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Transfusion Practice and Red Blood Cell Use in Patients in Critical Condition: Effects on Survival

Abstract

Objective: Transfusion decisions critically influence outcomes in severe illness. Patient Blood Management (PBM) strategies optimize transfusion practice and mitigate immunological risk.

Materials and Methods: This retrospective study reviewed 30-month transfusion records across all departments. Transfusion endpoints—including red blood cell (RBC), platelet , and fresh frozen plasma—were evaluated. RBC recipients were stratified into critical-risk units versus other clinical departments. Outcomes were defined by survival status during follow-up. Analyses comprised Kaplan–Meier survival curves, logistic regression (univariate and multivariate), and ROC curve evaluation.

Results: Among 1,805 patients receiving 4,999 RBC transfusions, 208 were analyzed (Oct–Dec 2023; median follow-up 12.45 months). Of these, 42.3% were transfused in critical-risk departments and 43.3% died. Survivors showed higher pre- and post-transfusion RBC and lymphocyte counts ($p < 0.05$). Mortality was independently associated with transfusion intensity, malignancy, and critical care admission. Multivariate analysis confirmed age, malignancy, and critical care admission as predictors of poor survival. ROC analysis indicated strong model performance (AUC = 0.859), and Kaplan–Meier curves revealed significantly reduced survival in high-risk subgroups.

Conclusion: Transfusion burden and immune parameters shape survival in critical illness, underscoring individualized, risk-adapted PBM.

Key words: Transfusion Practice, Red Blood Cell, Critical Risk Units , Survival

Introduction

Red blood cell (RBC) transfusion is essential in critical illness, but it must be individualized based on the patient's specific needs and clinical context. Patient Blood Management (PBM) aims to provide patients with the most appropriate treatment by reducing unnecessary transfusions. When applied effectively, PBM can reduce the risk of complications, improve outcomes, and lessen the financial impact of blood product use (1). Transfusion, though often beneficial, is not without consequence. Transfusion reactions, as well as subtle immunological and microcirculatory effects may further compromise recovery (2,3).

Evidence increasingly supports a cautious approach. In critically ill patients—those undergoing cardiac surgery, admitted to intensive care, or treated for malignancy—RBC transfusions have been linked to higher mortality, likely due to immunomodulatory disruptions (4). Randomized controlled trials evaluating RBC transfusion strategies in critically ill patients have demonstrated that restrictive (hemoglobin target: 7 g/dL) and liberal (hemoglobin target: 10 g/dL) thresholds yield comparable outcomes in terms of both mortality and length of hospital stay (5). These findings emphasise the importance of individualised transfusion strategies and caution against the routine liberal use of transfusions. The study aimed to evaluate transfusion practices by examining blood product usage, post-transfusion haematological changes, and the incidence of transfusion reactions. The transfusion response and survival of critically ill patients were also examined.

Materials and Methods

Study Design and Population

This retrospective study included adult patients who received blood product transfusions (red blood cells, platelets, or fresh frozen plasma) between 2023 and 2025. Patients treated in high-risk clinical departments, such as intensive care, hematology-oncology, palliative care, and coronary bypass, were evaluated separately and stratified into two groups based on their survival status during the follow-up period. Pediatric cases (<18 years), patients undergoing massive transfusion protocols, and records with missing laboratory data were excluded. The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of xxxxxxxxxx (Approval No: 2025/06-2, Reference No: E.7438, Date: June 17, 2025).

