERENCES

[1] B. Joel, S. Sibi Rajan, R. Vibinanth, D. Pamela, and P. Manimegalai, "I-Doc – A Cloud Based Data Management System For Health Care," 2022 6th International Conference on Devices, Circuits and Systems (ICDCS), Apr. 2022.

[2] D. Akhil, M. V. Vardhan, K. V. Reddy, C. Preetham, and N. Sangeeta, "Iot Based Icu Patient Monitoring Smart System," vol. 13, pp. 1–6, May 2024.

[3] C. V. Ravikanth, Kolangiammal, K. Chegondi, and V. Gowtham, "Cardio Monitoring and Cardiac disease prediction using Machine Learning," 2023 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computational Intelligence (RAEEUCCI), pp. 1–6, Apr. 2023.

[4] M. D. Aldhoayan and Y. Aljubran, "Prediction of ICU Patients' Deterioration Using Machine Learning Techniques," Cureus, May 2023.

[5] P. Koushik Reddy, P. Mohana Vamsi, C. Revanth Kumar, K. V. Yokesh Kumar, P. Jagruth Reddy, and K. L. Nisha, "Predictive Analysis from Patient Health Records Using Machine

Learning," 2023 4th International Conference for Emerging Technology (INCET), Belgaum, India, 2023.

[6] S. C, V. R, K. Sreelatha and S. V, "SIPMS: IoT based Smart ICU Patient Monitoring System," 2023 International Conference on Artificial Intelligence and Knowledge Discovery in Concurrent Engineering (ICECONF), Chennai, India, 2023, pp. 1-7.

[7] A. Ahmed, M. T. Mahmud, and M. M. Khan, "Info Hospital: Web/Mobile Application based Health Care System," *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, India, 2022, pp. 1546–1552.

[8] R. M. H, S. Udupa, S. A. Bhagavath, Shreesha, and V. Rao, "Centralised and Automated Healthcare Systems: A Essential Smart Application Post Covid-19," IEEE Xplore, Dec. 01, 2020.

[9] "AWS." Amazon Web Services. https://aws.amazon.com/.

[10] "Amazon DynamoDB." Amazon Web Services. https://aws.amazon.com/dynamodb/ .

[11] "MQTT." MQTT.org. https://mqtt.org/ .

[12] "Amazon Simple Notification Service (SNS)." Amazon Web Services. https://aws.amazon.com/sns/ .

[13] "Machine Learning | Gradient Boosting." GeeksforGeeks. https://www.geeksforgeeks.org/ml-gradient-boosting/ .

[14] "Machine Learning | K-Nearest Neighbours." GeeksforGeeks. https://www.geeksforgeeks.org/k-nearest-neighbours/ .

[15] "Machine Learning | Support Vector Machine Algorithm." GeeksforGeeks. https://www.geeksforgeeks.org/support-vector-machine-algorithm/.

[16] "Electronic Health Record." Wikipedia. https://en.wikipedia.org/wiki/Electronic_health_record#:~:text=An%20electronic%20health%20record%20(EHR,across%20different%20health%20care%20settings.

[17] "Role-based Access Control." Wikipedia. https://en.wikipedia.org/wiki/Role-based_access_control .

[18] "Electronic Medical Record Systems." AHRQ Digital Healthcare. https://digital.ahrq.gov/electronic-medical-record-systems .

[19] OpenAI, *ChatGPT*, version 4, OpenAI, San Francisco, CA, 2024. Available: https://www.openai.com/chatgpt.

[20] Wikipedia, "*Web application*," Wikipedia, The Free Encyclopedia Available: https://en.wikipedia.org/wiki/Web_application.