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Predictive Surveillance of Multidrug Resistant Pathohens Using Ai-Based Contact Tracing and Clinical Data Integration

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Abstract: *Proactive management of multidrug resistant pathogens within clinical environments is achieved through a software-defined framework for digital contact tracing and risk assessment. Seamless synthesis of clinical data to identify potential exposure pathways is facilitated by deep integration with Electronic Health Records and Laboratory Information Systems. Through spatial-temporal analysis of Admission, Discharge, and Transfer logs, the system reconstructs patient-staff interaction networks without requiring supplementary hardware. Real-time processing of laboratory results via automated risk-stratification engines allows for the swift detection of multidrug resistant markers and the triggering of immediate alerts for infection control departments. Implementation of this computational oversight minimizes the reliance on shared physical diagnostic instruments, effectively reducing common vectors for cross-contamination. This scalable architecture and its data-driven protocols ensure robust clinical oversight and the rapid execution of containment strategies in modern healthcare facilities..*

Keywords: Multidrug Resistance, Digital Contact Tracing, Clinical Risk Assessment, EHR Integration, Infection Surveillance

I. INTRODUCTION

Antimicrobial resistance is a growing global health issue, with Multi-Drug Resistant (MDR) pathogens posing serious risks in hospital environments. These pathogens can survive multiple antibiotics, making infections difficult to treat and increasing patient complications. Hospitals are highly vulnerable due to frequent patient movement, shared equipment, and close interactions among healthcare workers. Factors such as prolonged hospital stays, invasive procedures, and weakened patient immunity further increase the risk of MDR transmission, leading to higher treatment costs and mortality rates.

Current infection-control methods rely on manual and delayed analysis, which limits timely detection and response. Although digital systems like Electronic Health Records exist, they are often not integrated for real-time monitoring. To address this, the proposed Digital Contact Tracing and Screening Tool provides a unified platform to track interactions, identify exposure risks, and enable early intervention. This system aims to improve infection control, reduce MDR spread, and enhance patient safety in hospitals.

II. LITERATURE SURVEY

2.1.EXPLAINABLE TEMPORAL INFERENCE FOR IRREGULARMULTIVARIATE TIME SERIES.

Publication Year: 2026
Author:Óscar Escudero-Arnanz
Journal Name:IEEE Access
Early detection of MDR pathogens is crucial to prevent hospital infections and improve patient safety. This study uses deep learning models like RNN, LSTM, and GRU to predict infections early with explainable AI support.

2.2. AI-DRIVEN PREDICTIVE ANALYTICS IN HEALTHCARE FOR EARLY DISEASE DETECTION

PublicationYear:2025
Authors:Mr. Vinod Sukalal Mahajan
Journal Name: IEEE Access
AI-driven predictive analytics enables early disease detection by analyzing clinical and patient data using models like LR, KNN, SVM, and CNN. This proactive approach improves diagnosis, supports timely treatment, and enhances patient outcomes, though challenges like data privacy and large data requirements remain.

2.3. AN AUTONOMOUS IOT-BASED CONTACT TRACING PLATFORM IN A COVID-19 PATIENT WARD

PublicationYear:2023
Authors: Asanka Rathnayaka
Journal Name: IEEE Access
An IoT-based contact tracing system uses wearable devices to track hospital interactions in real time, improving infection control and exposure detection.

2.4. FLEXIBLE MICROPLASMA DISCHARGE DEVICE FOR TREATING MULTIDRUG-RESISTANT FUNGAL AND BACTERIAL INFECTIONS

PublicationYear:2023
Authors: Parinaz Eskandari
Journal Name: IEEE Access
A flexible microplasma device is developed to effectively kill multidrug-resistant pathogens in wounds using reactive plasma species. It is lightweight, wearable, and offers a chemical-free sterilization solution for healthcare.

