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AI and IoT-Enabled Smart Healthcare Mat for Continuous Vital Sign Monitoring and Early Health Anomaly Detection

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Abstract

A major challenge in modern healthcare is the lack of continuous monitoring. Many individuals are unaware of their health condition until it becomes serious. Continuous monitoring is essential, but traditional systems do not support real-time observation. This paper presents a Smart Healthcare Mat that can continuously monitor health conditions without requiring any active effort from the user. The system uses embedded sensors to collect important data such as body pressure, heart activity, body movement, and temperature. The inclusion of temperature monitoring helps in detecting fever conditions, which is especially useful for children and babies who require frequent health checks. The collected data are processed using a microcontroller, which analyses the values and compares them with normal health ranges. If any abnormal condition is detected, such as irregular heart rate, increase in body temperature, the system immediately sends alerts to the user or caregivers through mobile application. This solution is highly useful for elderly individuals, patients recovering from illness, adults and babies. It reduces the need for manual checking and provides early warning of potential health issues, ensuring safety and timely medical response.

Keywords: Smart Healthcare System; Heart Rate Monitoring; Body Temperature Monitoring; Fever Detection; Non-Wearable Sensors; Real-Time Health Monitoring; Patient Monitoring System

How to Cite This Article

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Introduction

Health monitoring is becoming increasingly important in modern society. Many diseases develop slowly and do not show immediate symptoms. For example, heart problems, fever conditions, and sleep-related disorders often go unnoticed until they become serious. Traditional healthcare systems rely on periodic checkups, which means health is monitored only at specific times. This creates a gap where sudden changes, such as a rise in body temperature or irregular heart activity, may not be detected in time. With advancements in technology, smart healthcare systems have been introduced. However, many of these systems depend on wearable devices like smart watches, which are not always convenient. Some users forget to wear them, while children and elderly individuals may find them uncomfortable. The Smart Healthcare Mat provides a better solution for monitoring. The system automatically starts working when a person lies on the mat. It continuously collects data such as heart rate, movement, pressure, and temperature without disturbing the user.

This approach makes healthcare monitoring simple, natural, and suitable for all age groups, including babies and children who require constant observation, especially for fever detection.

Problem Statement

- In today's world, many health problems are becoming more common because people do not monitor their health regularly. Most individuals check their health only when they visit a hospital. This type of checking is not continuous, so it cannot show real-time changes in the body. Important conditions like heart rate changes or increase in body temperature may happen suddenly, but they are often not noticed at the right time.
- One of the biggest issues is the late detection of serious health problems. Heart-related conditions, such as irregular heartbeat or sudden heart attacks, can occur without clear early symptoms. At the same time, body temperature can increase quickly due to fever or infection, especially in children and babies. If these changes are not monitored continuously, they may lead to serious health risks.
- Another major problem is the difficulty in monitoring elderly people, patients, and young children. Elderly individuals are more likely to face heart-related issues, while babies and children are more sensitive to temperature changes like fever. Caregivers often have to check them manually, which is not always possible throughout the day and night. Because of this, sudden health changes may go unnoticed.
- Existing healthcare systems also depend on wearable devices like smartwatches and fitness bands. However, many people feel uncomfortable wearing them for long periods. Children and elderly people may remove them or forget to use them properly. This reduces the effectiveness of continuous monitoring.
- In emergency situations, such as a sudden increase in heart rate or high body temperature, immediate action is very important. But in many cases, there is no system that can automatically detect these conditions and send alerts. This delay can make the situation more serious.
- Because of all these problems, there is a strong need for a system that can continuously monitor both heart condition and body temperature in a simple and comfortable way. The system should work automatically without requiring user effort and should provide quick alerts when any abnormal condition is detected. Such a solution can improve safety, especially for elderly people, patients, and children.

Objectives

- To make the system work automatically without any effort from the user

The person does not need to do anything. Just sitting, standing, or lying on the mat is enough. The system will start working on its own. This makes it very easy to use for everyone.

- To avoid using wearable devices like watches or bands

Many people feel uncomfortable wearing devices or may forget to wear them. This system solves that problem by using a mat, so nothing needs to be worn on the body.

- To check multiple health values at the same time

The system does not depend on just one value. It checks heart rate, body temperature, movement, and pressure together. This gives a better and clearer idea about the person's health.

