Predictive In-Flight Medical Assistance Using Wearables

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Abstract

This project explores the predictive in-flight medical assistance system using wearables to improve the passenger health monitoring and safety during flights. By utilizing wearable devices to continuously track vital signs such as heart rate, blood pressure, and oxygen levels, it processes real-time data using advanced machine learning algorithms onboard. This permits the prediction and early detection of potential medical conditions before they become critical, allowing for prompt interventions. Alerts are provided to both passengers and cabin crews to ensure prompt and effective replies. The system's integration with existing airline infrastructure provides a comprehensive and seamless solution for managing in-flight medical crises, considerably improving both the overall travel experience and safety.

1. Problem Statement

Air travel has unique health risks due to restricted surroundings, fluctuations in air pressure, and prolonged immobility. In-flight medical crises, which occur in approximately one out of every 604 trips, range from minor concerns to catastrophic circumstances such as cardiac arrest and respiratory problems. Traditional emergency response systems frequently lack real-time health data and predictive insights, which limits the effectiveness of interventions.

To address these challenges, we have developed a pioneering project to improve passenger safety and health monitoring by developing a wearable technology-based Predictive In-Flight Medical Assistance System. Our method uses wearable technology to enable continuous, real-time monitoring of vital signs including blood pressure, heart rate, oxygen levels, blood glucose levels, and body temperature unlike any other aviation industry solution currently in place. The proactive health monitoring made possible by this creative wearables' integration into the aircraft environment greatly enhances the reaction to medical emergencies.

To provide seamless data collecting, processing, and alerting, the system will interface with the airline's infrastructure and current in-flight entertainment systems. Passengers and cabin crew will receive real-time notifications, allowing for prompt interventions and enhancing the overall in-flight experience. The goal of this project is to ensure data security and compliance with health standards such as GDPR and HIPAA by integrating wearable technology that is currently on the market into the aviation setting.

By achieving continuous health monitoring, predictive analytics, and real-time alerts, the Predictive In-Flight Medical Assistance system strives to improve passenger safety, handle in-flight medical emergencies more skilfully, and provide a complete health monitoring solution in aviation.

2. Market/Customer/Business Needs Assessment

2.1 Market Need Assessment

The aviation sector is rapidly developing, with more than 4.5 billion passengers traveling each year. As air travel grows, so does the demand for improved solutions to properly address in-flight medical situations. Current approaches, which mostly rely on basic medical equipment and flight attendant training, are frequently insufficient to manage complex health conditions. There is an increasing demand for novel systems that offer real-time health monitoring and predictive analytics. Wearables that continuously monitor passengers' vital signs and analyse health data can dramatically improve the ability to predict and respond to medical emergencies before they escalate.

2.2 Customer Need Assessment

2.2.1 Primary Needs

- Real-Time Health Monitoring: In order to discover potential health risks early, passengers must continuously track vital signs using wearable devices.
- Predictive Alerts: Flight crews require timely notification regarding potential medical emergencies in order to respond quickly and efficiently.
- Integration with Aircraft Systems: In order to provide comprehensive medical care, the system must work smoothly with existing aircraft technology.
- Regulatory Compliance: The solution must follow aviation and health laws while maintaining data confidentiality and privacy.

2.2.2 Secondary Needs

- Enhanced Passenger Safety: Advanced health monitoring technologies provide passengers with additional reassurance while they are flying.
- Improved Response Protocols: With clear, actionable instructions based on predictive signals, flight crews can better manage in-flight medical emergencies.
- Data Protection: To protect sensitive health information while adhering to legal requirements, robust security measures are required.

2.3 Business Need Assessment

2.3.1 Revenue streams

- Airline Partnerships: Form license or subscription arrangements with airlines to integrate the wearable system into their fleets.
- Premium Features: Provide additional features or analytics as part of a premium service package that adds value to airlines.
- Data Insights: Provide stakeholders with anonymized health data to help them understand industry trends and make improvements.

2.3.2 Operating Requirements

- Technology Development: Invest in technology development, including wearable health devices, onboard sensors, and predictive analytics.
- Pilot Testing: Run pilot programs with airlines to test and improve the system's functioning and efficacy.
- Regulatory Compliance: Ensure that the system complies with all applicable aviation and health laws while maintaining high levels of data security.

2.3.3 Scalability and Growth

- Expansion Opportunities: Based on the success of pilot programs, the system will be expanded to other airlines and international markets.
- Service Enhancements: To keep ahead of market demands, continuously improve the system with new features and integrations.
- User Engagement: Create tactics to boost airline adoption and demonstrate the system's benefits through success stories and case studies.

3. Target Specifications and Characterization

3.1 Core Design and Functionality

3.1.1 Wearable Devices

- Design: The wearable must be lightweight, comfortable, and adjustable to fit various body sizes, so it can be worn throughout the flight without discomfort. It should be water-resistant and able to tolerate the changing circumstances of the cabin environment.
- Health Monitoring: High-precision sensors track key health indicators such as heart rate, blood oxygen levels, and body temperature. To achieve accurate health tracking, the device must provide continuous, real-time data.
- Data Transmission: Utilizes secure, low-energy wireless communication (e.g., Bluetooth) to transmit health data to the mobile app and cabin crew website efficiently and reliably.

3.1.2 Mobile App for Passengers

- Real-Time Health Monitoring: The app should display real health data from the wearable as visual graphs and alerts for abnormal readings, keeping passengers and crew informed of any imminent health problems.
- Alerts & Notifications: Sends instant notifications of any detected health anomalies or emergency situations, along with practical advice and instructions for immediate response.
- In-App Help: The app will have an emergency button that passengers can use to notify the flight crew of an urgent medical condition. This will automatically alert the staff via the website dashboard.
- Historical Data: Users can analyse their health data over time to gain insights into trends and patterns that will help them manage their health more effectively. Storing this historical data is crucial for:

    1. Enabling detection of significant deviations by comparing current readings with the passenger's baseline values.
    2. Allowing for tailored risk assessments based on individual health history, reducing false alerts.
    3. Improving the accuracy of predictions and early detection by helping algorithms understand unique health patterns.
- Privacy and Security: Encrypts data and follows relevant health data legislation to ensure the confidentiality and security of user information.

