



RESEARCH ARTICLE

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Design of Traditional Nebulizer for Patients with Coughs

Muty Dewi Hasanah^{1(CA)}, Agus Khoirul Anam², Wiwin Martiningsih³^{1,2,3} Department of Nursing Poltekkes Kemenkes Malang, IndonesiaCorrespondence author's email (^{CA}): mutydewihasanah@gmail.com

ABSTRACT

Cough is a common respiratory disorder that may become chronic in the elderly and reduce quality of life. Limited access to conventional nebulizers necessitates the development of more affordable inhalation therapy alternatives. This study aimed to design a herbal-based traditional nebulizer as an alternative inhalation therapy for patients with productive cough. This study used a Research and Development (R&D) approach with the ADDIE model. It was conducted at Griya Sakinah Nursing Home, Blitar, Indonesia, from January to April 2025. Data were collected using expert validation and field-testing checklists rated on a 1–5 scale, which underwent expert judgment to ensure content validity. Validation involved three experts, followed by a limited trial on two elderly participants. Expert validation yielded a feasibility score of 77.25% (feasible), while participant trials showed 81.17% (very feasible). The device consists of a clay pot heater, plastic tubing, an aluminum sheath, and *Piper betle* leaves with mucolytic and expectorant properties. No significant adverse effects were observed. This device is potentially beneficial, practical, and cost-effective for use in resource-limited settings. However, the very small sample size limits generalizability.

Keywords: Traditional nebulizer; inhalation therapy; cough; herbal ingredients; elderly

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INTRODUCTION

Cough is a fundamental protective reflex of the respiratory system that facilitates the clearance of excessive mucus and foreign particles from the airway. Despite its physiological role, cough represents a significant global health concern due to its high prevalence and potential progression into chronic conditions. Epidemiological data suggest that cough affects approximately 10% of the adult population worldwide, with variability across regions and demographic groups. In a questionnaire-based study involving 373 individuals, the mean age was 65 years and more than 70% were female, indicating a higher burden among older populations [1].

The prevalence has also been reported at approximately 15% in children and 20% in adults, although these figures vary depending on the study setting and population characteristics [1].

In Indonesia, rapid urbanization and increased exposure to air pollution contribute to the rising incidence of respiratory disorders, including cough [1]. Elderly individuals are particularly vulnerable due to age-related physiological decline, reduced mucociliary clearance, and increased susceptibility to chronic respiratory conditions.

Clinically, persistent cough is often associated with ineffective airway clearance, a nursing diagnosis defined as the inability to clear secretions or obstructions from the respiratory tract, which may compromise ventilation and increase the risk of complications [2]. Standard management strategies include effective coughing techniques, deep breathing exercises, chest physiotherapy, and inhalation therapy using nebulizers [3]. Nebulizers deliver aerosolized medication directly into the lungs, facilitating bronchodilation and enhancing mucus clearance [4]. However, their utilization is frequently constrained by cost, electricity dependence, and limited availability in low-resource settings.

As an alternative, traditional nebulizers utilizing herbal-based steam inhalation have gained attention due to their affordability and accessibility. These devices typically employ a clay pot to generate steam infused with herbal ingredients such as betel leaves, mint, ginger, or curcuma. Piper betle (betel leaf), in particular, contains bioactive compounds such as flavonoids, phenolic compounds, and essential oils that exhibit antimicrobial, anti-inflammatory, and mucolytic properties, which may support sputum clearance and reduce airway irritation [5]. Traditional steam inhalation may also enhance airway humidification, thereby decreasing mucus viscosity and facilitating expectoration [6].

Although such approaches have been widely used in community settings, current evidence remains limited, particularly regarding standardized product design, safety evaluation, and feasibility validation. Most existing studies focus on symptomatic relief without rigorous assessment of usability or clinical applicability. Therefore, this study aims to design and evaluate the feasibility, usability, and safety of a herbal-based traditional nebulizer as a potential inhalation therapy alternative for patients with productive cough, particularly in resource-limited settings.