- To combine heart rate and temperature monitoring in one system

This is one of the important and unique parts of the project. It checks both heart activity and body temperature together. This helps in finding problems like fever and heart issues more easily.

- To find health problems at an early stage

Small changes in heart rate or temperature can be the first sign of a problem. This system notices those changes early so that action can be taken quickly.

- To give immediate alerts when something is wrong

If the system finds anything unusual, like high temperature or abnormal heart rate, it sends a message or alert immediately. This helps the user or caregiver take quick action.

- To make it useful for babies, children, and elderly people

Some people cannot use complex devices. This system is very simple and works automatically, so it is suitable for all age groups, especially babies and older people.

- To reduce the need for manual checking

For example, checking a baby's temperature again and again can be difficult. This system does it automatically and gives alerts when needed, saving time and effort.

- To provide a comfortable and non-disturbing system

Since everything is inside a mat, it does not disturb the person while sleeping or resting. It works quietly in the background.

Scope of the Project

The scope of the Smart Healthcare Monitoring Mat project is wide and has strong potential to improve healthcare in daily life. The system is designed to continuously monitor important health parameters such as heart rate, body pressure, movement patterns, and body temperature. By combining heart-related monitoring with temperature tracking, the system provides a more complete understanding of a person's health condition. In its current form, the system can be effectively used in home environments, especially for elderly individuals, patients, and children. Elderly people are more likely to face heart-related problems such as irregular heartbeat, while children and babies are more sensitive to changes in body temperature, such as fever. The system helps in continuously monitoring both these conditions without the need for manual checking. This reduces the burden on caregivers and provides a sense of safety and confidence for family members. In hospital settings, the system can support healthcare professionals by providing continuous data about patients. Instead of checking heart rate and temperature manually at regular intervals, doctors and nurses can rely on the system for real-time monitoring. This helps in reducing workload and allows faster response when any abnormal condition is detected. The project also has useful applications in workplaces, where monitoring employee health can help improve productivity and reduce health risks. Similarly, in hostels, old-age homes, and shared living spaces, the system can act as a safety solution for individuals living alone by detecting sudden changes in heart rate or body temperature and sending alerts. Another important aspect of this system is its ability to reduce the need for manual monitoring. For example, parents often need to check the temperature of babies repeatedly to detect fever. With this system, temperature is monitored automatically, and alerts are generated when there is an increase. At the same time, heart rate monitoring ensures that any unusual cardiac condition is also detected early. Looking towards the future, the scope of this project can be expanded further by integrating Internet of Things (IoT) technology. This will allow remote monitoring, where doctors and caregivers can access real-time health data from anywhere. In addition, machine learning techniques can be applied to analyze past data and predict possible health risks based on patterns in heart rate and temperature changes. Thus, the Smart Healthcare Monitoring Mat is not only useful in its current stage but also has strong potential for future development. By combining heart monitoring and temperature tracking in a single system, it offers a reliable, continuous, and user-friendly healthcare solution suitable for people of all age groups.

Literature Review

1. In recent years, wearable health monitoring devices such as smart bands and watches have been widely studied for tracking heart rate and movement. Researchers like Patel et al. (2012, *Journal of NeuroEngineering and Rehabilitation*) and Pantelopoulos & Bourbakis (2010, *IEEE Transactions on Systems, Man, and Cybernetics*) mentioned that these devices can detect abnormal heart conditions and sudden changes in pulse. However, they require the user to wear them all the time, which can be uncomfortable, especially for elderly people and children. This highlights the need for non-wearable, passive solutions like the Smart Healthcare Monitoring Mat.

2. Continuous remote monitoring has also gained attention. Majumder et al. (2017, *Sensors Journal*) emphasized that collecting health data continuously helps in early detection of problems. He et al. (2019, *Future Generation Computer Systems*) discussed IoT-based systems that send health data to mobile apps or cloud platforms, enabling doctors and caregivers to monitor patients in real time. This supports the concept of using IoT-enabled sensors in a mat for ongoing monitoring without the need for physical contact.