Data Collection

Clinical and laboratory data were extracted from the electronic records. Variables included transfusion indications, transfusion unit, pre- and post-transfusion laboratory parameters (e.g., hemoglobin, lymphocyte count), and total number of transfused units. Transfusion management, and the impact of transfusion on patient outcomes were assessed within a distinct cohort.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation or median (with range), depending on the normality of the distribution, as assessed by the Shapiro–Wilk test. Group comparisons were performed using Student's t-test or Mann–Whitney U test, as appropriate. Categorical variables were compared using chi-square or Fisher's exact test. Survival analysis was conducted using the Kaplan–Meier method, with group differences assessed via the log-rank test. Cox proportional hazards models were employed to identify independent predictors of survival, with backward elimination used for variable selection. Logistic regression was applied to determine factors associated with RBC transfusion, with model fit assessed using the Hosmer–Lemeshow test. Receiver operating characteristic (ROC) analysis was performed to evaluate the discriminatory performance of the logistic regression model. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS version 20.0.

Results

Between January 2023 and June 2025, 4,999 units of RBC were transfused to 1,805 patients, with a median of two RBC units per patient (range: 1–34). Of the total transfused units, 2,069 were administered in 2023, 2,024 in 2024, and 906 in the initial six months of 2025. Intensive care units recorded the highest transfusion volume (1,349 units), followed by obstetrics and gynecology (710 units), palliative care (538 units), and hematology (390 units). These are also demonstrated elevated transfusion intensity, with mean RBC units per patient of 4.59 in hematology, 4.15 in intensive care, and 3.56 in palliative care. Conversely, markedly lower rates were noted in neurology (1.17) and otorhinolaryngology (1.00) (Table 1).

Regarding ABO and Rh blood group distribution, the most frequently transfused groups were A Rh-positive (37.7%) and O Rh-positive (28.1%), collectively accounting for approximately 66% of all transfusions. The least transfused blood group was AB Rh-negative, comprising only 1.1% of total transfusions (Figure 1). This distribution remained consistent over the three years. Departmental differences in transfusion patterns were substantial, emphasizing the need for tailored strategies—particularly in high-intensity areas such as hematology and intensive care.

During the same period, 572 platelet suspensions were transfused to 172 patients. The median platelet count per patient was 2 (range: 1-23), with the highest platelet usage in clinical departments being in intensive care (363 units), palliative care (58 units), and haematology (56 units) services, respectively. These departments also had the highest platelet transfusion rates, with an average number of platelet units per patient of 4.12 in intensive care, 2.67 in haematology, and 2.64 in palliative care. Significantly lower transfusion rates were observed in departments such as orthopaedics (1.40) and the emergency department (1.78).

The ABO and Rh blood group distribution in platelet transfusions is similar to that of erythrocyte profiles. The most commonly used groups are A Rh-positive (46.2%) and O Rh-positive (30.2%), accounting for more than 76% of the total platelet units transfused. The group with the fewest platelet transfusions was B Rh-negative, representing only 0.2% of total transfusions. No platelet transfusions were administered to AB Rh-negative patients during this period.

In 2023, a total of 2,069 erythrocyte suspensions were transfused to 723 patients, and 267 platelet units were transfused to 71 patients. In 2024, 2,024 RBC were transfused to 713 patients, and 185 platelet units were transfused to 68 patients. The median number of RBC transfusions for both years was two units, while the average unit/patient ratio for platelets was calculated as 3.76 in 2023 and 2.72 in 2024. In the first six months of 2025, 906 RBC units were transfused to 369 patients, and 120 platelet units were transfused to 32 patients. During this period, the average unit-to-patient ratio for RBC was 2.46, and for platelets, it was 3.75. As the 2025 data only covers the first half of the year, no direct comparison with annual data has been made; the 2023 and 2024 data have been assessed at approximately the first six-month level, and based on this estimation model, RBC transfusion demand declined from approximately 1,035 units in early 2023 to 906 units in the same period of 2025. In contrast, platelet transfusions increased to 120 units in the first half of 2025, compared to earlier estimates of 134 units in 2023 and 93 units in 2024. Annual and periodic transfusion data are presented comparatively to assess the impact of PBM applications (Table 2).

