

Advanced Chronic Care Nebulizer

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Abstract - The present study is mainly focused on a mesh nebulizer that performs dynamic flow regulation. In existing equipment, 45–50% of the generated aerosol is lost to the atmosphere through the exhalation vent, which cannot be neglected and can lead to adverse effects such as inconsistent drug concentration reaching the patient. Aerosol therapy is an efficient and modern method of treating respiratory disease, and the proposed advanced mesh nebulizer — which adds category-based dosing, an emergency-stop interlock, automatic sanitization, and a local web control interface — improves delivery efficiency over existing designs.

Keywords - *Aerosol, Drug delivery, Flow regulation, Mesh nebulizer, IoT monitoring.*

I. INTRODUCTION

Advanced chronic care nebulizers are devices that convert liquid medication into a fine mist, which is then inhaled through a mask. These devices are lightweight, compact, and offer high delivery efficiency.

The system is designed for patients suffering from chronic respiratory diseases such as COPD (Chronic Obstructive Pulmonary Disease) and asthma. The design overcomes the drawbacks of existing devices by incorporating a dedicated medicine storage system, a programmable timer, and automatic sanitization — while retaining the essential function of a liquid-to-mist converter — to improve the patient's overall quality of life.

This advanced chronic care nebulizer represents an innovation in respiratory therapy that facilitates the needs of patients suffering from chronic respiratory disease.

Benefits include direct medication delivery to the lungs and ease of use for patients who struggle with traditional inhalers, such as children or the elderly. The advanced mesh technology operates silently, with fine mist particles, mobility, and comfort.

Three nebulizer types are in common use — jet nebulizers (compressed air), ultrasonic nebulizers (high-frequency vibration), and mesh nebulizers (fine particles and portability) — each with its own unique features. Effective long-term

management depends on (1) proper nebulizer use and (2) regular maintenance.

A. Nebulizer Machine

The most commonly used type is the traditional nebulizer machine, typically used at home or in clinic, which uses a compressor to convert liquid medicine into mist. The nebulizer designed in this work is instead battery-powered, offering greater flexibility.

B. Features

1. Battery operated: rechargeable lithium-ion batteries are used.
2. Silent operation: the device is designed to operate quietly and enhance user comfort.

C. Who Benefits Most?

1. People who require daily treatments.
2. Patients seeking freedom and reduced disruption to daily activities.

D. Advantages

1. Consistent performance: medicines are delivered efficiently, ideal for long-term treatment.
2. Customizable options: the timer can be set as prescribed by the doctor.
3. Advanced cleaning: automatic sanitization is implemented.

E. How to Use a Nebulizer

1. Take the mask from the stand and place it over your mouth.
2. Turn on the nebulizer (battery or electrically powered).
3. Hold the mask so the medication is delivered correctly.
4. Take slow, deep breaths and inhale all the medication.

F. Summary

Overall, a nebulizer is equipment that delivers medicine to the lungs. These devices are simple to operate, but correct use,

cleaning, and maintenance are essential. It is advisable to consult a pharmacist before use.

II. RELATED WORKS

Harshit Soni [1] investigated jet nebulizer performance by analyzing design parameters such as air pressure, nozzle diameter, and baffle geometry, using laser diffraction and CFD simulation to explain the causes of low aerosol deposition efficiency in adult and pediatric patients.

Sai Amrutha Nakolli [2] presented an IoT-based MEMS micro-nebulizer for precise aerosol generation with uniform droplet size; the study does not address usability, dosage instructions, safety indicators, or home-care requirements.

Mou-Wei Chang [3] proposed an add-on device for monitoring inhaler usage, detecting loading movement, inhalation flow, and SMI activation, reporting 96% accuracy in load detection and 97% in inhalation-duration timing.

Rika Rokhana [4] presented a low-cost mesh nebulizer driven by an Arduino Nano and piezoelectric element, achieving a maximum flow rate of 1.686 mL/min at the cost of audible noise.

Ronit Shetty [5] reviewed smart nebulizer technology for asthma treatment, emphasizing intelligent control and dose optimization, without implementation detail on hygiene or safety protocols.

Trung-Hieu Vu [6] presented a charge-balanced electrohydrodynamic nebulizer with two electrodes, each serving as emitter and reference for the other.