3.1.3 Website for Cabin Crew and Airlines

- Centralized Dashboard: The website must have comprehensive dashboard that displays real-time health data from all passengers, with the option to filter and monitor individual or group health parameters.
- Alert System: Automatically generated alerts for detected health conditions like arrhythmias, hypoxia, or fever, including severity and recommended measures. To ensure rapid responses, the system should smoothly interact with onboard communication capabilities.
- Incident Documentation: It should include tools for documenting and tracking medical occurrences, including action and result details, for post-flight review and compliance.
- Data Integration: Must work with existing aircraft systems to improve coordination with medical resources and communication channels.

3.2 Performance Requirements

3.2.1 Data Accuracy and Reliability

- Precision: High accuracy in health monitoring ensures reliable detection of probable medical problems. Sensors should be calibrated and tested on a regular basis to ensure their accuracy.
- Reliability: Continuous operation with little downtime. Ensure that the system operates consistently during the flight, even under variable conditions.

3.2.2 System Performance

- Speed: Real-time data processing and alert production allow for rapid responses to health issues.
- Uptime: Maintain 99.9% system uptime to maintain availability during all flight phases and itineraries.

3.2.3 Scalability

- Capacity: The ability to sustain a variable number of passengers and crew without compromising performance. Infrastructure should be scalable to meet increased demand and future growth.

3.3 Technical Specification

3.3.1 Data integration

- Communication: Effective interaction with aircraft systems and existing medical resources to provide coordinated responses.
- Synchronization: The real-time synchronization of health data between wearable devices, smartphone apps, and cabin crew dashboards.

3.3.2 Security & Compliance

- Data Protection: Implement strong encryption technologies and secure authentication to protect health data.
- Regulatory Compliance: Comply with aircraft safety requirements and health data protection rules (e.g., GDPR, HIPAA).

3.3.3 User Experience

- Interface Design: Both the mobile app and the website have simple, intuitive interfaces, making them easy to use for passengers and cabin crew alike.
- Support: Provide training materials and tools to guarantee that passengers and crew use the system effectively.

4. Benchmarking

I evaluated the proposed in-flight medical assistance system employing wearables by comparing it to existing solutions and industry standards. This benchmarking analysis helps to find best practices, gaps, and areas for improvement.

4.1 Current Solutions and Technologies

4.1.1 Existing In-Flight Medical Assistance

- MedAire: Provides comprehensive medical kits, telemedicine services, and specialized training to flight crew members. They provide real-time medical guidance via satellite transmission, guaranteeing that crew members receive prompt assistance from ground-based medical personnel.
- STAT-MD: Like MedAire, STAT-MD provides telemedicine help by linking flight crew with medical specialists who can provide guidance during in-flight situations.
- Panasonic Avionics Corporation: Provides medical aid systems with real-time connectivity for remote diagnostic and treatment recommendations, allowing for prompt and educated medical replies.

4.1.2 Wearable Health Monitoring Technologies

- Fitbit: Well-known for tracking heart rate, sleep habits, and activity levels, and its real-time data and alarms for irregular heartbeats can be used in in-flight monitoring systems.

- Apple Watch: Advanced health features include ECG monitoring, fall detection, and emergency SOS functionality. These capabilities can be integrated into the proposed system to provide continuous health monitoring and timely alarms.
- Garmin: Provides complete health data such as stress monitoring, oxygen saturation levels, and heart rate variability. These elements are critical for real-time health monitoring of people on flights.
- Smart Wristbands: Our proposed solution takes a new approach by using smart health monitoring wristbands. These wristbands may continuously monitor vital indications such as heart rate, oxygen levels, and stress indicators. Unlike ordinary wearables, our wristbands are specifically engineered for flight settings, assuring precise readings even with changing cabin pressures and altitudes.

4.2 Industry Standards and Regulations

4.2.1 Aviation Safety Standard

- FAA and EASA Regulations: Emphasize passenger safety and require airlines to carry medical kits and certified workers on board. To be successfully integrated into in-flight systems, wearable health monitors must comply with certain criteria.
- IATA Medical Manual: Provides guidelines for managing medical emergencies during flights, which can be enhanced by the real-time health monitoring capabilities of wearable devices.

4.2.2 Healthcare Data Privacy Standards

- GDPR (General Data Protection Regulation): Protects and maintains the privacy of personal health data gathered by wearable devices.
- HIPAA (Health Insurance Portability and Accountability Act): Governs the secure storage and use of health information in the United States, guaranteeing that data from wearable devices is managed with strict privacy standards.

4.3 Comparative Analysis

4.3.1 Advantages of Proposed Solution

- Real-time Monitoring: Unlike current solutions that rely primarily on crew training and telemedicine, sophisticated wristbands provide continuous real-time health monitoring, which may detect health issues before they worsen.
- Integration of Wearable: These wristbands can smoothly monitor vital indicators and deliver fast notifications, improving response time during medical situations.
- Enhanced Data Analytics: Wristbands collect substantial health data that can be studied after the flight in order to enhance physical health and personalize future in-flight medical support.

4.3.2 Challenges and considerations

- Technical Integration: This involves ensuring that the wristbands can communicate successfully with onboard systems and ground-based medical staff.
- Regulatory Compliance: Comply with aviation and healthcare rules governing data security, privacy, and gadget certification.
- User Comfort and Acceptance: Make sure that wristbands are comfortable and appropriate for passengers to wear during the trip.

5. Applicable Patents

Some of the patents include:

5.1 Wearable Health Monitoring Technology

- Apple Inc.: Monitoring blood oxygen levels and heart rate with sensor technology akin to those in the Apple Watch.
- Fitbit (Google LLC): Fitbit's cutting-edge health monitoring technologies are used to continuously monitor vital signals.

