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Drug Free Steam and Heat Therapy System for Sinus Congestion Relief

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Abstract
Sinus congestion is a common upper respiratory condition characterized by nasal blockage, mucus accumulation, facial pain, and pressure due to inflammation of the sinus cavities. Continuous dependence on medication may result in side effects, creating the need for safe, non-invasive, and drug-free supportive solutions. This paper presents the design and development of a Drug-Free Steam and Heat Therapy System intended to provide symptomatic relief through controlled steam inhalation and localized heat therapy. An ESP32-based control unit regulates therapy duration, temperature limits, and automatic shutoff to ensure safe operation. The proposed system is low-cost, user-friendly, and suitable for home-based sinus congestion relief applications.

Keywords: *Sinus Congestion; Steam Therapy; Heat Therapy; ESP32; Drug-Free Device; Assistive Healthcare*

1. Introduction
Sinus congestion is a common upper respiratory condition that affects millions of people worldwide. It is characterized by nasal blockage, mucus accumulation, facial pain, and pressure due to inflammation of the sinus cavities. This condition may occur as a result of infections, allergies, environmental changes, or chronic sinusitis, and it often reduces breathing comfort and overall quality of life. Conventional treatment for sinus congestion mainly depends on pharmacological approaches such as decongestants, antihistamines, nasal sprays, and antibiotics. Although these medications provide temporary relief, repeated or prolonged usage may lead to side effects including dryness, drowsiness, dependency, and reduced effectiveness over time. This creates a growing need for supportive, non-invasive, and drug-free therapeutic alternatives. Non-pharmacological methods such as manual steam inhalation, saline irrigation, yoga, and acupressure are also widely practiced for sinus relief. Among these, steam inhalation is known to loosen mucus and improve sinus drainage. However, traditional steam therapy lacks standardized control over temperature and duration, which may cause discomfort or safety risks. Additionally, manual techniques are user-dependent and may not provide consistent outcomes. To address these limitations, this project proposes the design and development of a Drug-Free Steam and Heat Therapy System for Sinus Congestion Relief. The system integrates controlled steam inhalation with localized heat therapy to provide safe and effective symptomatic relief. A microcontroller-based control unit ensures regulated temperature, therapy duration, and automatic shutoff, making the device suitable for low-cost, user-friendly, and home-based sinus congestion management. In recent years, the integration of embedded systems and smart healthcare technologies has enabled the development of automated assistive therapy devices for home-based applications. Microcontroller platforms such as ESP32 allow precise regulation of therapy parameters, ensuring improved safety and reliability compared to traditional methods. By incorporating sensors, relay-based control, and user-friendly interfaces, supportive devices can deliver consistent steam and heat therapy sessions with minimal manual effort. Such innovations not only reduce dependence on medication but also provide a convenient and cost-effective approach for managing sinus congestion symptoms in everyday life.

2. Methods
The proposed system combines controlled steam

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inhalation and localized heat therapy for sinus congestion relief. An ESP32 microcontroller is used to manage the overall operation of the device. A temperature sensor continuously monitors the therapy temperature to ensure safe limits. Relay modules are used to switch the vaporizer and heating pad modules automatically. The system provides timed therapy sessions with LCD indication and buzzer alerts for user safety. The overall working principle of the system is illustrated in Fig. 1.

2.1.System Overview

The proposed Drug-Free Steam and Heat Therapy System is designed to provide safe and non-invasive relief from sinus congestion through controlled therapeutic support. The system integrates a steam generation module and a localized heating pad to help loosen mucus, improve sinus drainage, and reduce facial discomfort. An ESP32 microcontroller serves as the central control unit, regulating therapy duration, temperature limits, and automatic shutoff for safety. A temperature sensor continuously monitors heat levels, while relay modules switch the steam and heating units securely. User interface components such as an LCD display and buzzer provide real-time status updates and alerts, making the device suitable for low-cost and home-based sinus congestion management.

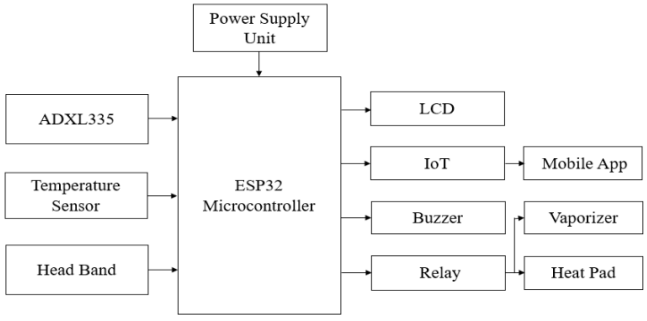

Figure 1 Block Diagram of the Proposed Sinus Congestion Relief System

2.1.1. Data Acquisition

In the proposed system, data acquisition refers to the collection of sensor information required for safe and controlled therapy delivery. The primary data is obtained from the temperature sensor, which continuously measures the heat level during steam and localized heating therapy. If a posture sensor such as ADXL335 is included, it acquires head orientation data to guide the user for improved sinus drainage. These sensor signals are converted into electrical data and sent to the ESP32 microcontroller for processing. The controller uses this acquired data to regulate therapy duration, activate relay switching, and ensure automatic shutoff under unsafe conditions. Thus, data acquisition plays a key role in maintaining user safety and providing consistent therapy operation.

2.2.Steam Inhalation

Steam inhalation is a widely used supportive therapy for relieving sinus congestion and nasal blockage. It works by delivering warm, moist air into the nasal passages, which helps loosen thick mucus accumulated in the sinus cavities. This improves sinus drainage, reduces inflammation, and provides relief from facial pressure and discomfort. In the proposed system, steam is generated in a controlled manner using a vaporizer module, ensuring safe temperature levels and consistent therapy duration. Compared to traditional manual methods, controlled steam inhalation offers improved safety, comfort, and effectiveness for home-based sinus congestion management.

