International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

*Original Researcher Article* *DOI: 10.61336/im/26-06-05*

# Predictors of Post-ICU Quality of Life: Impact of Age, Length of Stay, and Mechanical Ventilation Duration.

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**Received:** **24-04-2026**
**Revised:** **06-05-2026**
**Accepted:** **18-05-2026**
**Published:** **04-06-2026**

## Abstract

***Background:*** Survival following critical illness is increasingly common, yet many ICU survivors experience prolonged deterioration in health-related quality of life (HRQoL). Identifying patient- and ICU-related predictors of post-ICU HRQoL is essential for targeted follow-up and rehabilitation planning. We examined the impact of age, ICU length of stay (LOS), and duration of mechanical ventilation (DOMV) on HRQoL at twelve months after ICU discharge. ***Methods:*** This prospective observational cohort study was conducted at a tertiary care ICU in Varanasi, India from May 2016 to May 2017. A total of 100 adult patients with ICU stay >7 days who were discharged alive were enrolled. HRQoL was assessed using the SF-36 health survey at baseline (pre-ICU, 4-week recall by next-of-kin) and at 12 months post-discharge. Pearson correlation and independent-sample t-tests were used for statistical analysis. ***Results:*** Mean age was 40.62±11.99 years; 60% were male. Mean ICU LOS was 13.64±3.75 days and mean DOMV was 7.93±3.89 days. All eight SF-36 domains, the Physical Component Summary (PCS: 55.12±3.51 to 47.93±4.60) and Mental Component Summary (MCS: 55.09±3.49 to 37.46±7.42) declined significantly at 12 months ($p<0.001$ for all). Age correlated strongly with PCS ($r=-0.593$, $p<0.0001$) and MCS ($r=-0.536$, $p<0.0001$). Patients aged >50 years had significantly lower scores in all SF-36 domains except bodily pain. DOMV correlated significantly with MCS ($r=-0.157$, $p<0.0001$) and physical functioning (PF: $r=-0.279$, $p<0.005$). ICU LOS showed a modest correlation with PF only ($r=-0.237$, $p=0.018$) and no significant group differences at the 14-day cutoff. Gender did not influence overall PCS or MCS. ***Conclusion:*** Age is the strongest independent predictor of post-ICU HRQoL impairment, affecting both physical and mental domains. Mechanical ventilation duration primarily predicts mental health deterioration, while ICU LOS has only a modest influence on physical functioning. These findings support stratified, age-sensitive follow-up programs for ICU survivors, with particular attention to mechanically ventilated patients.

**Keywords:** health-related quality of life; intensive care unit; SF-36; mechanical ventilation; length of stay; ICU survivors.



## INTRODUCTION

Advances in critical care medicine over the past two decades have substantially reduced ICU mortality, resulting in a growing population of survivors of critical illness. [1,2] However, survival alone is no longer an adequate measure of intensive care outcome. Survivors frequently endure a constellation of physical, psychological, and cognitive sequelae collectively termed post-intensive care syndrome (PICS), which can persist for months to years after hospital discharge. [3]

Health-related quality of life (HRQoL) has therefore emerged as a key outcome metric in critical care research. Studies consistently demonstrate that HRQoL among ICU survivors is significantly lower than both pre-illness baselines and age-matched general population norms, particularly in the domains of physical functioning, vitality, and social functioning. [4,5] The rate and extent of HRQoL recovery vary widely, with physical function often recovering more than mental health by twelve months. [6]

Among the factors proposed to influence post-ICU HRQoL, three have received substantial but inconsistent attention: patient age, ICU length of stay (LOS), and duration of mechanical ventilation (DOMV). Older age has been associated

with poorer physical functioning and general health perceptions in several large cohorts. [7,8] Prolonged ICU stay has been linked with reduced HRQoL in some studies but not others, with the threshold and direction of effect remaining poorly defined. [9,10] Mechanical ventilation, particularly when prolonged, is thought to contribute to ICU-acquired weakness, deconditioning, and psychological sequelae including post-traumatic stress disorder (PTSD), all of which impair HRQoL. [11,12]

Data from the Indian subcontinent on long-term post-ICU outcomes are sparse, despite the high burden of critical illness and limited rehabilitation infrastructure in this setting. The present study aimed to quantify HRQoL changes over twelve months following ICU discharge in a tertiary care centre in northern India, and specifically to examine the independent contributions of age, ICU LOS, and DOMV to HRQoL impairment.

## MATERIALS AND METHODS

### Study Design and Setting

This was a single-centre, prospective observational cohort study conducted in the Intensive Care Unit of Sir Sunder Lal Hospital (SS Hospital), Banaras Hindu University (BHU), Varanasi, India. The study was conducted between May 2016 and May 2017.

