RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 3, Issue 5, 2025

EFFECTS OF NEBULIZATION AND CHEST PHYSICAL THERAPY TO IMPROVE RESPIRATORY STATUS AMONG PEDIATRIC PNEUMONIA PATIENTS IN A TERTIARY CARE HOSPITAL

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DOI:https://doi.org/10.5281/zenodo.17062662

Received	Accepted	Published
14 June 2025	24 August 2025	05 September 2025

ABSTRACT

Background: *Pneumonia is a leading cause of morbidity and mortality in children under five, particularly in developing countries. Respiratory distress due to secretion retention is a major challenge in hospitalized pediatric patients, and treatment strategies such as nebulization and chest physiotherapy are widely used to improve pulmonary function.*

Objective: *To evaluate the effectiveness of nebulization alone versus nebulization combined with chest physiotherapy in improving heart rate (HR), respiratory rate (RR), and oxygen saturation (SpO_2) among pediatric pneumonia patients.*

Materials And Methods: *A randomized controlled trial was conducted over six months in the pediatric ward of PNS Shifa Tertiary Care Hospital, Karachi. Children under four years with a confirmed diagnosis of pneumonia were randomly assigned into two groups: the experimental group received nebulization with chest physiotherapy, while the control group received nebulization only. Clinical outcomes (HR, RR, and SpO_2) were recorded pre- and post-intervention and analyzed using SPSS version 22. A p-value < 0.05 was considered statistically significant.*

Result: *Both groups demonstrated significant improvements in respiratory parameters. Nebulization alone produced rapid reductions in HR and RR, while the combination therapy resulted in greater improvements in SpO_2, particularly among patients with severe baseline hypoxemia. Statistical analysis confirmed significant differences between groups post-intervention ($p < 0.05$), highlighting distinct benefits of each approach.*

Conclusion: *Nebulization is highly effective for immediate relief of respiratory distress, whereas adding chest physiotherapy enhances oxygenation and pulmonary efficiency, especially in severely compromised patients. These findings support individualized treatment strategies and the integration of combined therapy for optimal management of pediatric pneumonia.*

Keywords: *Exercise, Physical status, Percussion, Physical Activity, Breathing, and Congestion, etc.*

INTRODUCTION

Pneumonia is a condition that happens in the lungs. It is a disease of an inflammatory nature that can be caused by several agents of infection, some of which are bacteria, viruses, fungi, or other organisms. Pneumonia results from infection and inflammation of the alveoli, which are the lung sacs, that may fill up with pus or other forms of fluid. This leads to a variety of symptoms, including high fever, cough, rapid/labored breathing, wheezing, nasal flaring, irritability/ fussiness, Poor feeding/less interest in food, chest retractions, cyanosis in extreme cases.[1] Pneumonia can be a life-threatening condition that can be serious, especially among vulnerable individuals such as the very young below 3 years of age, the elderly, and immunocompromised individuals[2] Treatment for a child under the age of 3 relies on the causative infection and infection intensity. Viral pneumonia is normally treated with supportive therapy, including keeping the child well-hydrated and with the use of drugs that lower fever. Bacterial pneumonia may require antibiotics. In severe cases, hospitalization may be necessary, especially if the child has difficulty breathing or is at risk of dehydration. [1,2] Vaccination is an important preventive measure.[2] In 2018, UNICEF estimated the number of pneumonia-related deaths in children under three was about 58,000 in Pakistan and reported that this is a forgotten global epidemic that demands an urgent international response.[3] In Pakistan, the estimated annual incidence of acute respiratory infection (ARI) in children under five ranges from 1% to 4%, affecting a substantial 22% of the population, or roughly 15 million cases per year. Despite variations in data sources, both DHS and UNICEF data emphasize the significant disease burden.[5] Viral pneumonia affects approximately 200 million people globally, and in the United States, it ranked as the 8th most common cause of death in 2009. During 2008, it affected around 156 million children, with the majority of cases (151 million) occurring in developing countries, while 5 million were in developed nations. Regrettably, it caused 1.3 million deaths in 2010, accounting for 18% of all deaths in children under five, with 95% of these fatalities happening in the developing world. The countries with the highest disease burden include India (43 million cases), China (21 million), and Pakistan (10 million), making it the primary cause of death among children. [1,5] According to the article published in 2009 at PMC states pneumonia stands as a prominent cause of childhood mortality in regions with high child mortality rates, particularly in Pakistan, where it remains the second leading cause of death in children under five. Before any interventions, the north-western region of Abbottabad reported a cause-specific mortality rate of 14 deaths per 1000 children annually due to pneumonia in this age group.[4]