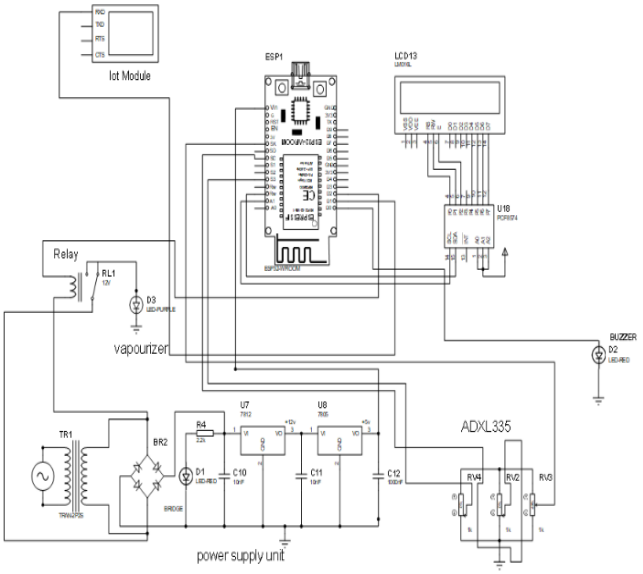

Figure 2 Circuit Diagram of the Proposed Sinus Congestion Relief System

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2.3.Localized Heat Therapy

Localized heat therapy is a non-invasive supportive technique used to reduce facial discomfort and pressure caused by sinus congestion. By applying mild, controlled heat to the sinus region, such as the forehead or areas around the cheeks, it helps improve blood circulation and relax inflamed tissues. This warming effect can ease sinus pain and promote better mucus drainage. In the proposed system, a low-power heating pad integrated into the therapy setup provides safe and regulated heat under microcontroller control. Compared to uncontrolled manual heating methods, localized heat therapy in this device ensures consistent, user-friendly, and safer sinus relief.

2.4.Data Processing

Data processing in the proposed system involves analyzing the sensor inputs to ensure safe and effective therapy operation. The ESP32 microcontroller receives real-time signals from the temperature sensor, and if included, posture sensor data from the headband module. These signals are processed to determine whether the therapy conditions remain within predefined safe limits. Based on the processed data, the controller activates or deactivates the steam generator and heating pad through relay switching. It also manages therapy timing, automatic shutoff, and user alerts through the LCD display and buzzer. Thus, data processing enables controlled therapy delivery, enhances safety, and ensures consistent performance of the system.

2.5.Circuit Implementation

The ESP32 microcontroller controls the vaporizer and heating pad through relay modules. A temperature sensor ensures safe therapy by monitoring heat levels continuously. LCD and buzzer provide user indication, while the power supply supports stable circuit operation. The circuit implementation of the proposed system, showing sensor interfacing and microcontroller connections, is illustrated in Fig. 2.

3. Results and Discussion

3.1.Results

The developed prototype of the Drug-Free Steam and Heat Therapy System successfully demonstrated controlled steam generation and localized heat delivery for sinus congestion relief. The ESP32 microcontroller effectively regulated the operation of the vaporizer and heating pad modules through relay switching. Temperature monitoring ensured that therapy was maintained within safe limits, and the automatic shutoff mechanism prevented overheating. The LCD display and buzzer alerts provided clear user indications, improving ease of operation. Overall, the system achieved consistent and safe therapy sessions compared to traditional manual steam inhalation methods. The proposed system successfully delivered controlled steam and localized heat therapy for sinus relief. Temperature monitoring ensured safe operation by preventing overheating during therapy sessions. Relay switching provided reliable control of both the vaporizer and heating pad modules. User indications through the LCD display and buzzer improved ease of use and safety awareness. Overall, the prototype demonstrated a consistent, low-cost, and drug-free approach for sinus congestion management.

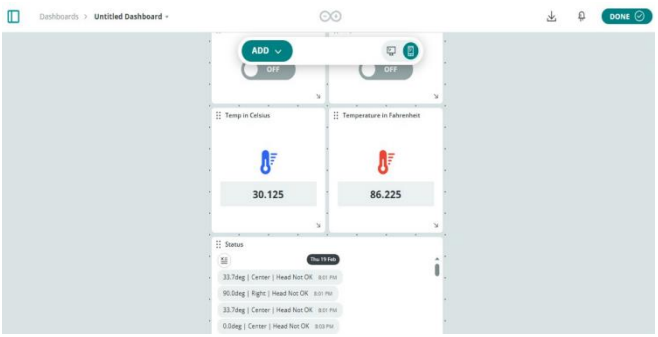

Figure 3 Steam and Heat Therapy Output

3.2.Discussion

The results show that combining steam inhalation with localized heat therapy can effectively support sinus congestion relief. Unlike traditional manual methods, the proposed system provides controlled temperature and timed operation for improved safety. Automation reduces user dependency and minimizes risks such as excessive heat exposure. The integration of sensors and relay control ensures consistent and reliable therapy delivery. This device has potential as a low-cost, non-invasive alternative for home-based sinus symptom management.

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Conclusion

The Drug-Free Steam and Heat Therapy System provides a safe and non-invasive solution for sinus congestion relief. By combining controlled steam inhalation with localized heat therapy, it helps reduce nasal blockage and facial discomfort. The ESP32-based automation ensures regulated temperature, timed operation, and user safety through automatic shutoff. The prototype is low-cost, user-friendly, and suitable for repeated home-based therapy sessions. Future improvements can include advanced feedback control and clinical validation for wider healthcare applications.

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