2.5.CONTACT TRACING IN HEALTHCARE DIGITAL ECOSYSTEMS FOR INFECTIOUS DISEASECONTROL AND QUARANTINE MANAGEMENT

PublicationYear:2020
Authors: Kan-IonLeong
Journal Name: IEEE Access
The paper proposes a digital system that automates contact tracing using healthcare data to quickly identify infection sources and high-risk individuals. It improves outbreak detection, reduces manual effort, and supports faster decision-making, though challenges like data privacy and integration remain.

III. METHODOLOGIES

The proposed system follows a structured methodology to enable predictive surveillance of multidrug-resistant (MDR) pathogens in hospital environments. The process begins with continuous data collection from hospital information systems, including Electronic Health Records (EHR), laboratory reports, and Admission–Discharge–Transfer (ADT) logs. These data sources provide information about patient movements, clinical history, and pathogen detection. The collected data is then preprocessed to remove inconsistencies, handle missing values, and ensure proper integration into a unified dataset.

A key component of the methodology is digital contact tracing, where patient and healthcare worker interactions are identified using spatial and temporal data. Based on co-location and time overlap, the system constructs a contact network that represents possible exposure pathways. This network is analyzed to extract important features such as contact duration, frequency, and interaction patterns, which are essential for risk evaluation.

The system further applies AI-based predictive models to assess the risk of MDR transmission. Machine learning algorithms analyze clinical data, laboratory results, and contact features to classify individuals into different risk levels. The model continuously updates risk scores as new data becomes available, enabling real-time monitoring and early detection of potential infection spread.

Finally, an alert and decision-support mechanism is integrated into the system. When high-risk cases are identified, automated alerts are generated for infection control teams, allowing timely actions such as isolation, testing, and treatment. This structured methodology ensures efficient monitoring, early prediction, and improved infection control within hospital settings.

IV. SYSTEM ARCHITECTURE

A. Architecture Overview

The proposed system follows a layered architecture designed to support efficient monitoring and prediction of multidrug-resistant (MDR) pathogen transmission in hospital environments. The architecture consists of multiple layers, including the data source layer, data integration layer, contact tracing layer, AI-based risk assessment layer, and application layer. The data source layer collects information from Electronic Health Records (EHR), laboratory systems, and Admission–Discharge–Transfer (ADT) logs.

The integration layer processes and standardizes the collected data to ensure consistency and reliability. The contact tracing layer identifies interactions between patients and healthcare workers based on spatial and temporal information. The AI-based layer analyzes these interactions along with clinical data to predict infection risk. Finally, the application layer provides dashboards and alerts for healthcare professionals. This architecture ensures real-time monitoring, accurate risk prediction, and efficient infection control within hospital settings.

B. Component Description

The system consists of several key components that work together to enable predictive surveillance. The data collection component gathers patient movement, clinical, and laboratory data from hospital systems. The preprocessing component cleans and integrates the data into a unified format. The contact tracing component constructs interaction networks by analyzing co-location and time overlap between individuals.

The AI-based risk assessment component applies machine learning algorithms to classify individuals based on their risk of MDR infection. The alert and notification component generates real-time alerts for high-risk cases, enabling timely intervention. Additionally, the visualization component provides dashboards to display contact networks, risk levels, and infection trends. Together, these components form an integrated system that enhances infection surveillance, improves decision-making, and reduces the spread of MDR pathogens in hospitals.