3. Some studies explored multi-parameter monitoring using body sensor networks. Yang (2014, *Springer Publications*) and Castaneda et al. (2018, *International Journal of Biosensors & Bioelectronics*) mentioned that combining multiple sensors can track heart rate,

movement, and other vital signs together. However, many of these systems still focus mostly on heart-related data and do not continuously monitor body temperature, which is important for detecting fever or infection. This aligns with our approach of integrating both heart rate and temperature monitoring in a single mat.

4. Monitoring body temperature is especially important for vulnerable groups. Singh & Sharma (2020, *International Journal of Engineering Research & Technology*) and Khan et al. (2019, *Advanced Materials Technologies*) highlighted that sudden changes in temperature can indicate fever or infection, particularly in children and elderly individuals. This emphasizes the need for automatic, continuous temperature sensing in the mat.

5. Many wearable devices face challenges in comfort and long-term use. Guk et al. (2019, *Nanomaterials*) noted that physical contact can be uncomfortable, while Albahri et al. (2021, *Journal of Network and Computer Applications*) and Lee & Park (2018, *IEEE Access*) recommended non-invasive, passive monitoring. These insights inspired the mat's design to work without touching the body while providing real-time alerts.

6. Research also shows that combining multiple sensors improves accuracy. Patel & Wang (2019, *IEEE Wireless Communications*) and Kumar & Lee (2012, *Sensors Journal*) explained that analyzing heart rate, movement, and pressure together helps detect abnormal conditions. Jovanov (2005, *IEEE Engineering in Medicine and Biology Magazine*) mentioned that wireless sensor networks can effectively integrate multiple sensors. In the mat, combining pressure, motion, heart rate, and temperature sensors ensures reliable monitoring and early detection of unusual health conditions.

7. From these studies, it is clear that while heart rate monitoring is well-studied, continuous temperature monitoring is often overlooked. In real-life situations, temperature and heart rate are closely related—for example, fever often increases heart rate. The Smart Healthcare Monitoring Mat addresses this gap by simultaneously monitoring heart rate, body temperature, movement, and pressure in a non-wearable, easy-to-use system, making it particularly useful for elderly people, children, and patients who require constant monitoring.

Proposed Solution

Fig. 1. *System Use Case*

The proposed system is a Smart Healthcare Monitoring Mat designed to continuously observe a user's health condition in a simple, comfortable, and non-intrusive manner. Unlike traditional healthcare systems that depend on wearable devices, this system works passively. The user does not need to wear or operate any device. The monitoring process starts automatically when a person sits, stands, or lies on the mat. This approach improves comfort and ensures that health monitoring happens continuously without interruption. The mat is embedded with multiple sensors that are capable of collecting both physical and physiological data from the human body. These include body pressure, heart rate, movement, and body temperature. By combining heart rate monitoring with temperature sensing, the system provides a more complete and accurate understanding of a person's health condition. Heart rate monitoring helps in identifying conditions such as irregular heartbeat, stress, or possible cardiac risks. At the same time, temperature monitoring plays an important role in detecting fever or infection. This is especially useful for babies and children, as their body temperature can change quickly and requires frequent observation. By integrating both heart and temperature monitoring, the system can detect multiple types of health risks at an early stage. Once the data is collected, it is sent to a microcontroller, which acts as the main processing unit of the system. The microcontroller analyzes the incoming data by comparing it with predefined normal values. For example, normal heart rate ranges and normal body

temperature levels are used as reference points. If the system detects values outside these ranges, such as a sudden increase in temperature or irregular heart activity, it identifies the condition as abnormal. In addition to this, the system also monitors movement patterns. It can detect inactivity or unusual behavior, which may indicate a possible health issue. For example, if a person remains inactive for a long time or shows no movement along with abnormal heart rate or temperature changes, the system treats it as a potential risk. When any abnormal condition is detected, the system immediately generates an alert. This alert is sent to a mobile device or caregiver, allowing quick response and timely action. This feature is very important in emergency situations, where early detection can prevent serious health complications. For example, if a child develops a fever or if an elderly person shows irregular heart activity, the system can notify caregivers instantly without the need for manual checking.