Between January 2023 and June 2025, a total of 1,278 units of fresh-frozen plasma (FFP) were transfused to 654 patients. Annual transfusion volumes were 569 units in 2023, 456 in 2024, and 253 during the first half of 2025. The highest utilisation of FFP was in intensive care (521 units), followed by obstetrics and gynaecology (256 units) and general surgery (117 units). These three departments together comprised almost 70% of all FFP transfusions (Table 3). FFP use was limited in neurology, nephrology, cardiology, and infectious diseases. Patient numbers declined over time (290 in 2023, 245 in 2024, 110 in early 2025), while median units per patient remained stable.

The clinical characteristics of a total of 208 patients who received erythrocyte suspension between October and December 2023 were examined. In this period, laboratory and follow-up data were available. 65.9% of the patients were female (n=137) and 34.1% were male (n=71), with a median age

of 58 (range: 19–101). The most frequently transfused blood groups were A Rh-positive (37.5%) and O Rh-positive (28.4%), with negative Rh groups accounting for 12% of total transfusions. The least frequently administered group was AB Rh negative (1.0%). During this period, 42.3% of patients were monitored in critical clinical departments, including intensive care, palliative care, oncology, and haematology; the remaining 57.7% were monitored in obstetrics, internal medicine, general surgery, and other departments. Among the 206 patients with available comorbidity data, 32.5% had no underlying disease, 26.2% had malignancy, and 41.3% had other chronic illnesses. The predominant transfusion indication was chronic disease anaemia (68.3%), followed by pregnancy-related anaemia (15.4%), acute bleeding (8.7%), unidentified causes (5.3%), and iron deficiency anaemia (2.4%).

The median follow-up duration was 12.45 months (range: 0.33–24 months). During this period, 90 patients (43.3%) died. The median haemoglobin level prior to transfusion was 7.6 g/dL (range: 3.9–12.8), which increased to 9.55 g/dL (range: 6.1–17.1) following RBC transfusion administration.

The clinical and laboratory data of 208 patients who underwent transfusion during the study period were compared according to survival status. Patients who died were significantly older than survivors ($p < 0.001$) and had significantly shorter follow-up periods ($p < 0.001$). Pre-transfusion creatinine levels were higher in the exitus group ($p < 0.001$). At the same time, red blood cell (RBC) count, haemoglobin (Hb), haematocrit (HCT), and lymphocyte count/ratio were significantly higher in surviving patients ($p < 0.05$).

A similar trend was observed in the parameters assessed after transfusion. RBC and lymphocyte levels were significantly higher in survivors in the post-transfusion period ($p < 0.001$). Haematocrit levels were also higher in survivors, although this difference was borderline statistically significant ($p = 0.081$). No significant differences were found between the groups in terms of platelet count, MPV, and post-transfusion haemoglobin levels ($p > 0.05$) (Table 4).

In this study, survival outcomes were examined in relation to a range of demographic, clinical, and transfusion-related variables using chi-square analysis. Variables such as gender, the department where transfusion was administered (haematology, oncology, palliative care, intensive care unit), transfusion indication, presence of additional diseases, and transfusion intensity were found to be statistically significantly associated with survival ($p < 0.05$). Mortality was notably elevated among patients with malignancy, those transfused in critical care, and recipients of ≥5 units. In contrast, no significant association was observed for certain variables, such as blood group, Rh factor, and the volume of the last transfusion. These findings emphasise the need to evaluate transfusion decisions in a clinical context and highlight the impact of underlying diseases on prognosis (Table 5).

Patients monitored in critical care units were significantly older ($p < 0.001$) and had shorter follow-up periods ($p < 0.001$). In this group, RBC count, lymphocyte count, and lymphocyte percentage were significantly lower in both the pre- and post-transfusion periods ($p < 0.001$). The HCT level was mildly low and significant in the critical group ($p = 0.008$). No significant differences were found in other parameters such as Hb, creatinine, PLT, and MPV ($p > 0.05$). The findings indicate that patients in critical care have a weaker immunological and haematological profile. Patients in critical care units exhibited higher rates of malignancy, chronic disease, anemia, and mortality ($p < 0.001$), alongside increased transfusion intensity in the first three months ($p < 0.01$). The need for ≥5 units of transfusion was three times higher in critical care settings. In contrast, blood group and Rh factor distributions showed no significant departmental variation ($p > 0.6$) (Table 6).