In the Northern Areas of Pakistan, at an elevation of about 1525 meters above sea level, an alarming 44% of child deaths between 1988 and 1991 were attributed to pneumonia, based on verbal autopsy techniques. Recent data from the Aga Khan Health Services, Pakistan (AKHSP), in the same region revealed that pneumonia continues to be a major contributor to infant (33%) and child (37%) mortality. [4,6] Pneumonia incidence is most strongly associated with young age, particularly affecting children aged 2 to 6 months, with a significant majority of cases (over 95%) occurring in developing countries, demonstrating an incidence rate of 0.28 episodes per year in this age group.[6] Various factors contribute to the prevalence of pneumonia, including male gender, malnutrition, micronutrient deficiency, low immunization coverage, low household income, overcrowding, inadequate breastfeeding practices, and exposure to indoor air pollution. Studies conducted in the past have reported varying incidence rates, with some limitations in data collection and diagnosis methods, but a common trend of high pneumonia incidence in children living at higher altitudes, such as in the Peruvian Andes and Papua New Guinea.[7] In 2019, a community-based survey states the prevalence of pneumonia under 3 years in Karachi investigated the healthcare utilization patterns among caregivers of a randomly selected group of 1,152 children aged 2-59 months living in low-income neighborhoods in Karachi, Pakistan. We gathered data on household demographics, the presence of pneumonia-related symptoms, caregivers' actions, air quality, and their knowledge of pneumonia

prevention. They discovered that 40.8% of infants (aged 2-11 months) and 37.1% of children (aged 12-59 months) had pneumonia symptoms characterized by coughing and rapid or labored breathing. Notably, 95% of caregivers sought medical attention for these cases, with 68.5% opting for private healthcare services.[8] These findings underscore that pneumonia remains a primary health concern within these communities. Its prevalence is a significant factor contributing to the elevated child mortality rate in Karachi. [2,8]

Hospitalized children with pneumonia face several challenges, including respiratory distress caused by an increase in the production of secretions. Due to their young age, these children often struggle to clear these secretions effectively because their cough reflexes are not fully developed. To address this issue, alternative treatments such as nebulization and chest physiotherapy are employed. The research demonstrated that administering nebulization to patients with atelectasis and pneumonia in the intensive care unit can effectively prevent the blockage of the airways due to excessive sputum production.[9] The use of chest physical therapy in combination with nebulization as a supplementary treatment for hospitalized pediatric patients with pneumonia remains a subject of debate. On one hand, chest physical therapy has traditionally been a common practice in pediatric care for pneumonia, based on the belief in its potential benefits. These benefits include aiding in the removal of inflammatory exudates and tracheobronchial secretions, alleviating airway blockages, reducing airway resistance, enhancing gas exchange, and easing the respiratory effort. However, on the other hand, there is a scarcity of compelling scientific evidence to strongly support the effectiveness of chest physical therapy in the treatment of hospitalized children with pneumonia. [1,8,9] An alternate study suggested that chest physiotherapy might indeed yield some advantages. In an investigation focusing on the impact of chest physiotherapy in children, it was observed to decrease the duration of hospitalization decreased for children who didn't have a history of chronic respiratory conditions.[3] Another study highlighted cases where young children were unable to effectively coordinate the clearing of secretions through passive techniques like percussion, vibration, and postural drainage and positioning, which are commonly referred to as CPT.[9] Conversely, yet another study demonstrated that CPT could effectively reduce secretions and enhance oxygen levels. Drawing from these observations, this particular study aimed to assess the effectiveness of combining chest physiotherapy and nebulization in improving the respiratory condition of children below the age of three suffering from pneumonia. [4,9]