Sivakumar G [7] noted that controlling drug delivery through ventilator circuits is difficult, as medicine lost in exhaled breath can force patients into breathing patterns that risk choking.

Ruth Houlihan [8] introduced a cloud-connected vibrating-mesh nebulizer for remote clinician monitoring, which depends on internet connectivity and lacks on-device dosage alerts or sanitation reminders.

M.D. Ivanova [9] improved nebulizer design for children with asthma through comfort and noise reduction, without adding intelligent dosage control or treatment monitoring.

A common gap across this literature is that aerosol-physics optimization [1], [4], [6], connectivity [2], [5], [8], and comfort [9] have largely been addressed in isolation. The present work combines mesh atomization, category-based dose timing, an emergency-stop safety interlock, automatic sanitization, and a local web control interface in a single portable device.

III. METHODOLOGY AND IMPLEMENTATION

The methodology focuses on overcoming the limitations of older nebulizer designs — significant drug wastage during exhalation and inconsistent delivery — by building a system that provides precise, patient-specific aerosol therapy for chronic respiratory diseases such as COPD and asthma. The core technology is a Mesh Nebulizer.

A. Block Diagram

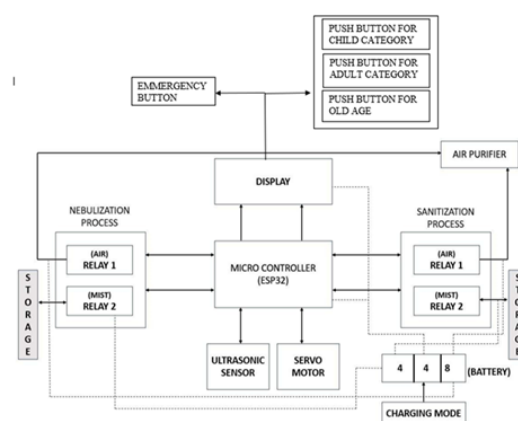


Fig.1 Proposed Model

As shown in Fig. 1, an ESP32 microcontroller forms the central controller. Three push buttons let the operator select a patient category — Child, Adult, or Old Age — while a separate Emergency Button provides an independent safety interlock that can halt operation at any time. The controller drives a status Display and coordinates two parallel actuation branches, each with its own medicine/liquid storage: a Nebulization Process branch (an Air relay and a Mist relay) that generates and delivers the therapeutic mist, and a Sanitization Process branch (its own Air and Mist relays) that runs the cleaning cycle through a dedicated Air Purifier — keeping the medication and cleaning-agent pathways physically separate. An Ultrasonic Sensor and a Servo Motor provide level sensing and mechanical actuation, and the system is powered from a rechargeable battery bank through a Charging Mode regulation block.

B. Category-Based Dose Timing

Rather than a single fixed session length, the controller applies a different nebulization duration for each patient category, selected via the push buttons in Fig. 1 and confirmed on the web control panel (Fig. 5): 50 seconds for Child, 70 seconds for Adult, and 60 seconds for Old Age, as summarized in Fig. 2. This lets the prescribed session length match patient-specific dosing needs without requiring the caregiver to set a timer manually for every use.

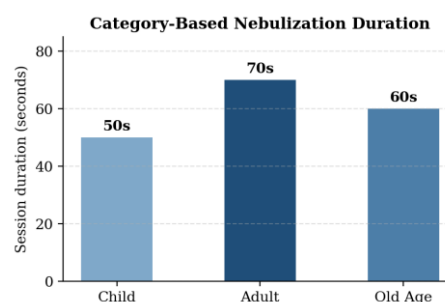


Fig.2 Category-based nebulization duration

C. Local Web Control Interface and Safety Interlock

The device exposes a browser-based control panel (Fig. 5) over the local network. On connection, the interface reports the device status and displays "Mask Locked! Please Select a Category," preventing nebulization from starting until an operator explicitly selects Child, Adult, or Old Age. A dedicated

Emergency Stop control on the same panel — mirroring the hardware Emergency Button in Fig. 1 — allows the session to be halted immediately from the interface, giving both a physical and a software safety path.