In univariate logistic regression analysis, age, haemoglobin, erythrocyte, and lymphocyte counts were found to be positively associated with survival ($p < 0.05$). Survival probability decreased with increasing age. Meanwhile, elevated haemoglobin (OR: 1.36), erythrocyte (OR: 3.51), and lymphocyte (OR: 1.86) levels were associated with improved outcomes. Admission to critical care significantly reduced the likelihood of survival (OR: 0.066), whereas receiving <5 transfused units correlated with higher survival (OR: 2.87). The presence of malignancy reduced survival odds (OR: 0.25). Serum creatinine level showed borderline significance ($p = 0.075$) (Table 7).

Multivariate logistic regression analysis identified age, malignancy status, and critical care admission as independent predictors of survival. Increasing age was significantly associated with reduced survival probability (OR: 0.958; 95% CI: 0.931–0.985; p = 0.003). Patients admitted to critical care units exhibited significantly lower odds of survival (OR: 0.154; 95% CI: 0.057–0.417; p < 0.001). Malignancy was also negatively associated with survival (OR: 0.275; 95% CI: 0.095–0.795; p = 0.017). Other variables—including creatinine, red blood cell count, haemoglobin, haematocrit, lymphocyte count, and transfusion volume—did not retain statistical significance in the adjusted model (p > 0.05). The overall model demonstrated good fit (Nagelkerke $R^2 = 0.492$) and predictive accuracy (81.9%), with sensitivity and specificity values of 72.0% and 88.3%, respectively (Table 8). ROC analysis demonstrated strong discrimination (AUC = 0.859), confirming the model's ability to distinguish between survivors and non-survivors.

Over the 30-month follow-up period, the median survival was 21.83 months (SE = 1.37; 95% CI: 19.14–24.53). Subgroup analyses revealed significantly reduced survival in cancer-diagnosed patients (3.87 months; SE = 2.04; 95% CI: 0.00–7.87) compared to those with other diagnoses (9.33 months; not estimable) (p = 0.021). Patients admitted to critical care units also exhibited markedly lower survival (1.60 months; SE = 0.46; 95% CI: 0.69–2.51) relative to those in other departments (24.00 months; not estimable) (p < 0.001). Patients receiving ≥5 RBC transfusions within three months had significantly lower median survival (4.90 months; SE = 4.35; 95% CI: 0.00–13.42) compared to those receiving fewer transfusions (21.83 months; SE = 1.37; 95% CI: 19.14–24.53; p = 0.046) (Figure 2).

Discussion

Our study analysed thirty months of transfusion data, demonstrating the integration of PBM principles into clinical practice and the evolution of transfusion decisions toward patient-specific assessments. In addition to quantifying shifts in product utilization, the data enabled a comprehensive evaluation of the immunological and prognostic implications of transfusion practices. Despite stable RBC transfusion use in 2023–2024, platelet transfusions declined by 30%, consistent with Bolcato et al.'s multidisciplinary PBM model (6). In particular, being more selective in platelet decisions demonstrates that PBM can provide guidance not only for erythrocytes but for all components. RBC transfusion usage declined by approximately 12% in early 2025, reflecting a shift toward more individualized, patient-specific transfusion practices. The increased selectivity in platelet transfusion decisions highlights the broader applicability of PBM principles to all blood components, extending beyond erythrocytes. Periodic variations in platelet transfusion rates are attributable to differences in patient demographics, hematologic diagnoses, and institutional service demands. Recent evidence suggests that even a single-unit RBC transfusion may increase the risk of mortality (7). Transfusion-related immunomodulation (TRIM) and thromboembolic complications have been associated with higher rates of infection, cancer recurrence, and acute coronary events (8–10).