Block Diagram

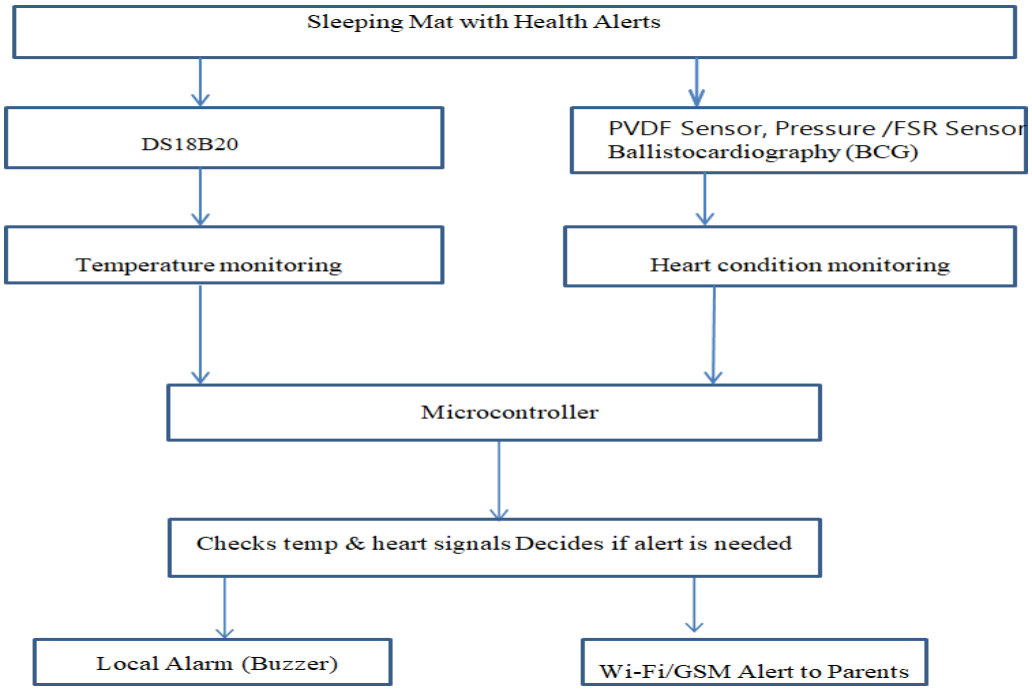

Fig. 2. *System Architecture of Multi-Sensor Smart Healthcare Mat*

The intelligent healthcare mat is designed to continuously monitor a person's health using different sensors placed inside the mat. These sensors measure body pressure to understand posture and weight distribution, heart rate to monitor pulse, body temperature to detect fever or abnormal changes, and motion to identify movement or long periods of inactivity. All the collected information is sent to a microcontroller, which acts as the brain of the system. It converts the sensor readings into meaningful values, compares them with normal health ranges, and checks for any unusual conditions by analyzing all the data together. Instead of depending on only one sensor, the system combines information from multiple sensors to improve accuracy and provide more reliable health monitoring. The processed data is then transmitted wirelessly through Bluetooth or Wi-Fi to a mobile application, allowing users and caregivers to view real-time health information from anywhere. If the system detects an abnormal heart rate, high or low body temperature, no movement for a long time, or unusual pressure patterns, it immediately sends alerts through mobile notifications and a buzzer. This helps caregivers respond quickly and provide timely assistance, making the system especially useful for elderly people, patients, and children who require continuous health monitoring.

Methodology

The proposed Smart Healthcare Mat is designed to continuously monitor a person's vital signs while they are sitting or lying on the mat. The system uses multiple sensors, including pressure, heart rate, temperature, and motion sensors, to collect real-time health information. These sensors measure body posture, pulse rate, body temperature, and movement without causing any discomfort to the user. The collected sensor data is sent to a microcontroller, where it is converted into digital values and processed to remove unwanted noise. The microcontroller compares the measured values with normal health ranges to identify any abnormal conditions, such as an irregular heart rate, fever, prolonged inactivity, or unusual pressure patterns. To improve accuracy, the system analyzes all sensor readings together instead of relying on a single parameter. Once the data is processed, it is transmitted to a mobile application through a wireless communication module such as Bluetooth or Wi-Fi, allowing users and caregivers to monitor health conditions in real time. If any abnormal condition is detected, the system immediately generates an alert through the mobile application and a buzzer, enabling quick

medical attention. The entire monitoring process runs continuously, providing reliable, real-time health monitoring for elderly people, patients, children, and individuals who require regular observation.