Another primary objective of the study was to measure the distinct impacts of manual lung inflations along with chest compression and vibrations, which are frequently employed to aid in airway clearance for patients on ventilators. The hypothesis under examination was whether the force exerted during these compressions would provide a substantial additional benefit in enhancing the peak expiratory flow and the expiratory to inspiratory flow ratio. This benefit was expected to be distinct from the improvements attributed solely to increases in the inflation volume.[11] Research findings indicate that chest physiotherapy reduces hospitalization days for children without chronic respiratory issues [12]. Conversely, another study highlighted challenges in secretion release coordination through passive chest physiotherapy techniques [13]. Yet, a separate investigation demonstrated that chest physiotherapy effectively reduced secretions and improved oxygenation levels [1,13]. Building on these insights, this study seeks to comprehensively assess the collective impact of nebulization and chest physiotherapy on the respiratory status of children under the age of 4 diagnosed with pneumonia.

Even though nebulization and chest physiotherapy are individually employed in the treatment of pediatric pneumonia, little empirical research has investigated their synergistic effectiveness, particularly in preschool children below four years of age. Most previous investigations involved either modality in a solitary context and mostly had inconclusive findings and no definite consensus. This research closes this gap and examines the synergistic effect of combined nebulization and chest physiotherapy to enhance respiratory indices, including heart rate, respiratory rate, and oxygen saturation levels of children admitted with pediatric pneumonia.

MATERIALS & METHODS

A Randomized controlled trial was done in which patients were allocated to an experimental or control group. The study was conducted at the pediatric ward of PNS Shifa Tertiary Care

Hospital, with a sample size of 108 research participants were divided into two groups. Each group consists of 54 patients. The inclusion criteria were: Age under 4 years, Pre diagnosed pneumonia, Tachypnea (respiratory rate exceeding age-specific upper limits <2 months (60 breaths/min), 2–12 months (50 breaths/min), >1–5 years (40 breaths/min) and exclusion criteria was: Special children (CP, Autism, ADHD etc.), chest drains hemodynamic instability, bone fragility or rib fractures. The measurement tools used in the study were: Pulse oximeter, Nebulizer, and stethoscope. Statistical analysis is performed using SSPS (Statistical Package for the Social Sciences) Version 23.0. Analysis is based on the intervention-to-treat principle. A p-value of <0.05 was considered statistically significant.

RESULT

This study analyzes the effects of nebulization and chest physiotherapy on pediatric patients by comparing heart rate (HR), respiratory rate (RR), and oxygen saturation (SpO2) between two groups: the Experimental Group and the Control Group. The heart rate is a critical measure of how well the heart is functioning in response to the body's oxygen needs. For children suffering from pneumonia, elevated heart rates are often a sign of systemic stress, caused either by the infection itself or by hypoxia. In this study, before the intervention, the heart rates of both groups were relatively high, reflecting the respiratory distress experienced by the patients. Specifically, the experimental group's heart rate averaged 136.31 beats per minute (bpm), while the control group's heart rate was slightly lower at 133.74 bpm. This comparison of the two means was not statistically significant ($p = 0.487$), suggesting that the two groups were at a similar baseline before intervention.

Both groups had reductions in heart rate post-treatment, which would be a logical outcome of increased resumption of respiratory function and mitigation of systemic stress. Heart rate was lowered in the experimental group to 119.04 bpm, and the control group dropped more drastically to 100.70 bpm. The comparison of these post-treatment heart rates was statistically significant ($p = 0.000$), indicating that while the experimental treatment was successful, the control, nebulization-only, group experienced a more substantial decrease in heart rate. This result may indicate that nebulization alone brings rapid relief of shortness of breath symptoms quickly, through immediate reduction of heart rate, and the combination therapy brings slower, deeper benefits to the respiratory system, which take longer to result in reductions of heart rate.