5.2 Sensor and Component Technology

- Texas Instruments Incorporated: For low-power sensor technologies that guarantee ongoing data gathering while using the least amount of energy.
- Analog Devices, Inc.: Accurately tracking a range of health data, including body temperature and electrocardiogram, using their precision health sensors.

5.3 Real-Time Data Transmission and Communication

- Bluetooth SIG, Inc.: Transferring data from the wristband to the smartphone application and airline systems via low-energy, secure Bluetooth communication protocols.

5.4 Predictive Analytics and Machine Learning Algorithms

- IBM Corporation: Use IBM Watson's machine learning frameworks for predictive health analytics.
- Google LLC: Implement TensorFlow for machine learning models to assess health data and forecast any medical problems.

5.5 Wristband Design and Manufacturing

- 3M Company: The wristband must be made using advanced materials and manufacturing processes to guarantee durability, comfort and wearability.

6. Applicable Regulations

- The safety and efficacy of the system are guaranteed by adhering to FAA, HIPAA, and ISO standards; this guards against potential health concerns for both passengers and crew and guarantees the accuracy of health monitoring data.

- Adhering to WEEE and RoHS regulations guarantees that wearable technology is eco-friendly, encouraging recycling and sustainable use.
- By fulfilling the MDR regulations set forth by the FDA and the EU, wearables devices can be licensed for usage in large markets, which promotes system confidence and widespread adoption.
- Adhering to ISO/IEC 27001:2013 ensures the security and confidentiality of passengers' health data, fostering trust and compliance with data protection regulations.
- Compliance with Bluetooth SIG standards ensure robust and secure communication between devices, enhancing the system's reliability and user experience.

7. Applicable Constraints

7.1 Internal Constraints

7.1.1 Space Constraints

- Aircraft Cabin Space: There isn't much room in the aircraft cabin for extra gadgets and equipment.
- Impact: Small and light are requirements for both the wearable technology and any required hardware. The layout should be optimized for maximum space use and little disruption to the current cabin systems.

7.1.2 Budget Constraints

- Development Costs: Budget for testing, development, and research is constrained.
- Impact: Demands prudent resource management, giving top priority to necessary features and functionalities. It could be necessary to seek out more financing and collaborations or to implement the plan in phases.

7.1.3 Expertise Constraints

- Technical Skills: Limited availability of specialized expertise in machine learning, wearable technology, and aviation-specific health monitoring.
- Impact: It could be necessary to bring on more specialists or give the current team members specialized training. It may be required to work in conjunction with outside experts or professionals.

7.2 External Constraints

7.2.1 Market Constraints

- Competition: The existence of competing goods and innovations in the market.
- Impact: Strong marketing tactics, improved user experiences, and distinctive features are required for differentiation. It takes market research to find opportunities and gaps.

7.2.2 Environmental Constraints

- In-Flight Conditions: Variability in temperature, humidity, and cabin pressure during flying.
- Impact: Reliability of operation in a range of environmental conditions is a requirement for wearable devices and system components. There must be thorough testing and validation.

7.2.3 Health and Safety Constraints

- Regulatory Compliance: Must abide by health and aviation laws, including EU MDR, HIPAA, and FAA.
- Impact: Necessitates careful understanding and adherence to pertinent guidelines. Processes for compliance may take a long time and require for more testing and documentation.

7.2.4 Integration Constraints

- Compatibility with Current Systems: Seamless interaction with the medical infrastructure and airline IT systems of today is required.
- Impact: To guarantee seamless integration with current systems, compatibility testing and maybe custom development are needed. It's crucial to work together with airline IT teams.

8. Monetization Idea

8.1 Direct Sales and Licensing

- Airline Contracts: In order to include the system into an airline's fleet, negotiate contracts with them. This could be a one-time payment or an aircraft license cost.
- White-Label Solutions: Provide a white-label version of your system for airlines to brand as their own.

8.2 Subscription Model

- Passenger Subscriptions: Charge a membership fee for access to premium features or improved health monitoring services. This can be priority support, access to historical health data, or advanced analytics.
- Airline Subscriptions: Provide airlines a subscription-based plan that gives them access to new features as they become available, frequent upgrades, and support.

8.3 Data and Analytics

- Health Insights Reports: Charge a fee to airlines or health institutions for access to anonymised, aggregated health data and insights. Both passenger health management and overall flight safety may benefit from this.
- Custom Analytics: Provide airlines with analytics services that are specifically designed to help them better understand passenger health trends and enhance their reaction procedures.

8.4 Training and Support

- Training Programs: Charge for specialized training programs for airline staff on how to use the system effectively.
- Technical Support: Offer tiered support packages for airlines, ranging from basic assistance to comprehensive 24/7 support.

8.5 Enhanced Features for Medical Professionals

- Consultation Services: For a surcharge, offer real-time consultations or comprehensive health reviews with access to a network of medical specialists.

8.6 Integration Fees

- System Integration: Charge airlines for integrating the system with their existing infrastructure, such as aircraft systems or onboard medical equipment.

9. Concept Development

The development of In-Flight Medical Assistance System begins with the creation of sophisticated wristband (other wearables can be tested like watches akin to those of Apple, but we use a unique approach here because it can specifically be used for in-flight medical monitoring and can also include any new features that are not used in the existing technology and tailored to in flight medical issues) to monitor critical health issues.

This wristband will include a variety of sensors for measuring heart rate, blood pressure, blood oxygen level, blood glucose, and body temperature. Sensors included are photoplethysmography (PPG) sensors for heart rate and blood oxygen levels, a pressure sensor for blood pressure measurements, CGM sensors for blood glucose level and thermistor sensors for body temperature.

The wristband will send health data to a mobile app using Bluetooth Low Energy (BLE). This mobile software will monitor passengers' health in real time, displaying data via intuitive visual graphs and giving fast notifications if any health anomalies are identified. These alerts will give clear advice to assist passengers and staff in managing the issue properly.
The app will also allow users to view past health data, providing useful insights into their health trends over time. To ensure the security of health data, the app will use powerful encryption technologies to protect user information.