Additionally, certain component therapies may paradoxically increase the risk of bleeding under specific clinical conditions (10,11). Meta-analyses confirm that PBM strategies can reduce transfusion rates by up to 39% and mortality by approximately 11% (12). PBM programmes have been demonstrated to be a practical approach to improving clinical outcomes in surgical and non-surgical patients (13). Our data further validate this impact, showing that transfusion intensity, malignancy status, and critical care admission are independently associated with reduced survival—emphasizing the need for cautious, patient-centered transfusion practices.

In our study, transfusion frequency was increased in critical departments, and the significantly lower survival rate, particularly in patients receiving five or more units of packed red blood cells, highlights the need to question liberal transfusion strategies. This implication aligns with the TRICC trial (Hebert et al., 1999), which demonstrated that a restrictive transfusion strategy (Hb threshold of 7 g/dL) was at least as effective as a liberal approach (Hb threshold of 10 g/dL), with improved outcomes in select patient groups (14). Our findings are also supported by the TRISS trial (Holst et al., 2014), which similarly demonstrated no significant difference in 90-day mortality between restrictive (Hb threshold: 7 g/dL) and liberal transfusion strategies (Hb threshold: 9 g/dL) in critically ill patients (15). The

restrictive approach lowered transfusion volume and improved survival in younger, less severely ill patients. In the meta-analysis by Wisnawa et al., the restrictive transfusion threshold was defined as a haemoglobin level of <10 g/dL, and the liberal threshold as ≥10 g/dL; no significant differences were found between the two strategies regarding mortality, sepsis, or wound infection (16). These findings confirm that higher transfusion volume is linked to lower survival, supporting restrictive, patient-specific strategies in critical care.

In our study, age, presence of malignancy, and critical care unit survival emerged as factors independently affecting outcomes in multivariate analyses. Notably, the significantly lower median survival time in malignant patients suggests that transfusion has limited efficacy in improving prognosis. While Benyahia et al. demonstrated that intraoperative transfusions and prolonged hospital stays negatively affect survival in ovarian cancer surgery, our study extended this observation to a broader critical care population, showing that transfusion intensity (≥ five units), malignancy status, and admission to high-risk departments independently predict poor outcomes—underscoring the need for immunologically informed, patient-specific PBM strategies across both oncologic and non-oncologic settings (17). In a large patient population undergoing oncological surgery, the RBC transfusion rate decreased over the follow-up period. Despite this decrease, no change was observed in the rate of postoperative wound site infection and renal failure; however, an apparent increase in perioperative myocardial infarction was detected. This situation suggests that transfusion decisions should be evaluated more carefully and on an immunological basis, especially in patients with a history of cardiovascular disease (18). These findings underscore the importance of individualized transfusion decisions, particularly in patients with underlying cardiovascular disease, where immunological considerations may be critical.

The association of immunological parameters, such as lymphocyte count and percentage, with survival indicates the immunomodulatory effects of transfusion. Michael Murphy et al. emphasised that PBM should be evaluated not only at the hematological level but also at the immunological level (19). The Frankfurt Consensus accepted the Hb <7 g/dL threshold as safe in critically ill patients and recommended the adoption of PBM as the standard of care (20). The low lymphocyte levels and high mortality rates observed in our study suggest that the transfusion-related immunomodulation effect may be clinically significant.

The relationship between female gender and transfusion volume is consistent with the study conducted by Wester et al., which used data from the Netherlands Heart Registry. Our data also shows that transfusion volume is higher in female patients, indicating that gender should be considered in clinical decision-making processes (21). Despite the REDS-III study reporting no gender–mortality association, similar to our findings, haematological diseases were identified as the leading indication for transfusion, with a median pre-transfusion haemoglobin level of 7–8 g/dL (22). Our study also shows that the integration of local data at the national level demonstrates that PBM practices in our hospital are comparable to international standards.