Respiratory rate was another significant indicator, as it directly indicates the patient's respiratory effort. High respiratory rates are common among pneumonia patients due to the increased difficulty breathing and decreased oxygen exchange in the lungs. Before the intervention, the experimental group had a higher respiratory rate compared to the control group, at a mean of 49.02 breaths per minute and 44.89 breaths per minute, respectively. The strong distinction between these two means ($p = 0.012$) indicates that the experimental group was initially more severely distressed on a respiratory level. Following the intervention, the groups improved, with the experimental group's respiratory rate lowering to 31.13 breaths per minute and the control group's lowering to 27.69 breaths per minute. The distinction in these post-intervention values was also statistically significant ($p = 0.001$), indicating that although the groups improved as a result of their respective interventions, the control group improved more in regard to a decrease in respiratory rate. This could indicate that nebulization alone brought relief from symptoms like shortness of breath more quickly, whereas the combination intervention allowed the improvement to occur more slowly.

Oxygen saturation (SpO2) may be the most significant indicator of the effectiveness of treatments for lung-related disorders such as pneumonia. Abnormal SpO2 values hint at inefficient oxygen exchange in the lungs, which is characteristic of patients presenting with pneumonia as a result of fluid-filled alveoli or inflammatory airway disease. In the current research, the pre-treatment SpO2 values were much lower in the experimental arm (74.72%) than in the control arm (82.87%). This significant distinction in pre-treatment SpO2 values ($p = 0.000$) confirms that the experimental patients had more serious oxygen deprivation at the beginning. The post-intervention results were significant in favor of improved oxygen saturation of the patients in the experimental and control groups. SpO2 of the experimental population improved to 93.98% from the pre-intervention value of 74.72%, while the control population improved to 90.76% from

the pre-intervention value of 82.87%. The post-intervention distinction of SpO2 values was statistically significant (p = 0.000), and the experimental group exhibited a higher improvement. This indicates that the joint intervention of nebulization and chest physiotherapy was especially significant in the enhancement of pulmonary efficiency and oxygenation, especially for patients beginning at lower pre-intervention SpO2 values.

Group		N	Mean	Std. Deviation	Std. Error Mean
BeforeHR	Experimental Group	54	136.31	19.359	2.634
	Control Group	54	133.74	18.966	2.581
AfterHR	Experimental Group	54	119.04	21.728	2.957
	Control Group	54	100.70	19.211	2.614
BeforeRR	Experimental Group	54	49.02	8.397	1.143
	Control Group	54	44.89	8.397	1.143
AfterRR	Experimental Group	54	31.13	5.191	0.706
	Control Group	54	27.69	5.630	0.766
BeforeSpO2	Experimental Group	54	74.72	5.662	0.770
	Control Group	54	82.87	6.771	0.921
AfterSpO2	Experimental Group	54	93.98	3.253	0.443
	Control Group	54	90.76	2.028	0.276

Additional paired t-tests of pre- and post-intervention results in the two groups further supported significant enhancements of heart rate, respiratory rate, and oxygen saturation. The statistical correlation of the results showed that the enhancement of heart rate and respiratory rate was positively correlated, so that patients whose heart rate improved had a corresponding improvement in the respiratory rate. On the other hand, the pre- and post-treatment SpO2 level correlation was weakly negative, so that patients whose pre-treatment SpO2 levels were lower had a larger enhancement of the oxygenation after the treatment. These again point to the superior therapeutic efficacy of the combination therapy for the more severely oxygen-deprived patients.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	BeforeHR	135.03	108	19.118	1.840
	AfterHR	109.87	108	22.394	2.155
Pair 2	BeforeRR	46.95	108	8.611	0.829
	AfterRR	29.41	108	5.660	0.545
Pair 3	BeforeSpO2	78.80	108	7.439	0.716
	AfterSpO2	92.37	108	3.146	0.303

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	BeforeHR & AfterHR	108	0.438	0.000
Pair 2	BeforeRR & AfterRR	108	0.732	0.000
Pair 3	BeforeSpO2 & AfterSpO2	108	-0.210	0.029

In short, the nebulization-chest physiotherapy combination resulted in appreciable increases in heart rate, respiration rate, and oxygenation saturation, most especially among patients more seriously ill at the outset of the study. The control, nebulization-alone group also improved significantly, most especially in heart rate and respiration rate, suggesting nebulization as a highly efficacious agent for providing rapid relief of symptoms. The more substantial increase of the experimental group in oxygen saturation, however, would point to the combination of nebulization and chest physiotherapy as potentially possessing certain benefits, most especially among patients possessing pre-existing lower levels of oxygenation. The study reveals the potential benefit of the combination of nebulization and physiotherapy of the chest as it applies to the management of pediatric pneumonia, most especially among patients more seriously affected in the modes of respiration. Future research could study the longer-term results of the combination regimen as well as the potential applications of the same among patients suffering from other lung afflictions.