Algorithm

The Smart Healthcare Monitoring Mat begins its operation by powering on and initializing all the sensors, including the pressure, heart rate, motion, and temperature sensors, along with the microcontroller and wireless communication module. The system first checks whether a user is present on the mat using the pressure sensor. If no user is detected, it remains in standby mode to save power. Once a user is detected, the system starts collecting real-time data such as body posture, heart rate, body temperature, and movement. The collected sensor data is then cleaned by removing unwanted noise, converting analog signals into digital values, and filtering unstable readings to improve accuracy. The microcontroller analyzes the processed data by comparing the heart rate and body temperature with normal ranges while also checking movement and pressure patterns. If all values are within the normal limits, the system continues monitoring without generating any alerts. However, if it detects an abnormal heart rate, fever, prolonged inactivity, sudden changes in body pressure, or a combination of these conditions, it identifies the situation as a possible health risk. The system immediately sends an alert to the mobile application and activates a buzzer to notify the caregiver. At the same time, all health information, including heart rate, temperature, movement, and pressure data, is stored for future health analysis and medical review. This entire process runs continuously in a loop, allowing the system to monitor the user's health in real time and respond quickly whenever an abnormal condition is detected.

Working Principle

The Smart Healthcare Monitoring Mat works by continuously monitoring a person's health while they are sitting or lying on the mat. When the user comes into contact with the mat, the built-in pressure, heart rate, motion, and temperature sensors begin collecting body information in real time. The pressure sensor detects body posture and weight distribution, the heart rate sensor measures the pulse, the motion sensor tracks body movement or inactivity, and the temperature sensor checks the body's heat level to identify fever or abnormal temperature changes. These sensor readings are initially collected as electrical signals and then converted into digital values so that the microcontroller can process them. The microcontroller analyzes the data by comparing the heart rate and body temperature with normal values while also examining movement and pressure patterns. By combining information from multiple sensors instead of relying on a single reading, the system provides more accurate health monitoring and reduces false alerts. If it detects conditions such as an irregular heartbeat, high body temperature, prolonged inactivity, or unusual pressure patterns, it immediately identifies the situation as abnormal and sends an alert through a mobile application or buzzer. For example, if a child develops a fever with an increased heart rate and reduced movement, or if an elderly person has an irregular heartbeat and remains motionless for a long time, the system recognizes the possible health risk and promptly notifies the caregiver, allowing timely medical attention.

Applications

- Home Healthcare-Used for daily monitoring of heart rate and body temperature, helping family members detect health issues early.
- Hospitals-Supports continuous patient monitoring and provides instant alerts for abnormal health conditions.
- Hostels-Monitors students' health during rest and notifies caregivers if any unusual condition is detected.
- Child and Baby Care-Helps parents monitor a child's heart rate and temperature while providing early fever alerts.
- Elderly Care-Continuously tracks the health of older adults and sends alerts during possible emergencies.
- Emergency Monitoring-Detects abnormal heart rate, fever, or prolonged inactivity and generates immediate alerts.
- Rural Healthcare-Provides basic health monitoring in remote areas where medical facilities are limited.

Results and Analysis

The results from the Smart Healthcare Monitoring Mat show that the system can continuously observe and understand both heart rate and body temperature at the same time. The data collected is divided into three main stages: normal condition, emergency condition, and recovery phase. At the beginning (0–3 minutes), both heart rate and temperature are within normal limits. The heart rate stays around 72–75 BPM, and the temperature remains between 36.5°C and 36.8°C. This shows that the person is in a stable and healthy condition. Between 4–6 minutes, both values start increasing slowly. The temperature crosses 37°C, and the heart rate also begins to rise. This stage can be considered as a warning stage, where the system detects that something is changing in the body, but it is not yet a dangerous condition. From 7–11 minutes, a sharp increase is observed in both parameters. The temperature goes above 39°C, which indicates a high fever, and the heart rate rises above 130 BPM. This clearly shows that the body is under stress. Since both values increase together, the system identifies this as a serious condition and sends an alert. This stage represents the emergency phase. After this peak stage, from 12–15 minutes, both heart rate and temperature start decreasing gradually. This indicates that the condition is improving and the person is moving towards recovery. Finally, in the last stage (16–17 minutes), both values return to normal levels. This confirms that the system can

not only detect abnormal conditions but also track recovery effectively. Overall, the results clearly show that when body temperature increases, heart rate also increases. This proves that monitoring both heart rate and temperature together gives better and more accurate health information than checking them separately. The system is able to detect early warning signs, identify emergency situations, and follow recovery, making it very useful for real-time health monitoring.