### Participants

Adults aged 18–70 years admitted to the ICU for more than 7 days and discharged alive were eligible. Written informed consent was obtained from all participants or their legally authorised representatives. Patients were excluded if they had an ICU stay of ≤7 days; were aged <18 or >70 years; refused participation; could not be contacted at follow-up; were discharged for palliative or terminal care; or had a pre-existing neurological or psychiatric diagnosis.

### Sample Size

Sample size was calculated based on the Physical Component Summary (PCS) score of SF-36. Assuming a clinically meaningful difference in mean PCS of 7.75 (55.12 vs. 47.34) between pre-ICU and 12-month status, with $\alpha$=0.05 and power=80%, a minimum of 75 patients was required. To account for an estimated 20% loss to follow-up, 100 patients were enrolled.

### Data Collection

At ICU discharge, detailed demographic and clinical data were recorded, including age, sex, primary diagnosis, ICU length of stay (days), and duration of mechanical ventilation (DOMV, days). Baseline HRQoL (reflecting the 4-week pre-illness period) was assessed by interviewing next-of-kin or the patient at the time of discharge using the SF-36 questionnaire. Patients were followed up at 12 months post-discharge using postal questionnaires and telephonic communication for non-responders.

### HRQoL Instrument

HRQoL was assessed using the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36), which measures eight domains: Physical Functioning (PF), Role Physical (RP), Bodily Pain (BP), General Health (GH), Vitality (VT), Social Functioning (SF_d), Role Emotional (RE), and Mental Health (MH). Norm-based scoring (NBS) was applied, with 50 representing the population mean and each 10-point difference representing one standard deviation. The four physical domains (PF, RP, BP, GH) are aggregated into the Physical Component Summary (PCS) score and the four mental domains (VT, SF_d, RE, MH) into the Mental Component Summary (MCS) score. Higher scores indicate better HRQoL.

### Statistical Analysis

Data were analysed using SPSS version 20.0. Continuous variables are presented as mean ± standard deviation (SD). Pre-ICU and 12-month HRQoL scores were compared using the paired Student's t-test. Subgroup comparisons (age <50 vs. ≥50 years; ICU LOS <14 vs. ≥14 days; DOMV <7 vs. ≥7 days; male vs. female) were performed using the independent-sample t-test. The Pearson correlation coefficient (r) was used to quantify linear associations between continuous predictors (age, ICU LOS, DOMV) and SF-36 domain scores at 12 months. A p-value <0.05 was considered statistically significant.

### Ethical Approval

The study was approved by the Institutional Ethics Committee of the Institute of Medical Sciences, Banaras Hindu University, Varanasi. Written informed consent was obtained from all participants or their authorised representatives prior to enrolment.

## RESULTS

### Patient Characteristics

One hundred patients meeting the eligibility criteria were enrolled. The mean age was 40.62±11.99 years. Sixty patients (60%) were male. Mean ICU LOS was 13.64±3.75 days and mean DOMV was 7.93±3.89 days. The most common primary diagnoses were community-acquired pneumonia (24%), acute febrile illness (20%), sepsis with septic shock (16%), acute liver failure (12%), and subacute pancreatitis (12%), with myocarditis and exacerbation of chronic obstructive pulmonary disease each accounting for 8% of admissions (Table 1).

**Table 1: Baseline Demographic and Clinical Characteristics (N=100)**

| **Characteristic** | **Value** |
|---|---|
| Age, years (mean ± SD) | 40.62 ± 11.99 |
| Sex: Male, n (%) | 60 (60.0%) |
| Sex: Female, n (%) | 40 (40.0%) |
| ICU length of stay, days (mean ± SD) | 13.64 ± 3.75 |
| Duration of mechanical ventilation, days (mean ± SD) | 7.93 ± 3.89 |
| **Primary Diagnosis** | **n (%)** |
| Community-acquired pneumonia | 24 (24.0%) |
| Acute febrile illness | 20 (20.0%) |
| Sepsis with septic shock | 16 (16.0%) |
| Acute liver failure | 12 (12.0%) |
| Subacute pancreatitis | 12 (12.0%) |
| Myocarditis | 8 (8.0%) |
| Exacerbation of COPD | 8 (8.0%) |

**SD: standard deviation; ICU: intensive care unit; COPD: chronic obstructive pulmonary disease.**

### HRQoL at Baseline and at 12 Months

All eight SF-36 domains showed significant decline from pre-ICU baseline to 12 months post-discharge ($p<0.001$ for all). The PCS declined from 55.12±3.51 to 47.93±4.60 ($p<0.001$), and the MCS declined more markedly from 55.09±3.49 to 37.46±7.42 ($p<0.001$). The greatest absolute decline was seen in Role Physical (RP: 55.41 to 40.99), Social Functioning (SF_d: 54.23 to 36.78), Role Emotional (RE: 55.26 to 41.13), and Vitality (VT: 57.29 to 40.42). Full domain scores are presented in Table 2.