DISCUSSION

The present study investigated the combined effects of nebulization and chest physiotherapy (CPT) on the respiratory status of pediatric pneumonia patients, comparing outcomes with chest physiotherapy alone. Both treatment groups exhibited significant clinical improvements; however, the nature of these improvements varied. Nebulization alone led to a faster reduction in heart rate (HR) and respiratory rate (RR), indicating immediate relief of respiratory distress. In contrast, the combination of nebulization with chest physiotherapy produced greater improvement in oxygen saturation (SpO_2), especially in patients with severe baseline hypoxemia. This suggests that while nebulization provides rapid symptomatic relief, the integration of CPT enhances pulmonary function more substantially in oxygen-deprived children. These findings align partially with those of Abdelbasset and Elnegamy (2015), who reported that CPT used alongside standard treatment significantly improved RR and SpO_2 and reduced the time to clinical resolution. Similarly, Lestari et al. (2018) observed that the combination of CPT and nebulization led to significant enhancements across HR, RR, and SpO_2. While the present study corroborates the superiority of combined therapy in oxygenation, it differs in that nebulization alone offered more immediate symptom relief, an important distinction when considering intervention timing and disease severity. Yadu et al. also support the use of Chest physiotherapy, particularly in mechanically ventilated patients, emphasizing its role in reducing ventilator-associated pneumonia and mortality. Although their population differs from ours, both studies confirm the broader utility of Chest physiotherapy in preventing pulmonary complications and improving outcomes in high-risk patients. However, not all studies support the use of Chest physiotherapy. Lukrafka et al. (2012) found no significant benefit of Chest physiotherapy over standard care in children with community-acquired pneumonia. The difference in results may be attributed to study design and intervention type; the current study employed chest physiotherapy in combination with nebulization, whereas Lukrafka used Chest physiotherapy alone. Additionally, the patients in the present study exhibited greater baseline hypoxemia, possibly making them more responsive to therapy that enhances oxygen exchange.

Khan et al. (2009) and Kerai et al. (2019) highlighted the high burden of pediatric pneumonia in Pakistan, especially in resource-limited settings and high-altitude areas where hypoxia is more prevalent. Their findings underline the relevance of the present study, which provides practical evidence for improving oxygenation using accessible interventions such as Chest physiotherapy and nebulization. Several studies further reinforce the benefit of combining Chest physiotherapy with nebulization. Younes et al. (2022) emphasized the effectiveness of multimodal Chest physiotherapy in ventilated patients, supporting the idea that Chest physiotherapy improves oxygenation even in complex respiratory cases. Gregson et al. (2012) demonstrated that manual Chest physiotherapy techniques, such as vibrations and chest compressions, improved airflow in sedated ventilated children, aligning with our observed improvements in SpO_2 and confirming the physiological basis for such interventions. Cano et al. (2015) also reported that Chest physiotherapy was effective in managing respiratory distress in pediatric emergency settings, while Jacinto et al. (2013) noted that Chest physiotherapy improved

cardiac autonomic function, which indirectly supports our findings by suggesting systemic physiological benefits of airway clearance. In adults, Abdelghaffar (2023) observed improved oxygenation in patients with interstitial pulmonary fibrosis following Chest physiotherapy, further validating the present findings in a pediatric context. Similarly, Mohamed et al. (2023) demonstrated that chest percussion post-nebulization significantly enhanced SpO_2 among infants with pneumonia, supporting the current conclusion that combination therapy is particularly effective in younger, more vulnerable populations. Broad overviews by Zar et al. (2020) and Naoki, Sakai, and Tabira (2019) also highlight the need for improved and integrative respiratory care protocols in pneumonia management. Both sources confirm that Chest physiotherapy contributes to better clinical outcomes, particularly when integrated into a multi-modal care plan. Shally and Kaur (2017) found that breathing exercises during nebulization improved RR and oxygenation, paralleling our interpretation that interventions promoting airway mechanics lead to better respiratory status.