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V. FLOWCHART

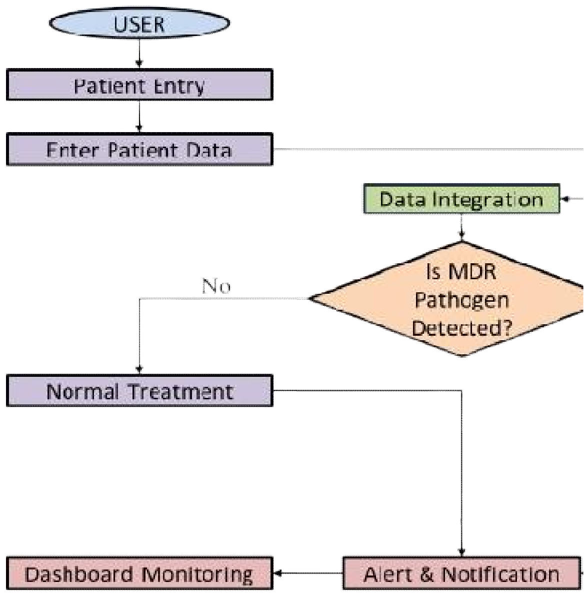

Fig1-flowchart

VI. IMPLEMENTATION

The proposed system is implemented using a scalable and data-driven architecture to support predictive surveillance of multidrug-resistant (MDR) pathogens in hospital environments. The system integrates hospital data sources such as Electronic Health Records (EHR), laboratory systems, and Admission–Discharge–Transfer (ADT) logs for continuous data collection and monitoring. Data processing and analysis are performed using modern data analytics and machine learning frameworks, enabling efficient handling of large-scale clinical datasets.

The backend is designed to manage data integration, preprocessing, and risk assessment, while the analytical components construct contact networks and perform predictive modeling. The system supports near real-time operation, allowing continuous updates of risk scores and rapid identification of potential transmission events. Visualization dashboards and alert mechanisms are implemented to provide actionable insights for infection control teams. This implementation ensures a reliable, scalable, and efficient solution for hospital infection surveillance.

Module Description

1) Data Collection Module:This module gathers data from multiple hospital systems, including patient movement records, clinical information, and laboratory results. It ensures continuous data acquisition required for monitoring MDR transmission.

2) Data Preprocessing Module:The preprocessing module cleans, standardizes, and integrates data from different sources. It handles missing values, removes inconsistencies, and prepares the dataset for further analysis.

3) Contact Tracing Module:This module identifies interactions between patients and healthcare workers based on spatial and temporal data. It constructs contact networks to represent exposure relationships and transmission pathways.

4) AI-Based Risk Assessment Module:The risk assessment module applies machine learning algorithms to predict the likelihood of MDR infection. It analyzes clinical data, laboratory results, and contact features to classify individuals into different risk levels.

5) Alert and Visualization Module: This module generates real-time alerts for high-risk cases and provides dashboards to visualize contact networks, risk levels, and infection trends. It supports timely decision-making and effective infection control.

VII. RESULT AND DISCUSSION

The proposed system was implemented and evaluated to assess its effectiveness in monitoring and controlling multidrug-resistant (MDR) pathogen transmission in hospital environments. The system successfully integrates clinical, laboratory, and interaction data to enable automated contact tracing and risk assessment. It accurately identifies patient–staff interactions and reconstructs exposure pathways, improving the detection of potential transmission events.

One of the key outcomes is the system's ability to perform real-time risk analysis using AI-based models. High-risk individuals are identified based on contact duration, interaction frequency, and clinical indicators. The alert mechanism generates timely notifications, allowing infection control teams to take immediate actions such as isolation and testing. This significantly reduces reliance on manual tracing and improves response efficiency.

The system also demonstrates improved surveillance capability through continuous monitoring and data integration. Visualization dashboards provide clear insights into contact networks, risk levels, and infection trends, supporting better decision-making. Compared to traditional methods, the proposed approach enhances accuracy, reduces delays, and enables proactive infection control. Overall, the results indicate that the system is reliable, efficient, and suitable for real-time hospital infection surveillance.