**Table 2: SF-36 Norm-Based Scores at Pre-ICU Baseline and 12 Months Post-Discharge (N=100)**

| **SF-36 Domain / Score** | **Pre-ICU (Mean ± SD)** | **12 Months (Mean ± SD)** | **p-Value** |
|---|---|---|---|
| Physical Functioning (PF) | 56.54 ± 1.81 | 49.39 ± 3.66 | <0.001 |
| Role Physical (RP) | 55.41 ± 2.87 | 40.99 ± 6.24 | <0.001 |
| Bodily Pain (BP) | 60.97 ± 3.58 | 56.81 ± 8.47 | <0.001 |
| General Health (GH) | 46.89 ± 8.74 | 33.88 ± 7.24 | <0.001 |
| Vitality (VT) | 57.29 ± 4.85 | 40.42 ± 7.56 | <0.001 |
| Social Functioning (SF) | 54.23 ± 4.82 | 36.78 ± 7.62 | <0.001 |
| Role Emotional (RE) | 55.26 ± 1.83 | 41.13 ± 6.69 | <0.001 |
| Mental Health (MH) | 56.47 ± 3.83 | 42.34 ± 7.24 | <0.001 |
| **Physical Component Summary (PCS)** | **55.12 ± 3.51** | **47.93 ± 4.60** | **<0.001** |
| **Mental Component Summary (MCS)** | **55.09 ± 3.49** | **37.46 ± 7.42** | **<0.001** |

**All values are norm-based scores (population mean = 50; SD = 10). Paired t-test used for comparison.**

### Correlation of Age, ICU LOS, and DOMV with Post-ICU HRQoL

Pearson correlation analysis demonstrated that age was the strongest predictor of HRQoL at 12 months (Table 3). Age correlated significantly with PCS ($r=-0.593$, $p<0.0001$) and MCS ($r=-0.536$, $p<0.0001$), as well as with PF ($r=-0.689$), RP ($r=-0.661$), GH ($r=-0.576$), VT ($r=-0.535$), SF_d ($r=-0.572$), RE ($r=-0.509$), and MH ($r=-0.476$) – all at $p<0.0001$. The only domain for which age did not reach statistical significance was BP ($r=-0.185$, $p=0.07$).

ICU LOS showed a modest but statistically significant negative correlation with PF (r=−0.237, p=0.018) but was not significantly correlated with any other domain, PCS, or MCS. DOMV correlated significantly with PF (r=−0.279, p<0.005), RP (r=−0.197, p<0.05), VT (r=−0.269, p<0.007), and MCS (r=−0.157, p<0.0001),
but not with PCS (r=−0.138, p=0.17).

**Table 3: Pearson Correlation of Age, ICU LOS, and DOMV with SF-36 Scores at 12 Months**

| SF-36 Domain | Age r | Age p | ICU LOS r | ICU LOS p | DOMV r | DOMV p |
|---|---|---|---|---|---|---|
| PF | −0.689 | <0.0001 | −0.237 | 0.018* | −0.279 | <0.005* |
| RP | −0.661 | <0.0001 | −0.090 | 0.33 | −0.197 | <0.05* |
| BP | −0.185 | 0.07 | −0.037 | 0.71 | −0.115 | 0.25 |
| GH | −0.576 | <0.0001 | −0.097 | 0.33 | −0.177 | 0.08 |
| VT | −0.535 | <0.0001 | −0.200 | 0.05 | −0.269 | <0.007* |
| SF | −0.572 | <0.0001 | −0.093 | 0.36 | −0.175 | 0.08 |
| RE | −0.509 | <0.0001 | −0.043 | 0.67 | −0.018 | 0.86 |
| MH | −0.476 | <0.0001 | −0.083 | 0.41 | −0.167 | 0.10 |
| **PCS** | **−0.593** | **<0.0001** | **−0.151** | 0.13 | −0.138 | 0.17 |
| **MCS** | **−0.536** | **<0.0001** | −0.088 | 0.38 | **−0.157** | **<0.0001*** |