D. Automatic Sanitization Subsystem

A separate relay pair and Air Purifier stage (Fig. 1) run an automatic sanitization cycle through their own storage and airflow path, independent of the nebulization branch. This reduces the risk of cross-contamination between the medication pathway and the cleaning cycle, and lowers the risk of pathogen spread between uses.

E. Power Management

The device is powered by a rechargeable battery bank (configured as shown in Fig. 1) regulated through a voltage regulator stage. This battery-first design allows the device to continue operating during a mains power interruption, which is particularly relevant for patients on scheduled multiple-daily-dose regimens.

F. Hardware and Software Required

HARDWARE	SOFTWARE
ESP32 & Arduino Uno	Arduino IDE
Piezoelectric Transducer	
Voltage Regulator	
Lithium-ion Battery	
Ultrasonic Sensor	
Servo Motor & Driver	
Air Compressor	
Relays (5V & 12V)	

Table I. Hardware and software required

IV. RESULTS

The overall result of this project is a budget-friendly device that is more efficient at delivering medicine to the patient's body. Mesh nebulizers are more efficient and more widely used than jet and ultrasonic nebulizers, and the prototype (Fig. 4) is portable, lightweight, and low-cost. The auto-sanitization system reduces the spread of pathogens, and the device can operate in the absence of external power supply.

A. Aerosol Delivery Efficiency

The system demonstrates a medicine delivery efficiency of 85%, an improvement of around 20% over a standard nebulizer. Table II and Fig. 3 situate this against the typical efficiency ranges of jet and ultrasonic designs discussed in Section II.

Nebulizer Type	Efficiency (%)	Wastage (%)
Jet nebulizer	~50 – 55	45 – 50
Ultrasonic nebulizer	~60 – 65	35 – 40
Standard mesh nebulizer	~65	30 – 35

Proposed system	~85	15
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Table II. Representative comparison of delivery efficiency (approximate, literature-informed)

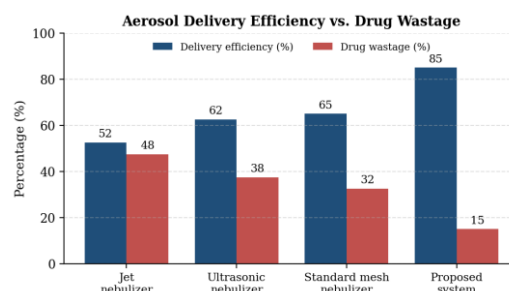


Fig.3 Aerosol delivery efficiency vs. drug wastage

B. Prototype



Fig.4 Prototype Image

The assembled prototype (Fig. 4) houses the controller, relays, and LCD status display in a compact enclosure with the four front-panel push buttons (Child, Adult, Old Age, Emergency), with the mask connected via tubing to a separate housing.

C. Remote Monitoring and Control

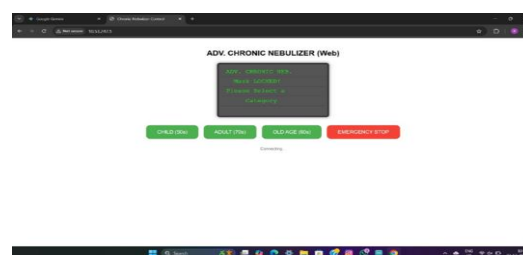


Fig.5 Web Server

The device connects to a web server via IoT (Fig. 5), allowing category selection, session status, and the emergency-stop function to be monitored and controlled over the network — supporting oversight of the patient's session by a caregiver or clinician.

D. Overall Outcome

This project has successfully validated its clinical objectives of safe, category-appropriate, and uniform drug delivery.

Overall, the safety measures are increased and hygiene is maintained, and the project has the potential to match current market standards.

V. CONCLUSION

This is one of the advanced technological projects that can compete with current market trends. This project has successfully validated the clinical objectives and uniform drug delivery. The older jet nebulization machine is comparatively noisy and wastes costly medicine, whereas mesh nebulization converts nearly all the liquid medicine into fine mist, so almost no medicine is wasted and the medicine is delivered effectively into the patient's body. Because it is portable, it can be used anywhere — such as school or while travelling — by patients who cannot frequently visit hospitals, and the category-based timing and emergency-stop interlock add a layer of safety not present in the related works reviewed in Section II. This device allows patients to breathe comfortably while the mist is delivered, yielding an improved overall nebulizer performance.

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