A specialized website for cabin crew and airline staff will be created, complete with a centralized dashboard displaying real-time health data from all passengers. This dashboard will send out automated alerts for any recognized health conditions, including their severity and recommended measures. The website will also contain facilities for documenting and tracking medical incidents, as well as integration with existing aircraft systems to ensure seamless communication and coordination with medical personnel. The data from the mobile app will be securely transmitted to the website using, ensuring that cabin crew receive fast and correct information.

The transmission of health data from mobile app to the crew interface will be automatic and secure. When the wristband detects a health anomaly, it transmits the information to the mobile app via BLE. The program then automatically encrypts the data before sending it to the centralized server using secure internet protocols. This procedure ensures that health data is regularly updated and securely transmitted to the website in real time. The server interprets this data and updates the cabin crew's unified dashboard, which provides them with timely and accurate health alarms as well as actionable insights.

The mobile application uses background services for automatic data transmission, constantly checking for new data from the wearable and securely sending it to the server without user intervention. Power-efficient algorithms reduce battery consumption while providing ongoing monitoring.

BLE beacons should be installed throughout the aircraft to identify the exact location of the passenger within the aircraft, such as their seat number which is crucial for cabin crew to know exactly where the passenger in need of assistance is seated.

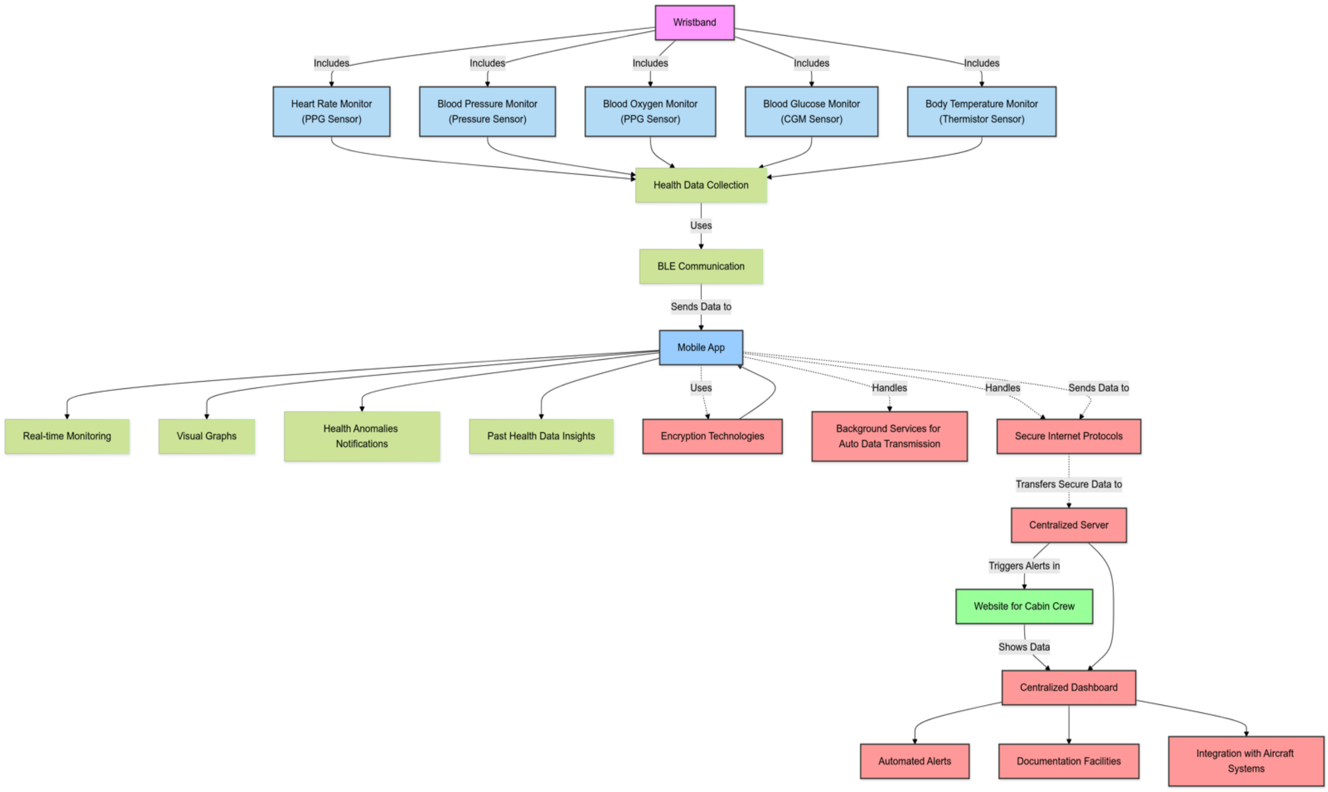

Figure 1. Summary Flow Chart of In-Flight Medical Assistance System Development

10. Final Design

The Final Product Prototype is the result of our concept development, combining advanced wearable technology, a user-friendly mobile application, crew website and a strong backend infrastructure to provide comprehensive in-flight health monitoring and emergency response capabilities.