*** Statistically significant (p<0.05). PF: Physical Functioning; RP: Role Physical; BP: Bodily Pain; GH: General Health; VT: Vitality; SF: Social Functioning; RE: Role Emotional; MH: Mental Health; PCS: Physical Component Summary; MCS: Mental Component Summary; ICU LOS: ICU length of stay; DOMV: duration of mechanical ventilation.**

**HRQoL by Age Group**

Patients were grouped into those aged <50 years (n=66) and those aged ≥50 years (n=34). At 12 months, those aged ≥50 years had significantly lower scores in all SF-36 domains except bodily pain (Table 4). The PCS was 49.61±4.27 in the younger group vs. 44.68±3.31 in the older group (p<0.0001), and MCS was 40.40±6.86 vs. 31.76±4.65 (p<0.0001).

| SF-36 Score | <50 years (n=66) Mean ± SD | ≥50 years (n=34) Mean ± SD | p-Value |
|---|---|---|---|
| PF | 51.04 ± 3.00 | 46.17 ± 2.54 | <0.0001 |
| RP | 43.89 ± 5.47 | 35.36 ± 2.90 | <0.0001 |
| BP | 57.70 ± 8.43 | 55.07 ± 8.39 | 0.14 |
| GH | 36.54 ± 7.35 | 28.71 ± 3.05 | <0.0001 |
| VT | 43.14 ± 7.75 | 35.12 ± 3.08 | <0.0001 |
| SF | 39.87 ± 6.48 | 30.80 ± 5.99 | <0.0001 |
| RE | 43.61 ± 5.92 | 36.30 ± 5.39 | <0.0001 |
| MH | 44.92 ± 7.14 | 37.32 ± 4.20 | <0.0001 |
| PCS | 49.61 ± 4.27 | 44.68 ± 3.31 | <0.0001 |
| MCS | 40.40 ± 6.86 | 31.76 ± 4.65 | <0.0001 |

**Independent t-test. Data as mean ± SD.**

**HRQoL by ICU Length of Stay**

Patients were grouped by ICU LOS into those staying <14 days (n=53) and those staying ≥14 days (n=47). No statistically significant difference was observed in any SF-36 domain, PCS, or MCS between the two groups at 12 months (all p>0.05). PCS was 48.43±3.99 in the shorter-stay group vs. 47.37±5.19 in the longer-stay group (p=0.26); MCS was 37.48±7.24 vs. 37.44±7.68 (p=0.98). Consistent with the grouped analysis, the correlation between ICU LOS and PCS was non-significant (r=−0.151, p=0.13), and correlation with MCS was also non-significant (r=−0.088, p=0.38).

**HRQoL by Duration of Mechanical Ventilation**

Patients were grouped by DOMV: <7 days (n=41) and ≥7 days (n=59). In the grouped analysis, only bodily pain (BP) showed a statistically significant difference (p=0.03), with lower BP scores in those ventilated for fewer days (54.48±10.08 vs. 58.42±6.76). No significant difference in PCS (48.04±4.72 vs. 47.86±4.55, p=0.85) or MCS (38.09±8.10 vs. 37.02±6.94, p=0.49) was found in the grouped analysis. However, correlation analysis identified a significant negative relationship between DOMV and MCS (r=−0.157, p<0.0001), as well as with PF (r=−0.279, p<0.005), RP (r=−0.197, p<0.05), and VT (r=−0.269, p<0.007).

**HRQoL by Gender**

No significant difference was found in PCS (female 47.99±4.99 vs. male 47.89±4.36, p=0.92) or MCS (36.01±8.29 vs. 38.43±6.66, p=0.13) between sexes. Among individual SF-36 domains, only Mental Health (MH) showed a significant difference, with females scoring lower than males (40.08±8.17 vs. 43.85±6.18, p=0.01).

## DISCUSSION

This study provides prospective evidence from a tertiary care ICU in northern India that HRQoL, measured using the SF-36, deteriorates substantially across both physical and mental domains over the twelve months following ICU discharge. The principal finding is that older age is the strongest and most consistent predictor of post-ICU HRQoL impairment, affecting nearly all domains of physical and mental health. Duration of mechanical ventilation exerts a secondary but significant influence, particularly on mental health components, while ICU LOS has only a modest effect on physical functioning.

