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Non-ICU mortality and hospital stay comparison among Indian patients: The effects of modified pulmonary rehabilitation with supervised hydration, structured exercise and proper nutrition

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Abstract:
Modified pulmonary rehabilitation (MPR) incorporates fluid maintenance, appropriate exercise regimens and improved nutrition, which may enhance outcomes for respondents. Hence, 136 subjects were fractionated into 2 groups: group A (MPR) and group B (controls), with 68 respondents in each group. The mortality rate during hospitalisation in MPR was lower than in controls (5.9% vs 19.1%, p = 0.020), corresponding to a 69% relative risk reduction (RR = 0.31; 95% CI: 0.11–0.86). The inpatient duration was lower in MPR than in controls (p<0.001). The MPR group exhibits substantially higher functional rehabilitation, with heightened responses in 6-minute walk distance, handgrip strength and serum albumin concentrations (p<0.001). Thus, data shows that MPR approach should be integrated into inpatient respiratory units in hospital settings.

Keywords: Mortality, pulmonary disease, pulmonary rehabilitation, hospitalisation, nutrition, exercise

Background:
The cardinal source of morbidity, mortality and protracted inpatient stay is pulmonary disorders globally **[1]**. Chronic obstructive pulmonary disease (COPD), bronchiectasis and repetitive pneumonic infections are the chronic respiratory diseases that customarily result in acute exacerbation, entailing hospitalisation **[2]**. The treatment of intensely diseased subjects is a requisite in intensive care units (ICUs) and few patients with respiratory illnesses are admitted in non-ICU settings, where mortality and untimely recuperation still pose substantial challenges. The subjects endure lengthy hospitalisations, physical rehabilitation, nutritional deficits, electrolyte disparity, wasting of muscles and enhanced probability of early readmission, augmenting long-term results and boosting healthcare costs **[3]**. The admission of respiratory cases in hospitals is an important factor for the contracting function. The cardiopulmonary function is hindered due to bed rest, nutritional decline and limited hydration and wasting of muscle. These difficulties reduce exercise tolerance, resulting in prolonged recovery and recurrent hospital stays. The non-ICU hospitalised pulmonary subjects often evolve functional impediment, contrasting to ICU survivors, if early rehabilitation strategies are not integrated, as discovered in various research **[4, 5]**. Modified pulmonary rehabilitation (MPR) is a validated approach that helps patients with respiratory illness improves function and survival. The integration of MPR at the beginning of the inpatient stay accelerates recovery, shortens hospital length of stay and reduces mortality, as shown by various studies **[6, 7]**. Pulmonary rehabilitation (PR) is a key component of the management of respiratory illness, as outlined by the American Thoracic Society and the European Respiratory Society **[8]**. The usual PR is not adequately useful in hospital settings where the resources are limited. It has been observed that the rehabilitation approach focuses solely on exercise while overlooking vital elements of recuperation, such as hydration, electrolyte balance and nutritional status. Loss of fluids and decreased albumin are the most typical respiratory illnesses during inpatient stay and are linked with poor outcomes, prolonged healing of wounds, diminished muscle mass and greater mortality **[9, 10]**. Therefore, it is of interest to assess the impact of modified pulmonary rehabilitation with adequate hydration, scheduled exercise and proper nutrition on the functional outcomes of Non-ICU patients.

Materials and Methods:
This is a prospective comparative survey conducted on 136 respondents. Respondents with illnesses that do not require ICU admission, aged over 18 years and haemodynamically stable were included in the present research survey. The respondents having serious illness (like pneumonia, bronchiectasis or COPD exacerbation) requiring ICU admission, having any kind of behaviour impediment, unstable haemodynamically or enteral feeding and performing exercise were the exclusions of the present investigative survey. The required sample size was calculated by assessing the effect of an organised pulmonary rehabilitation strategy on mortality and inpatient length of stay among non-ICU hospitalised cases **[6, 7]**. The primary outputs were inpatient mortality and duration (in days). The size of the respondents according to the inpatient duration (2-sample mean comparison), formula is

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$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times 2\sigma^2}{d^2}$$

Previous investigations found that the mean inpatient duration (in days) was 6.0 ± 2.5 in the intervention arm, whilst 8.2 ± 3.0 in the control arm; the sample size was 25 respondents per group. A two-proportion comparison was utilised to establish the size of respondents on inpatient mortality using the equation as follows

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times [p_1(1-p_1) + p_2(1-p_2)]}{(p_1 - p_2)^2}$$

The mortality was 20% in the control arm and 8% in the intervention arm, as reported in previous research. The value of N was 127 in each group. So, we conducted our research on inpatient mortality, using a 10% dropout rate, resulting in the current survey of 136 respondents. All respondents were divided into 2 groups: group A (intervention group, MPR), comprising 68 respondents and group B (control arm), comprising 68 respondents.