11. Product Details

11.1 How does it work?

- The smart wristband continuously tracks passengers' vital signs, specifically heart rate, blood oxygen levels, blood pressure, blood glucose levels and body temperature, using integrated PPG, Pressure, CGM and Thermator sensors.
- Health data is streamed in real-time to the passenger's smartphone application via Bluetooth Low Energy (BLE), ensuring efficient and low-power communication.
- Upon receipt, the mobile app processes the incoming data by filtering out any inconsistencies or noise to maintain measurement accuracy.
- The processed data is then standardized through normalization, allowing for reliable comparisons against historical records and standard health benchmarks.
- The app accesses the passenger’s previous health information stored securely in a cloud database, including historical vital signs and any existing medical conditions.
- Advanced machine learning techniques, such as Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) models, analyse the data to identify significant patterns and potential health anomalies.
- These algorithms assess the data to compute a risk score that indicates the likelihood of a medical event, such as a heart attack, based on detected irregularities.
- If the risk score surpasses established clinical thresholds, the system generates an alert detailing the passenger’s health status, the identified risk, and recommended immediate actions.
- This alert, along with the passenger’s location determined by in-cabin BLE beacons, is sent to the cabin crew’s secure web-based dashboard, providing them with real-time health visualizations and step-by-step guidance for appropriate response measures.
- The cabin crew's website displays a digital map of the aircraft's seating layout. The map is dynamic, meaning it updates in real-time. If a passenger moves from their assigned seat to another part of the aircraft, the BLE beacons detect this change, and the passenger’s symbol on the map shifts to reflect their new location.
- Each passenger could be represented by a small dot or circle on the map which is dynamically linked to their health status. The colour of the dot could indicate the passenger's current health status (e.g., green for normal, red for alert).

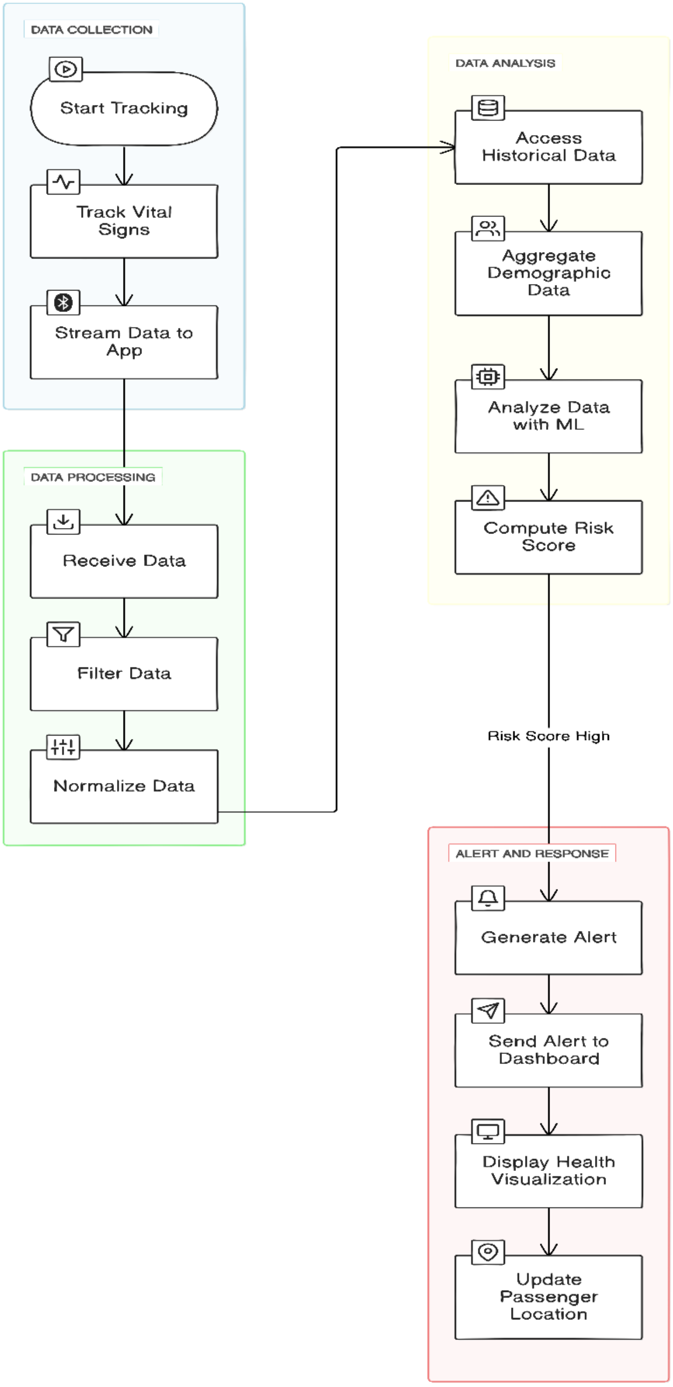

Figure 2. Working of the System

11.2 Data Sources

11.2.1 Wearables Sensors

- Photoplethysmography (PPG) Sensors: Measure heart rate and blood oxygen levels. Pressure sensors measure blood pressure.
- Pressure Sensors: Measure blood pressure
- Continuous Glucose Monitoring (CGM) Sensors: Monitor blood glucose levels.
- Thermistor Sensors: Measure body temperature.

11.2.2 Historical Health Data

- Data from the passenger's previous health records is used to determine baseline measures and trends. A separate section can be provided where passengers can input their medical history.

11.2.3 In-Flight Environment Data

- Information on cabin pressure, altitude, and other environmental conditions that may affect passenger health.

11.2.4 Medical Knowledge Base

- A collection of medical data and symptom profiles for comparing real-time data to recognized health conditions.

11.3 Algorithms, Frameworks, Software

11.3.1 Machine Learning Algorithms

- Analysing vital sign trends can help forecast impending health emergencies by using Random Forest, RNN, LSTM etc.
- Identify irregularities in real-time health data using K-means.
- Customize notifications and recommendations based on individual passenger profiles.

11.3.2 Frameworks

- TensorFlow / PyTorch: For creating and training machine learning models.
- Scikit-Learn: For implementing multiple machine learning methods to do data preparation, feature selection, and model evaluation.
- Keras: A framework for creating and testing neural networks.

11.3.3 Software

Mobile Applications consists of following algorithms and framework:

- Frontend: Built with React Native for cross-platform interoperability.
- Backend: Node.js with the Express framework for API management.
- Database: MongoDB is used to securely store health data.

Website for crews consists of:

- Use Angular or React on the frontend for dynamic and responsive user interfaces.
- Use Django or Ruby on Rails for strong server-side processing.
- Real-time data processing using Socket.io or WebSockets.

11.3.4 Encryption and Security

- TLS/SSL: Enables secure data transmission.