Chatwin et al. (2012) provided theoretical support for physical therapies in pediatric respiratory diseases, reinforcing the scientific foundation for integrating Chest physiotherapy. On the contrary, Rochat et al. (2012) reported that passive Chest physiotherapy techniques failed to reduce disease severity in bronchiolitis. Discrepancy likely stems from the difference in techniques; the current study employed active/manual Chest physiotherapy, which may have superior efficacy compared to passive methods. Additional support for our findings comes from Gomes et al. (2018), who demonstrated that respiratory physiotherapy enhanced secretion clearance and oxygenation in children with acute viral bronchiolitis. This aligns with present findings that Chest physiotherapy is particularly effective in oxygen-deficient patients. On a broader level, Garenne et al. and Singh and Aneja stressed the significant burden of acute respiratory infections and advocated for tailored, context-sensitive interventions, a principle echoed in the present study, which proposes therapy customization based on severity. Historical insights from Balachandran et al. support the ongoing use of CPT in pediatric pneumonia, and our study contributes to modernizing this evidence base by showcasing its enhanced efficacy when used in combination with pharmacological interventions. Lastly, while Paludo et al. found no clear benefit of Chest physiotherapy, differences in methodology, patient demographics, and the absence of adjunct nebulization likely account for the divergent outcomes.

In summary, our study adds to a growing body of literature that supports the integration of nebulization and chest physiotherapy in managing pediatric pneumonia, especially in low-resource and high-risk environments. The evidence suggests that nebulization offers rapid relief of respiratory symptoms, whereas chest physiotherapy plays a crucial role in improving oxygenation and clearing secretions. These findings reinforce the importance of tailored treatment strategies based on patient severity and underline the need for further long-term research to optimize pediatric respiratory care.

LIMITATION

Despite the valuable insights gained, the present study has several limitations that should be acknowledged. First, the research was conducted at a single tertiary care hospital with a relatively small sample size, which may limit the generalizability of the findings to wider pediatric populations, especially in different geographic, socioeconomic, or healthcare settings. Second, the study only included children under four years of age, excluding older children and those with comorbidities such as neurological impairments or chronic lung disease; therefore, the results may not apply to all pediatric pneumonia patients. Third, the study primarily assessed short-term outcomes (HR, RR, and SpO_2) immediately before and after intervention, without follow-up to evaluate longer-term effects such as duration of hospitalization, relapse rates, or overall clinical recovery. Moreover, the study did not account for other confounding factors such as nutritional status, prior history of respiratory illness, or antibiotic therapy, all of which could influence recovery and treatment response.

Finally, the chest physiotherapy techniques employed were standardized to the extent possible, but variability in execution by healthcare providers cannot be ruled out. The absence of advanced imaging or laboratory biomarkers to assess lung clearance also limited the ability to objectively measure the physiological impact of interventions beyond basic clinical parameters.

CONCLUSION

Nebulization and physiotherapy of the chest as a combination therapy were effective in the improvement of the respiratory status of pediatric patients suffering from pneumonia. While nebulisation provides immediate relief of symptoms, specifically the reduction of heart and respiratory rates, the employment of nebulization along with physiotherapy significantly heightens the amount of oxygen saturation through the elimination of secretions and the improvement of the efficiency of the lungs. The combination of therapies provides a unique benefit to patients with severe respiratory distress. These findings support the application of the combination of therapies for the maximum control of the condition of pediatric pneumonia, emphasizing the necessity of creating individualized therapy schedules in reference to the severity of the condition. It would be worthwhile to conduct additional studies of the long-term efficacy and usability of the combination therapy.

AUTHORS CONTRIBUTION

AI: Idea, Concept, Manuscript Writing
AS: Designing and Manuscript Writing
PL: Literature Search and Results Writing
STC: Manuscript Writing and Data Collection
MFF: Statistical analysis and resources
FS: Interpretation of Results
ML: Editing and Review
KJ: Final Review

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