The data were obtained from the respondents according to the following parameters:

[1] Demographic details like age, gender, BMI and smoking status
[2] Inpatient duration, mortality and readmissions
[3] Co-morbid conditions like the Charlson co-morbidity index, or certain conditions like diabetes, cardiovascular disorder and the seriousness of pulmonary disorder
[4] Exercise regimens, Volume of fluids to maintain hydration, diet (especially protein intake and calorie intake)
[5] Techniques like handgrip and scoring of difficulty in breathing
[6] The concentration of electrolytes and their ill effects
[7] The nature of discharge and transportation to the ICU

Ethical considerations:

Every respondent provided informed consent to participate in the present research. Our survey follows the Helsinki Declaration. Every protective strategy was adopted to safeguard the respondent's data. An institutional ethics committee provides ethical clearance for the conduct of the current research.

Statistical analysis:

All data obtained from the respondents were analysed using various statistical formulas in SPSS. A multivariate regression model was employed to analyse the primary outputs in the present research. Cohen's analysis, Kaplan-Meier analysis and the log-rank test were utilised in the current survey.

Results:

There was no substantial disparity noted between the two groups with respect to age, gender, BMI, smoking status, Charlson index and difficulty breathing, with p-values of 0.68, 0.72, 0.61, 0.72, 0.48 and 0.56, respectively. The inpatient mortality rate in the MPR group was 4 (5.9%) and in the control group, 13 (19.1%). The value χ^2 equals 5.37 with a P value of 0.020. Relative risk (RR) is 0.31 (95% CI: 0.11-0.86), indicating a 69% lower mortality with the intervention provided to respondents. The inpatient duration (in days) in the MPR group was 6.3 ± 2.1 and in the control group, it was 9.4 ± 3.0, with $p < 0.001$ indicating a significant difference between groups. Cohen's d equals 1.18, exhibiting a large effect size **(Table 1).** The Kaplan-Meier survival curve exhibited substantially better survival in the MPR group. Long-rank test: $\chi^2 = 6.11$, $p = 0.013$. The survival analysis shows that Cox Regression: HR = 0.28 (95% CI: 0.09–0.84), p = 0.023. The proposed organised exercise, maintenance of fluid status and nutritional status were associated with higher survival rates, even in non-ICU-admitted cases. MPR cases exhibit a higher recovery rate and shorter inpatient duration. The multivariate regression analysis revealed that survival benefit is independent of baseline characteristics, thereby identifying the effective MPR strategy. The MPR group showed post-discharge benefits, with early recovery and improved outcomes. The secondary outcomes showed the following results. 6-minute walk test: It was associated with improved cardiopulmonary and muscle performance. Handgrip strength showed decreased muscle wasting during inpatient status. Serum Albumin was associated with metabolic recovery. 30-day readmission was lower, sustaining post-discharge stability.

Table 1: Depicts the multivariate logistic regression analysis, linear regression for primary outputs and secondary outputs

Logistic Regression analysis for Mortality inpatient - primary output			
Predictor	Adjusted OR	95% CI	P
Modified PR intervention	0.24	0.08–0.71	0.010
Age	1.03	0.99–1.07	0.11
Charlson Index	1.36	1.02–1.82	0.034
BMI	0.92	0.85–1.01	0.08
Linear Regression for inpatient duration – primary output			
Predictor	β (days)	95% CI	P
Modified PR	–2.87	–3.76 to –1.98	<0.001
Age	+0.04	–0.01 to 0.09	0.10
Charlson index	+0.63	0.31–0.95	<0.001
Secondary outcomes			
Outcome	MPR	Control	P-value
Δ6-Minute Walk Test (m)	+71.6 ± 28.4	+21.9 ± 18.3	<0.001
Handgrip Strength (kg)	+6.1 ± 2.7	+1.8 ± 1.9	<0.001
Serum Albumin (g/dL)	+0.62 ± 0.29	+0.18 ± 0.24	<0.001
30-day Readmission (%)	7.4%	20.6%	0.031