- AES: Used to encrypt stored data.
- OAuth 2.0: For secure authentication and permission.

11.4 Teams Required to Develop

The teams required to develop our final product are:

Project Manager, Data Scientists/Machine Learning Engineers, Software Engineers, Hardware Engineers, UI/UX Designers, Security Experts, Quality Assurance (QA) Testers, and Healthcare Consultants.

12. Code Implementation

In our project, we use a dataset to anticipate numerous health issues that a person may encounter during a trip, such as increased body temperature, aberrant heart rate, or irregular blood pressure. This dataset demonstrates how our system continuously detects and analyses critical vital signals like heart rate, blood oxygen level, blood pressure, blood glucose, and body temperature. It is crucial to note that, while the validation dataset was not derived from wearable devices or real-time settings, it is used to replicate the types of health events that our system would detect.

Data Preparation: First, we organize and clean the dataset, which includes important health details like heart rate, blood pressure, oxygen levels, and body temperature, along with basic information such as age and gender. We also create extra features, such as averages and changes over time, to help the model better understand the data before training.

Model Training: Next, we train a machine learning model to predict potential health problems during the flight. By using patterns from past data, the model learns to identify which passengers might be at higher risk based on their current health readings, helping to flag those who may need attention.

Real-Time Monitoring: In a real-world scenario, the system would use live data from wearable devices that passengers could wear during the flight, monitoring their health continuously. In this project, we simulate that by using pre-recorded data to mimic real-time conditions, analysing the passengers' health at regular intervals.

Prediction and Alerts: If the model detects any signs of a serious health issue, it alerts the cabin crew. These alerts include specific recommendations for actions, like providing immediate care or calling for further medical help, ensuring the crew can quickly respond and keep the passengers safe.

Code:

In [1]:
```python
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_auc_score
from datetime import datetime
```

In [2]:
```python
vital_signs = pd.read_csv("C:/Users/Nirmal/Downloads/inflight_medical_assistance_data_corrected.csv")
passenger_info = pd.read_csv("C:/Users/Nirmal/Documents/Python Scripts/passenger_profiles_60_passengers_cleaned.csv")
```

In [3]:
```python
vital_signs
```

Out[3]:

	Passenger_ID	SeatNumber	Timestamp	Heart_Rate_BPM	Blood_Oxygen_Level_%	Blood_Pressure_Systolic	Blood_Pressure_Diastolic	Blood_Glucose	Bod
0	1	B23	29-09-2024 12:10	73	98.1	111	66	89.7	
1	1	B23	29-09-2024 12:30	82	96.2	114	74	88.8	
2	1	B23	29-09-2024 12:50	66	95.5	106	60	101.1	
3	1	B23	29-09-2024 13:10	83	96.9	105	61	90.4	
4	1	B23	29-09-2024 13:30	68	98.8	101	77	118.3	
...	...	...	...	...	...	...	...	...	
535	60	A13	29-09-2024 13:30	85	98.1	112	69	135.1	
536	60	A13	29-09-2024 13:50	86	96.2	107	69	76.9	
537	60	A13	29-09-2024 14:10	61	97.1	119	60	87.1	
538	60	A13	29-09-2024 14:30	61	96.4	98	60	89.4	
539	60	A13	29-09-2024 14:50	94	98.9	94	69	123.9	

540 rows × 13 columns

In [4]:
```python
passenger_info
```

Out[4]:

	Passenger_ID	Age	Gender	Allergies	Hypertension	Diabetes	Stroke History	Asthma	Anxiety	Obesity	High Cholesterol	Sleep Apnea	Smoking	Diet
0	1	66	Female	1	0	1	0	1	0	1	1	0	0	Average
1	2	24	Female	0	0	0	0	0	0	0	0	0	1	Healthy
2	3	55	Male	0	0	0	0	0	0	1	1	0	0	Average
3	4	32	Female	1	0	0	0	0	0	0	0	0	1	Unhealthy
4	5	49	Female	1	1	0	0	1	0	1	0	0	0	Unhealthy
5	6	37	Male	0	0	0	0	0	1	0	0	0	0	Healthy
6	7	20	Male	0	0	0	0	0	0	0	1	0	0	Healthy
7	8	70	Male	0	0	0	0	1	1	0	1	0	0	Unhealthy
8	9	44	Female	0	1	0	0	1	0	0	0	0	0	Unhealthy
9	10	55	Female	0	0	1	0	0	0	0	0	0	0	Healthy
10	11	58	Female	0	1	0	0	0	0	0	0	0	0	Average
11	12	36	Male	0	0	0	0	0	0	0	1	0	1	Unhealthy
12	13	48	Male	1	0	0	0	0	0	0	1	0	0	Healthy
13	14	51	Male	0	0	0	1	1	0	0	1	0	0	Average
14	15	57	Female	0	0	0	0	0	1	0	0	0	0	Healthy
15	16	36	Male	0	1	0	0	0	0	0	0	0	0	Healthy
16	17	32	Male	1	0	0	0	0	0	0	0	0	1	Unhealthy
17	18	21	Male	1	1	0	0	0	0	0	0	0	0	Unhealthy
18	19	55	Female	0	0	0	0	0	0	1	0	0	0	Healthy
19	20	63	Female	1	1	1	0	0	0	0	0	0	1	Unhealthy
20	21	52	Female	1	0	0	0	0	0	0	0	0	0	Unhealthy
21	22	63	Male	1	0	1	0	0	1	0	1	0	0	Healthy
22	23	24	Female	0	1	0	0	1	0	0	0	0	1	Average
23	24	30	Male	1	0	1	0	0	1	0	0	0	0	Unhealthy
24	25	75	Male	1	1	0	0	0	0	0	1	0	1	Average
25	26	33	Male	1	0	0	0	1	1	0	0	0	0	Unhealthy
26	27	78	Female	1	0	0	1	0	0	0	0	0	1	Healthy

In [5]:
```
data = pd.merge(vital_signs, passenger_info, on='Passenger_ID')
```

In [6]:
```
data
```

Out[6]:

	Passenger_ID	SeatNumber	Timestamp	Heart_Rate_BPM	Blood_Oxygen_Level_%	Blood_Pressure_Systolic	Blood_Pressure_Diastolic	Blood_Glucose	Bod
0	1	B23	29-09-2024 12:10	73	98.1	111	66	89.7	
1	1	B23	29-09-2024 12:30	82	96.2	114	74	88.8	
2	1	B23	29-09-2024 12:50	66	95.5	106	60	101.1	
3	1	B23	29-09-2024 13:10	83	96.9	105	61	90.4	
4	1	B23	29-09-2024 13:30	68	98.8	101	77	118.3	
...	...	...	...	...	...	...	...	...	
535	60	A13	29-09-2024 13:30	85	98.1	112	69	135.1	
536	60	A13	29-09-2024 13:50	86	96.2	107	69	76.9	
537	60	A13	29-09-2024 14:10	61	97.1	119	60	87.1	
538	60	A13	29-09-2024 14:30	61	96.4	98	60	89.4	
539	60	A13	29-09-2024 14:50	94	98.9	94	69	123.9	

540 rows × 26 columns

In [7]:
```
from sklearn.preprocessing import LabelEncoder
```

In [8]:
```
label_encoder = LabelEncoder()

columns_to_encode = ['Gender', 'Allergies', 'Diet', 'Movement_Activity']

for column in columns_to_encode:
    data[column] = label_encoder.fit_transform(data[column])

print(data.head())
```

```
   Passenger_ID SeatNumber         Timestamp  Heart_Rate_BPM  \
0             1        B23  29-09-2024 12:10              73
1             1        B23  29-09-2024 12:30              82
2             1        B23  29-09-2024 12:50              66
3             1        B23  29-09-2024 13:10              83
4             1        B23  29-09-2024 13:30              68

   Blood_Oxygen_Level_%  Blood_Pressure_Systolic  Blood_Pressure_Diastolic  \
0                  98.1                      111                        66
1                  96.2                      114                        74
2                  95.5                      106                        60
3                  96.9                      105                        61
4                  98.8                      101                        77

   Blood_Glucose  Body_Temperature  Flight_Altitude_ft  ...  Hypertension  \
0           89.7              37.0               30000  ...             0
1           88.8              36.2               30000  ...             0
2          101.1              36.8               30000  ...             0
3           90.4              36.1               30000  ...             0
4          118.3              36.1               30000  ...             0

   Diabetes  Stroke History  Asthma  Anxiety  Obesity  High Cholesterol  \
0         1               0       1        0        1                 1
1         1               0       1        0        1                 1
2         1               0       1        0        1                 1
3         1               0       1        0        1                 1
4         1               0       1        0        1                 1

   Sleep Apnea  Smoking  Diet
0            0        0     0
1            0        0     0
2            0        0     0
3            0        0     0
4            0        0     0

[5 rows x 26 columns]
```

In [9]:
```python
vital_signs_cols = ['Heart_Rate_BPM', 'Blood_Oxygen_Level_%', 'Blood_Pressure_Systolic',
                    'Blood_Pressure_Diastolic', 'Blood_Glucose', 'Body_Temperature']

for sign in vital_signs_cols:
    data[f'{sign}_rolling_avg_5'] = data.groupby('Passenger_ID')[sign].rolling(window=5).mean().reset_index(0, drop=True)
    data[f'{sign}_rolling_std_5'] = data.groupby('Passenger_ID')[sign].rolling(window=5).std().reset_index(0, drop=True)
```

In [10]:
```python
for sign in vital_signs_cols:
    data[f'{sign}_rate_of_change'] = data.groupby('Passenger_ID')[sign].diff()

data['BP_Ratio'] = data['Blood_Pressure_Systolic'] / data['Blood_Pressure_Diastolic']
data['HR_BP_Product'] = data['Heart_Rate_BPM'] * data['Blood_Pressure_Systolic']
```

In [11]:
```python
data.fillna(0, inplace=True)
```

In [12]:
```python
features = data.drop(['Passenger_ID', 'SeatNumber','Timestamp', 'Medical_Event_Flag'], axis=1)
target = data['Medical_Event_Flag']
```

In [13]:
```python
X_train, X_test, y_train, y_test = train_test_split(features, target, test_size=0.2, random_state=42)
```

In [14]:
```python
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
```

In [15]:
```python
model = RandomForestClassifier(n_estimators=100, random_state=42)
model.fit(X_train_scaled, y_train)
```

Out[15]:
```
RandomForestClassifier(random_state=42)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [16]:
```python
risk_scores = model.predict_proba(X_test_scaled)[:, 1]
```

In [17]:
```python
auc_score = roc_auc_score(y_test, risk_scores)
print(f"Model AUC-ROC Score: {auc_score}")
```

```
Model AUC-ROC Score: 1.0
```

In [18]:
```python
data['Risk_Score'] = model.predict_proba(scaler.transform(features))[:, 1]
high_risk_threshold = 0.7
high_risk_passengers = data[data['Risk_Score'] > high_risk_threshold]
```

In [19]:
```python
print("\nHigh-Risk Passengers:")
print(high_risk_passengers[['Passenger_ID', 'Risk_Score', 'Heart_Rate_BPM', 'Blood_Oxygen_Level_%', 'Blood_Pressure_Systolic',
                            'Blood_Pressure_Diastolic', 'Blood_Glucose', 'Body_Temperature']])
```

```

High-Risk Passengers:
    Passenger_ID  Risk_Score  Heart_Rate_BPM  Blood_Oxygen_Level_%  \
36             5        0.76              94                  98.2
37             5        0.80              79                  95.0
38             5        0.81              76                  98.8
40             5        0.87              76                  97.0
41             5        0.83              72                  97.2
43             5        0.83              65                  96.8
44             5        0.82              67                  98.4