7.1 OUTPUT

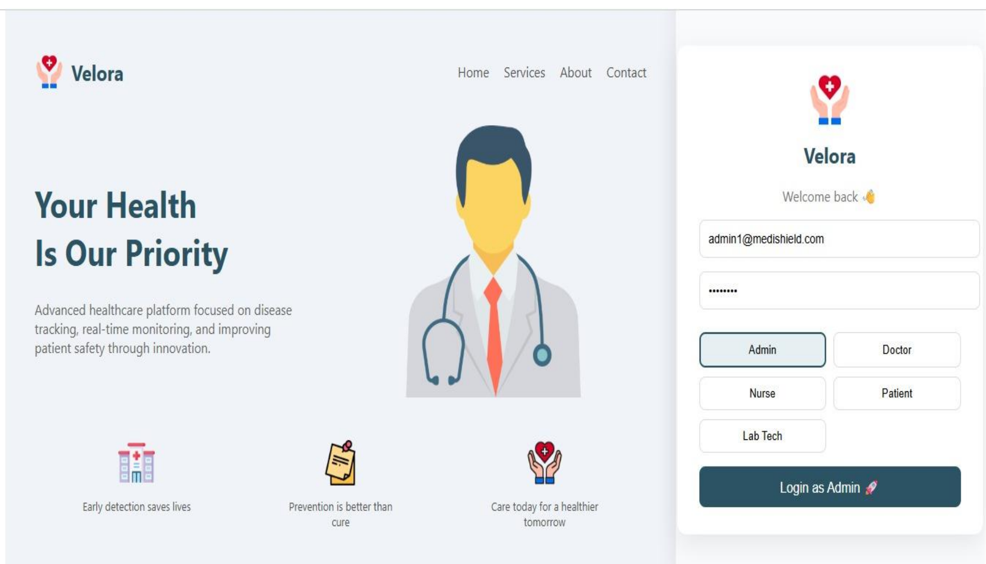

Fig2 – Login Page

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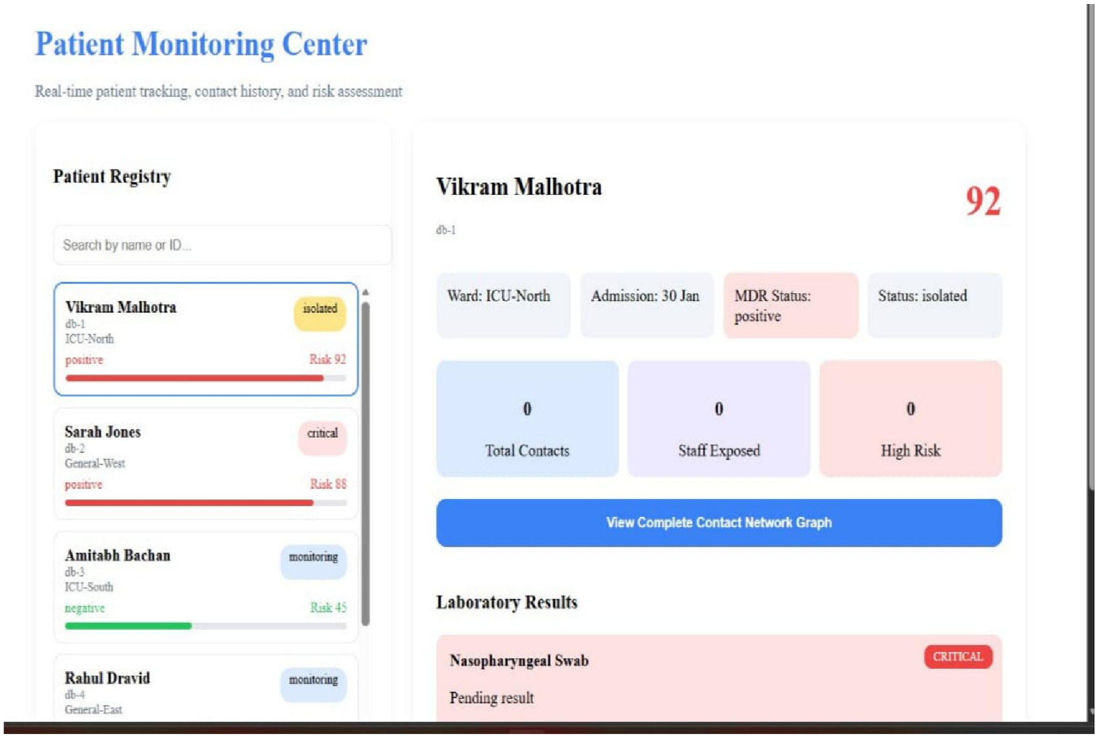