Discussion:

The current research found that an organised MPR approach during the inpatient stay, with team-based working, substantially improves clinical outcomes in non-ICU hospitalised pulmonary cases. The MPR group shows a 69% lower mortality rate among inpatients, a shorter inpatient stay with a mean of approximately 3 days, better functional recovery, better nutritional status and substantially lower 30-day readmission rates compared with the control group. The present research shows a lower mortality rate in the MPR group (5.9%) compared with the control group (19.1%). MPR was identified

as a strong independent predictor of survival, even after controlling for age, BMI and the Charlson comorbidity index. Mao *et al.* reported findings consistent with those of the present survey **[6]**. Asati *et al* uncovered 20% rate of mortality in hospitalised COPD cases **[11].** The survival benefit observed in the present research is due to the combined effects of exercise, adequate fluid intake and good nutritional support. Exercise reduces breathing difficulties, augments muscle strength and improves oxygen utilisation. The maintenance of fluids helps move mucociliary secretions, reduces viscosity and balances electrolytes, thereby diminishing the risk of respiratory failure **[11, 12]**. In the present survey, we found that inpatient stay was lower in the MPR group, with a large effect size (Cohen's d = 1.18) and these outcomes are similar to those reported by Zhu *et al.* **[7]**. Extended inpatient stay is linked with the probability of hospital-based infection, wasting of muscles, psychological stress and risk of occurrence of thromboembolism. It was found that 6-minute walk distance and handgrip strength were better in the MPR group than in the control group, resulting in improved survival and quality of life **[8]**. Arnold *et al.* reported better functional recovery and fewer readmissions among patients treated with MPR **[10]**. There was a significant improvement in the values of albumin in the MPR group, which is a known cause of extended inpatient stay, rate of mortality resulting in poor prognosis **[9]**. The 30- day readmission rate was significantly lower in the MPR group; approximately 3 times lower than in controls. Similar observations were achieved in various researches with organised PR **[6, 12]**. The results of this study are corroborated by the prevailing knowledge that pulmonary rehabilitation is a multidisciplinary approach and should encompass more than just exercise training. The ATS/ERS statement defines pulmonary rehabilitation as a multifaceted strategy encompassing exercise training, education, behavioral modification and long-term adherence methods for individuals with chronic respiratory conditions **[13, 14]**. Nonetheless, the evidence concerning very early inpatient rehabilitation has not been entirely consistent. Greening *et al.* indicated that early rehabilitation while hospital admission for exacerbation of chronic respiratory disease did not decrease readmission rates or enhance long-term functional recovery, underscoring the necessity for meticulous patient selection, oversight and suitable intervention intensity **[15]**. Conversely, Ryrsø *et al.* conducted a comprehensive review and meta-analysis that indicated reduced mortality following supervised early pulmonary rehabilitation commenced during or shortly after hospitalization for COPD exacerbation **[16]**. Lindenauer *et al.* similarly noted that commencing pulmonary rehabilitation within 90 days post-COPD hospitalization correlated with improved 1-year survival, underscoring the significance of ongoing rehabilitation after release **[17]**. The positive results noted in this study may possibly be attributed to the enhanced emphasis on nutritional support and hydration. Nutritional supplementation has demonstrated enhancement in functional outcomes, body weight and grip strength in individuals with COPD **[18]**. Airway hydration is biologically significant as dehydration of airway secretions elevates mucus viscosity and hinders mucociliary clearance, thereby exacerbating respiratory symptoms and recovery. The modified pulmonary rehabilitation technique employed in this study is therapeutically significant since it integrates supervised exercise, dietary optimization and hydration monitoring within a feasible inpatient framework **[19]**. This prospective research uncovered that MPR must be utilised at the beginning of the inpatient stay. The benefit of survival does not align with the demographic characteristics and comorbid conditions of the subjects, thereby augmenting the utilisation of interventions, which is crucial for the management of respiratory illnesses. This prospective analysis was conducted at a single centre, limiting its generalizability. Extended follow-ups were not assessed.

Conclusion:

MPR substantially improved outcomes in non-ICU hospitalised patients. The MPR exhibits low inpatient mortality, shorter inpatient stays, improved functional recovery, better nutrition and fewer early readmissions. These observations reinforce the applicability of MPR as a standard approach in inpatient respiratory cases to improve survival outcomes.

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