    Blood_Pressure_Systolic  Blood_Pressure_Diastolic  Blood_Glucose  \
36                       91                        68          120.4
37                       96                        69          136.7
38                      112                        67          121.3
40                       94                        74           96.7
41                       95                        76           92.5
43                      120                        63           78.2
44                       94                        68          106.0

    Body_Temperature
36              38.2
37              38.4
38              38.0
40              38.0
41              38.2
43              37.7
44              38.1
```

```python
In [22]: high_temperature_threshold = 37.5

normal_ranges = {
    'Heart Rate (BPM)': '60-100',
    'Blood Oxygen Level (%)': '95-100',
    'Blood Pressure (Systolic/Diastolic)': '90-120 / 60-80',
    'Blood Glucose (mg/dL)': '70-140',
    'Body Temperature (°C)': '36.5-37.5'
}

high_temp_passengers = high_risk_passengers[high_risk_passengers['Body_Temperature'] > high_temperature_threshold]

if not high_temp_passengers.empty:
    for index, row in high_temp_passengers.iterrows():
        timestamp = datetime.now().strftime("%Y-%m-%d %H:%M:%S")

        alert_message = f"""
        Medical Alert: Passenger ID {row['Passenger_ID']}
        Timestamp: {row['Timestamp']}
        Risk Level: High
        Health Anomalies Detected: Elevated Body Temperature

        Passenger Details:
        - Passenger ID: {row['Passenger_ID']}
        - Heart Rate (BPM): {row['Heart_Rate_BPM']} (Normal: {normal_ranges['Heart Rate (BPM)']})
        - Blood Oxygen Level (%): {row['Blood_Oxygen_Level_%']} (Normal: {normal_ranges['Blood Oxygen Level (%)']})
        - Blood Pressure (Systolic/Diastolic): {row['Blood_Pressure_Systolic']}/{row['Blood_Pressure_Diastolic']} (Normal: {norma
        - Blood Glucose (mg/dL): {row['Blood_Glucose']} (Normal: {normal_ranges['Blood Glucose (mg/dL)']})
        - Body Temperature (°C): {row['Body_Temperature']} (Normal: {normal_ranges['Body Temperature (°C)']})

        Risk Score: {row['Risk_Score']}

        Actions Needed:
        - Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to asses
        - Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.
        """
        print(alert_message)
else:
    print("No high temperature detected for any high-risk passengers.")
```

Output:

Medical Alert: Passenger ID 5
Timestamp: 29-09-2024 12:10
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:
- Passenger ID: 5
- Heart Rate (BPM): 94 (Normal: 60-100)
- Blood Oxygen Level (%): 98.2 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 91/68 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 120.4 (Normal: 70-140)
- Body Temperature (°C): 38.2 (Normal: 36.5-37.5)

Risk Score: 0.76

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

Medical Alert: Passenger ID 5
Timestamp: 29-09-2024 12:30
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:

- Passenger ID: 5
- Heart Rate (BPM): 79 (Normal: 60-100)
- Blood Oxygen Level (%): 95.0 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 96/69 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 136.7 (Normal: 70-140)
- Body Temperature (°C): 38.4 (Normal: 36.5-37.5)

Risk Score: 0.8

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

Medical Alert: Passenger ID 5
Timestamp: 29-09-2024 12:50
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:
- Passenger ID: 5
- Heart Rate (BPM): 76 (Normal: 60-100)
- Blood Oxygen Level (%): 98.8 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 112/67 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 121.3 (Normal: 70-140)
- Body Temperature (°C): 38.0 (Normal: 36.5-37.5)

Risk Score: 0.81

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

Medical Alert: Passenger ID 5
Timestamp: 29-09-2024 13:30
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:
- Passenger ID: 5
- Heart Rate (BPM): 76 (Normal: 60-100)
- Blood Oxygen Level (%): 97.0 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 94/74 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 96.7 (Normal: 70-140)
- Body Temperature (°C): 38.0 (Normal: 36.5-37.5)

Risk Score: 0.87

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

Medical Alert: Passenger ID 5
Timestamp: 29-09-2024 13:50
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:
- Passenger ID: 5
- Heart Rate (BPM): 72 (Normal: 60-100)
- Blood Oxygen Level (%): 97.2 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 95/76 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 92.5 (Normal: 70-140)
- Body Temperature (°C): 38.2 (Normal: 36.5-37.5)

Risk Score: 0.83

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

Medical Alert: Passenger ID 5
Timestamp: 29-09-2024 14:30
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:
- Passenger ID: 5
- Heart Rate (BPM): 65 (Normal: 60-100)
- Blood Oxygen Level (%): 96.8 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 120/63 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 78.2 (Normal: 70-140)
- Body Temperature (°C): 37.7 (Normal: 36.5-37.5)

Risk Score: 0.83

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

Medical Alert: Passenger ID 5

Timestamp: 29-09-2024 14:50
Risk Level: High
Health Anomalies Detected: Elevated Body Temperature

Passenger Details:
- Passenger ID: 5
- Heart Rate (BPM): 67 (Normal: 60-100)
- Blood Oxygen Level (%): 98.4 (Normal: 95-100)
- Blood Pressure (Systolic/Diastolic): 94/68 (Normal: 90-120 / 60-80)
- Blood Glucose (mg/dL): 106.0 (Normal: 70-140)
- Body Temperature (°C): 38.1 (Normal: 36.5-37.5)

Risk Score: 0.82

Actions Needed:
- Passenger's body temperature is abnormally high, indicating a potential fever. Immediate attention is required to assess possible causes, such as infection or inflammation.
- Cabin crew should assess the passenger's condition, ensure hydration, and contact medical personnel if necessary.

13. Conclusion

This project is intended to improve passenger safety and health management during flights. By combining modern wearable technology with real-time monitoring and machine learning capabilities, the system delivers timely notifications and actionable insights to both passengers and cabin personnel. This comprehensive approach guarantees that possible health risks are identified early and addressed swiftly, considerably improving the overall flying experience. As a result, the technology is a significant step forward in in-flight health care, providing peace of mind and increased safety for both passengers and crew.

14. References

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