Fig3 – Patient Data Entry Module

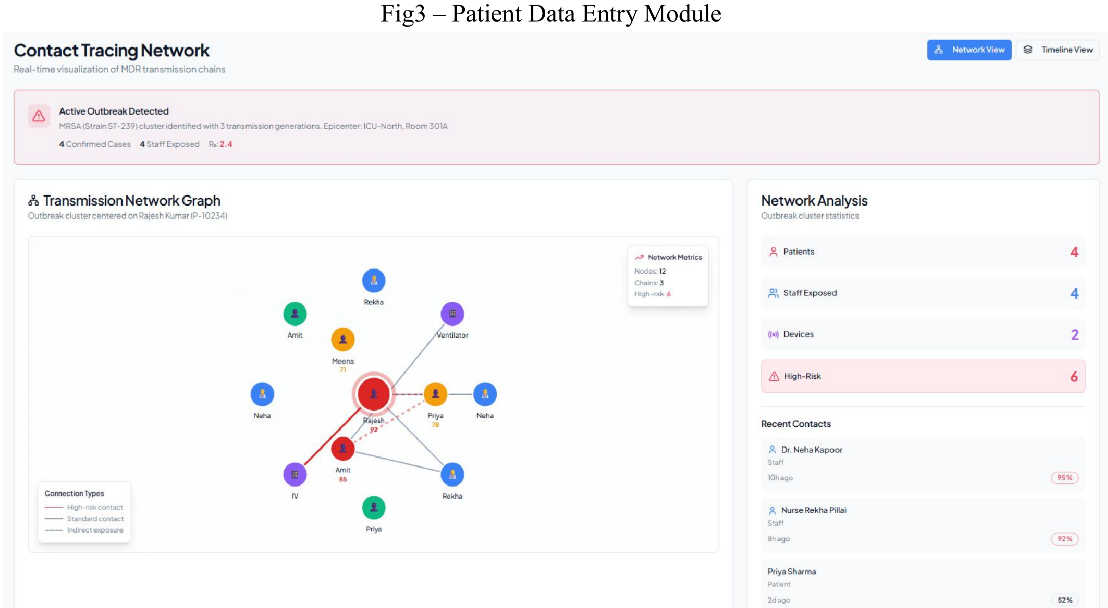

Fig4 – MDR Detection & Risk Prediction

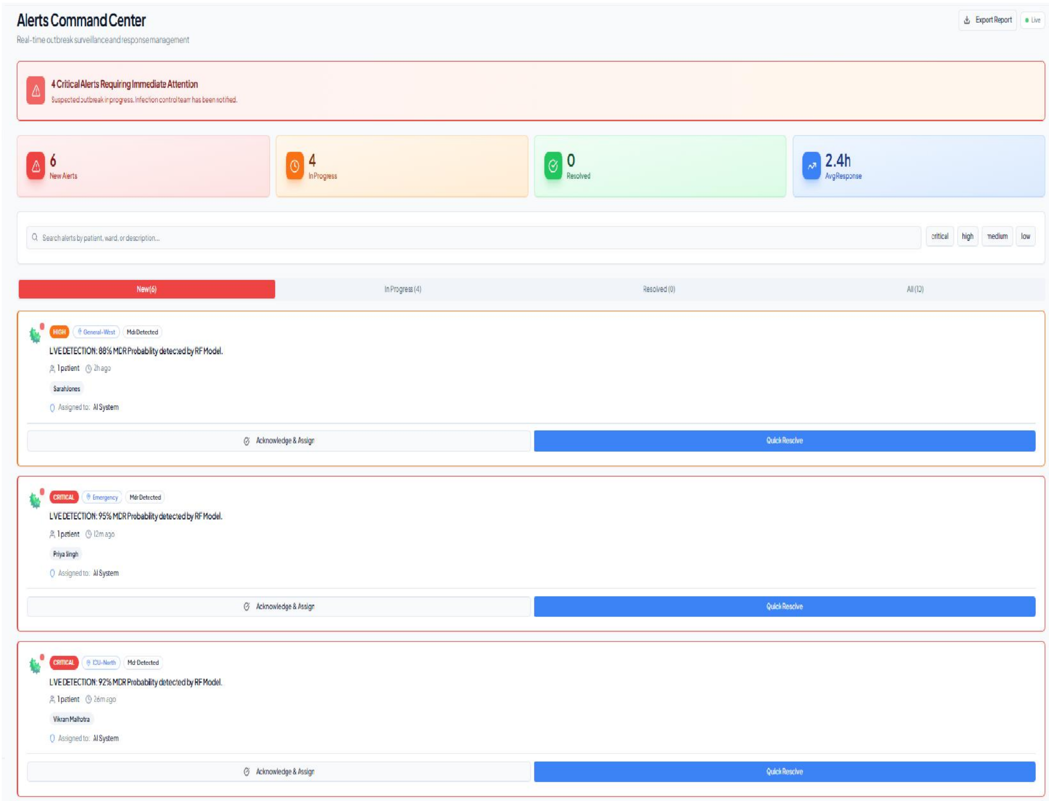

Fig5 – Alert & Monitoring Module

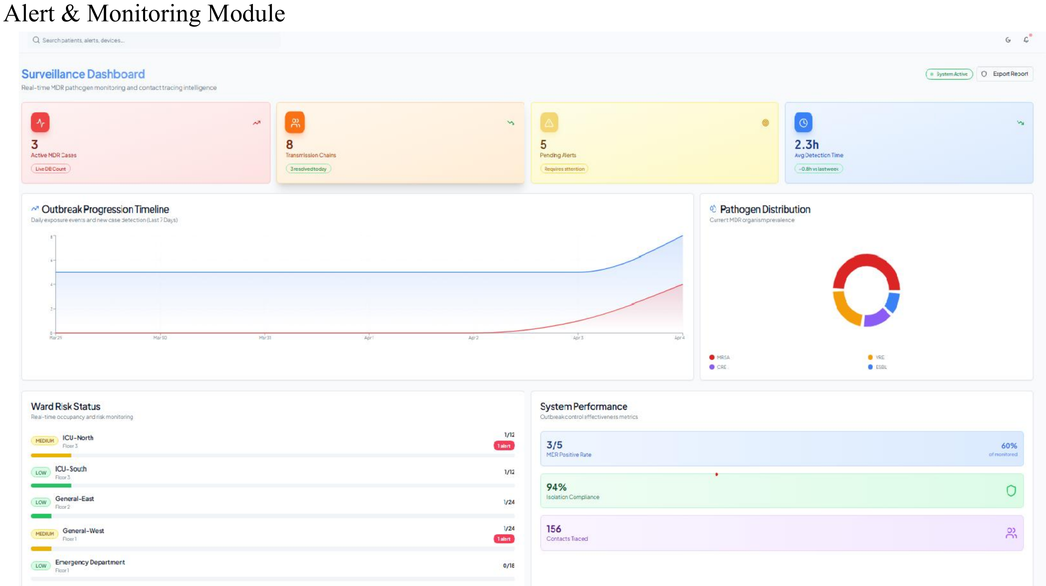

Fig6 – Dashboard

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VIII. CONCLUSION

In this paper, The proposed system provides an intelligent and scalable solution for monitoring and controlling the spread of multidrug-resistant (MDR) infections in hospital environments. By integrating patient data, laboratory results and movement records, the system enables effective contact tracing and exposure analysis. The use of machine learning for risk prediction enhances decision-making by identifying high-risk individuals and generating timely alerts. Overall, this project demonstrates a practical approach to improving infection control, reducing transmission risk, and supporting healthcare professionals with data-driven insights.

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