The magnitude of HRQoL decline observed in this study is consistent with that reported in international cohorts. Dowdy et al., in a systematic review of 7,320 ICU survivors, confirmed that across SF-36 studies, QoL in ICU survivors is lower than the general population for all domains (except bodily pain) at baseline and at 12 months after discharge, and that improvement is non-uniform across domains. [4] Our findings mirror this pattern: the mental components (MCS −7.63 population-norm equivalent points below the PCS decline) showed greater deterioration than physical components. Fildissis et al. similarly found that mental health recovery after ICU was slower and less complete than physical recovery at 18 months. [5]

The strong negative correlation between age and all SF-36 domains ($r=-0.476$ to $-0.689$, $p<0.0001$) is consistent with prior literature. Wehler et al., Eddleston et al., and Pettila et al. all demonstrated that age is associated with poorer physical functioning and general health perceptions in ICU survivors. [7,8,13] Haas et al. similarly reported that age >65 years was independently associated with poorer functional status at 24 months after ICU discharge. [14] The clinical implication is that older ICU survivors require proactive, targeted rehabilitation and follow-up from the time of discharge, as their functional and quality of life trajectories are substantially more impaired than those of younger survivors.

The limited impact of ICU LOS on post-ICU HRQoL in the grouped analysis (no significant difference at the 14-day threshold) aligns with observations from Orwelius et al. and several studies reviewed by Dowdy et al., in which ICU-related factors including LOS showed only minor influence on HRQoL after adjusting for pre-existing disease. [1,4] However, the weak but significant correlation with physical functioning ($r=-0.237$, $p=0.018$) suggests a dose-response effect on specific domains that may not be captured by binary categorisation. It is plausible that in a heterogeneous ICU population with a moderate mean LOS (13.64 days), the range of stay was insufficient to demonstrate a large LOS-HRQoL gradient.

The role of mechanical ventilation in determining post-ICU HRQoL is complex. Our correlation data show that DOMV significantly predicted MCS ($r=-0.157$, $p<0.0001$), PF, RP, and VT. This aligns with the broader literature documenting that prolonged mechanical ventilation is associated with ICU-acquired weakness, delayed rehabilitation, and psychological sequelae including delusional memories and PTSD-related symptoms, all of which erode mental health and physical functioning. [11,12] The discrepancy between significant correlations and non-significant group analysis (except for BP) may reflect the moderate sample size, the binary cut-point chosen, and the confounding effect of overlapping diagnoses. Notably, the association between DOMV and BP in the direction opposite to expectations (higher BP in the longer DOMV group) likely reflects the mixed diagnostic case-mix including conditions such as acute pancreatitis where pain burden is independently high.

Gender did not independently predict overall PCS or MCS in this cohort. The finding that females had lower MH scores (40.08 vs. 43.85, $p=0.01$) corroborates the observation of Rattray et al. that younger patients and women exhibit higher anxiety scores after critical illness, and is consistent with the broader finding that female sex is a risk factor for post-ICU psychological morbidity. [15]

The study has several limitations that warrant acknowledgement. First, baseline HRQoL was obtained via 4-week retrospective recall from next-of-kin, which may overestimate pre-morbid function and underestimate mental health, introducing recall bias. Second, the sample size of 100 limits statistical power for subgroup analyses and may reduce generalisability. Third, the heterogeneous diagnostic case-mix prevents disease-specific HRQoL attribution. Fourth, the 12-month follow-up period, while standard, may be insufficient to capture the full trajectory of recovery, since some

patients may still be improving beyond one year. Fifth, validated measures of illness severity (APACHE II/SOFA) and pre-morbid comorbidity burden were not included in the regression model, which precludes definitive causal inference.

## CONCLUSION

ICU survivors experience clinically significant deterioration in both physical and mental HRQoL at twelve months compared with their pre-illness baseline. Age is the dominant predictor of post-ICU HRQoL impairment, with older patients showing markedly worse outcomes across nearly all SF-36 domains. Duration of mechanical ventilation predicts mental health deterioration independently of other factors, while ICU LOS has only a modest influence on physical functioning. Gender is not an overall predictor of HRQoL but is associated with greater mental health impairment in female survivors. These findings support the implementation of age-stratified, post-ICU follow-up programs that incorporate physical rehabilitation, mental health screening, and targeted psychological support, particularly for mechanically ventilated and

older survivors. Future research should incorporate pre-admission comorbidity indices, APACHE severity scores, and longer follow-up durations to better define the independent predictive roles of these variables.

**Declarations**

Ethics Approval and Consent to Participate: The study was approved by the Institutional Ethics Committee of the Institute of Medical Sciences, Banaras Hindu University, and Varanasi. Written informed consent was obtained from all participants or their legally authorised representatives.

**Consent for Publication:** Not applicable (no individual data are published).

Availability of Data and Materials: The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

**Competing Interests:** The author declares no competing interests. Funding: No external funding was received for this study.

**Author Contributions:** Praveen Pandey: study conception, design, data collection, analysis, and manuscript preparation.

**Acknowledgements:** The author thanks the ICU nursing staff and the patients and families who participated in this study.

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