METHODS

This study employed a Research and Development (R&D) design using the ADDIE framework (analysis, design, development, implementation, and evaluation) to develop and assess herbal-based traditional nebulizer. The study was conducted at Griya Sakinah Nursing Home, Yayasan As-Sakinah, Talun District, Blitar Regency, East Java, Indonesia, from October 2024 to April 2025. Participants consisted of three expert validators with expertise in nursing care, health technology, and herbal-based therapy, as well as two elderly residents selected through purposive sampling based on the presence of productive cough and ability to follow instructions. During the analysis phase, needs assessment was conducted through interviews with nursing home staff to identify limitations in cough management and the absence of nebulizer devices. The design phase involved developing product specifications,

schematic design, and validation instruments.

In the development phase, a prototype was constructed using a clay pot as a heating source, plastic tubing for vapor delivery, and an aluminum sheath for heat insulation, combined with herbal components, and subsequently evaluated through expert validation. The implementation phase involved a limited field trial to assess usability, practicality, and comfort, followed by the evaluation phase in which feedback from validators and participants was analyzed for product refinement. Data were collected using a structured validation questionnaire assessing design, comfort, practicality, and ease of use on a 5-point Likert scale (1 = very poor to 5 = very good), which underwent expert judgment to ensure content validity. Feasibility was calculated using the formula $P = \frac{\sum R}{N} \times 100\%$, where P represents the feasibility percentage, $\sum R$ the total score obtained, and N the maximum possible score. Feasibility was categorized as very feasible (81%–100%), feasible (61%–80%), fairly feasible (41%–60%), less feasible (21%–40%), and not feasible (<20%) [7]. Ethical principles were applied, with informed consent obtained from all participants or their legal guardians and confidentiality maintained throughout the study.

RESULT

Table 1. Participants Characteristics

Name	Gender	Age	Address	Education	Occupation
Mrs. L	F	75 years old	Selokajang	-	-
Mrs. S	F	60 years old	West Java	-	-

Based on Table 1, the study involved two female participants aged 60 and 75 years. One participant lived in Selokajang and the other in West Java. Both participants were classified as older adults. Data regarding educational background and occupation were not available. These participant characteristics represent the target users involved in evaluating the developed product.

Table 2. Results of Expert Validation Assessment

Expert Validation	Total Score	Eligibility Standard Criteria	Description
Lecturer	69	$P = \frac{69}{85} \times 100\% = 81.17\%$	Very Feasible
Nursing Home Management	71	$P = \frac{71}{85} \times 100\% = 83.52\%$	Very Feasible
Nurse	57	$P = \frac{57}{85} \times 100\% = 67.05\%$	Feasible
Total	197	$P = \frac{197}{255} \times 100\% = 77.25\%$	Feasible

Based on the table above, it can be seen that the total score of the assessment from the expert validator is 197 criteria for determining the quality and feasibility level of the product obtained by the total score and the maximum score (255) formula:

$$P = \frac{197}{255} \times 100\% = 77.25\%$$

If the analysis results obtain the standard (61%-80%), then the product is classified as suitable for use, because the value obtained is fulfilled from several aspects of the assessment consisting of design, comfort aspects, practicality, and ease of use. However, responses, criticisms and suggestions from expert validators will be accepted by researchers as evaluation material [7].

Table 3. Results of Field Trial Participant Assessment

Participant	Total Score	Eligibility Standard Criteria	Description
Mrs. L	67	$P = \frac{67}{85} \times 100\% = 78.82\%$	Feasible
Mrs. S	71	$P = \frac{71}{85} \times 100\% = 83.52\%$	Very Feasible
Total	138	$P = \frac{138}{170} \times 100\% = 81.17\%$	Very Feasible

Based on the table above, it can be seen that the total score of the assessment from the field trial is 138. The criteria for determining the quality and level of product feasibility are obtained by the total score and the maximum score (170) formula:

$$P = \frac{138}{170} \times 100\% = 81.17\%$$

If the analysis results obtain the standard (81%-100%), then the product is included in the classification very feasible to use, because it is obtained a value that meets several aspects of the assessment consisting of design, comfort aspects, practicality, and ease of use. However, responses, criticisms and suggestions from participants will be accepted by researchers as evaluation material [7]. In this field trial activity, participants can follow orders and understand what is conveyed by the researcher well, participants are also interested in new product innovations made by researchers and hope that these products can be produced to help elderly patients.