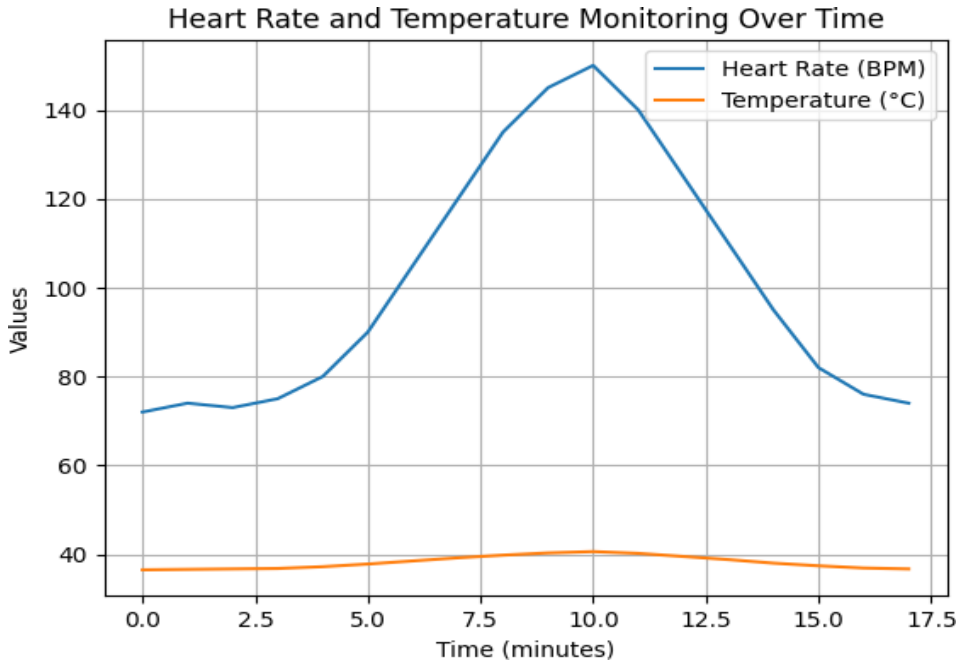

Fig. 3. *Combined Analysis of Heart Rate and Body Temperature Over Time*

Conclusion

The Smart Healthcare Monitoring Mat is an innovative and practical solution developed to overcome the limitations of traditional healthcare monitoring systems. Unlike conventional methods that depend on periodic checkups or wearable devices, this system provides

continuous, real-time monitoring in a passive and user-friendly manner. The user does not need to wear or operate any device, which makes the system highly comfortable and suitable for long-term use. One of the major strengths of this system is its ability to monitor multiple health parameters together, including heart rate, body temperature, movement, and pressure distribution. By combining heart monitoring with temperature sensing, the system offers a more complete and reliable understanding of a person's health condition. Changes in heart rate can indicate potential cardiac issues, while variations in body temperature can signal fever, infection, or other health problems. Monitoring both parameters together improves early detection and reduces the chances of missing important warning signs. The system is particularly useful for elderly individuals, who are more vulnerable to heart-related problems, and for children and babies, who require frequent temperature monitoring to detect fever. In many real-life situations, caregivers need to manually check a child's temperature repeatedly. This system eliminates that need by continuously tracking body temperature and generating alerts automatically when any abnormal change occurs. At the same time, heart rate monitoring ensures that any unusual cardiac activity is also identified at an early stage. Another important advantage of this system is its ability to detect early signs of health issues before they become serious. By continuously analysing data such as heart rate, temperature, movement, and pressure patterns, the system can identify abnormal conditions and provide immediate alerts. This helps in preventing emergencies and allows timely medical attention, which can significantly improve health outcomes. The system is also cost-effective and easy to use, making it accessible to a wide range of users, including patients, elderly individuals, and people living alone. It reduces the need for constant supervision and provides a sense of safety, independence, and confidence. Additionally, the use of simple technologies such as sensors and microcontrollers demonstrates that effective healthcare solutions can be developed without complex.

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