DISCUSSION

Interpretation of Product Development and Clinical Relevance

The findings of this study indicate that the development of a herbal-based traditional nebulizer addresses a critical gap in respiratory care delivery within resource-limited settings. The reliance on oral medication observed in the study setting reflects a common limitation in long-term care facilities, where access to aerosol-based therapy remains restricted. Steam inhalation has been recognized to improve airway humidification and facilitate mucus clearance by reducing secretion viscosity and promoting expectoration [2]. This mechanism supports airway patency and contributes to symptom relief in patients with productive cough. The absence of conventional nebulizers identified in this study highlights structural barriers in healthcare access that may compromise the effectiveness of respiratory management, particularly among elderly populations exposed to environmental risk factors [8].

From a clinical perspective, elderly individuals are more susceptible to ineffective airway clearance due to age-related decline in mucociliary function and respiratory muscle strength [9]. This condition increases the risk of secretion retention and subsequent respiratory complications if not

properly managed [10]. Therefore, the introduction of a simple inhalation device that promotes mucus mobilization has meaningful implications for improving respiratory outcomes. The use of *Piper betle* as a primary herbal component further strengthens the therapeutic rationale, as it contains bioactive compounds with antimicrobial and anti-inflammatory properties that support respiratory health [11]. Herbal-based therapies have also been associated with mucolytic and soothing effects that may enhance sputum clearance and reduce airway irritation [12].

Significance of Feasibility Outcomes

The feasibility score obtained from expert validation (77.25%) indicates that the product meets acceptable standards for usability, safety, and practicality within the “feasible” category [7]. This suggests that the design has achieved functional adequacy, although refinement remains necessary. In contrast, the higher feasibility score observed in field trials (81.17%) reflects strong user acceptance among elderly participants, indicating that the device is practical and applicable in real-world settings.

Differences between expert evaluation and user perception are common in development-based research, where users tend to prioritize comfort and simplicity over technical optimization [13]. The findings of this study align with previous research emphasizing the importance of user-centered design in healthcare innovation [14]. Furthermore, feasibility values within the range of 70–85% are generally considered acceptable for early-stage medical device development [15]. Studies on herbal inhalation therapy also report favorable user responses, particularly regarding comfort and perceived symptom relief [16]. However, many of these studies lack structured evaluation frameworks, which limits their applicability in clinical settings [17]. The current study addresses this gap by integrating systematic validation within a development model.

Comparison with Previous Studies

Previous research on herbal and steam inhalation therapy has primarily focused on symptomatic relief rather than product standardization or usability assessment [6]. While traditional practices demonstrate potential therapeutic benefits, they often lack consistency in dosage, delivery method, and evaluation criteria [16]. In contrast, this study applies a structured ADDIE-based development approach, enabling systematic assessment of feasibility and usability [13].

Low-cost medical device innovation emphasizes affordability, accessibility, and adaptability, particularly in developing countries [15]. The present findings are consistent with these principles, demonstrating that simple materials can be transformed into functional therapeutic tools. The use of non-electric components further enhances applicability in low-resource settings. This is supported by studies highlighting the importance of appropriate technology in improving healthcare accessibility [18]. Additionally, integrating traditional herbal knowledge into modern therapeutic design aligns with current trends in complementary and integrative medicine [19].

Implications for Practice and Future Research

The implementation of this traditional nebulizer has potential implications for community-based and long-term care settings. Its simplicity and low cost may improve access to inhalation therapy among elderly patients while supporting caregiver involvement in respiratory management. However, the study remains limited in evaluating clinical effectiveness due to the small sample size.

Future research should include larger sample sizes and objective clinical outcome measures such as sputum volume, cough frequency, and respiratory function parameters. Further studies are also required to standardize herbal formulations, optimize device performance, and evaluate long-term safety to strengthen clinical applicability [20].

CONCLUSION

Based on research on the product design of traditional nebulizer tools as an alternative to inhalation therapy for cough patients, it can be concluded that the need for inhalation tools is very important, especially for the elderly who have only relied on oral treatment without steam intervention to help expel sputum. The results of the analysis show that tools that are practical, economical, environmentally friendly, and easy to use are needed in an environment with limited health facilities. Products designed from natural materials such as clay pots, aluminum-coated plastic hoses, and betel leaves as expectorant herbal ingredients, show good potential. The process of designing the product through the design and development stages has produced a simple yet effective tool, and received a decent assessment from experts and field participants. With the final assessment showing that this tool is feasible and very feasible to use, this traditional nebulizer tool has the potential to be an alternative inhalation therapy that is useful in helping to reduce cough and improve the effectiveness of airway clearance, especially in areas with limited modern medical technology.

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