Our findings emphasize the importance of guiding transfusion decisions based on clinical context, immunological status, and patient-specific factors. PBM strategies not only reduce unnecessary product use but also influence survival-related parameters. Our study identified transfusion volume, malignancy, and critical care admission as independent predictors of survival. Future research should investigate these associations through prospective studies that incorporate immunological markers and department-specific PBM protocols.

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Rank	Department	Number of Patients (n)	Total ES Units	Units per Patient
1	Hematology	85	390	4.59
2	Intensive Care Unit	325	1,349	4.15
3	Palliative Care	151	538	3.56
4	Thoracic Surgery	27	87	3.22
5	Cardiovascular Surgery	10	31	3.10
6	General Surgery	63	177	2.81
7	Nephrology	23	62	2.70
8	Emergency Department	218	557	2.55
9	Urology	19	49	2.58
10	Infectious Diseases	16	36	2.25
11	Oncology	6	13	2.17
12	Internal Medicine	155	321	2.07
13	Pediatrics	113	232	2.05
14	Pulmonology	43	86	2.00
15	Orthopedics	93	185	1.99
16	Cardiology	55	104	1.89
17	Obstetrics & Gynecology	380	710	1.87
18	Neurosurgery	16	24	1.50
19	Neurology	12	14	1.17
20	Otorhinolaryngology (ENT)	2	2	1.00

Table 1. Distribution of Erythrocyte Suspension Units by Clinical Department and Transfusion Intensity

Table 2. Annual and Semiannual Transfusion Volumes of Erythrocyte Suspension and Platelets (2023–2025)

Time Period	ES Units	PLT Units	Total Patients	Avg. ES/Patient	Avg. PLT/Patient
2023 (12 mo)	2,069	267	794	2.86	3.76
2024 (12 mo)	2,024	185	781	2.84	2.72
2025 (H1, actual)	906	120	401	2.46	3.75
2023 (H1, est.)	~1,035	~134	397	2.86	3.76
2024 (H1, est.)	~1,012	~93	390	2.84	2.72

Estimated values for the first half of 2023 and 2024 (H1) were derived by applying a 50% proportion to annual totals to enable comparative analysis. Abbreviations: ES, erythrocyte suspension; PLT, platelet concentrate; Avg., average; est., estimated; mo, months.

Table 3. Fresh Frozen Plasma (FFP) Usage by Clinical Department and Year

Year	TDP (Unit)	Patients	ICU	OB-GYN	GS
2023	569	290	202	168	33
2024	456	245	186	65	45
2025*	253	110	133	23	39

Data for 2025 covers only the first six months. Abbreviations: GS, General Surgery; ICU, Intensive Care Unit; OB-GYN, Obstetrics and Gynecology; TDP, Fresh Frozen Plasma.

Table 4. Comparison of Pre- and Post-Transfusion Laboratory Parameters According to Survival Status

Parameter	**Exitus (n) – Mean ± SD or Mean Rank**	**Survivors (n) – Mean ± SD or Mean Rank**	**p-value**
Age (years)	141.28 (n=90)	76.45 (n=118)	<0.001*
Follow-up duration (months)	54.92 (n=90)	142.31 (n=118)	<0.001*
Creatinine (pre, mg/dL)	104.31 (n=83)	76.56 (n=95)	<0.001*
RBC (pre, $\times 10^6/\mu L$)	2.72 ± 0.55 (n=88)	3.23 ± 0.70 (n=116)	<0.001**
Hemoglobin (pre, g/dL)	93.12 (n=88)	110.43 (n=117)	0.039*
Hematocrit (pre, %)	86.50 (n=88)	115.41 (n=117)	0.001*
Platelet count (pre, $\times 10^3/\mu L$)	99.69 (n=88)	105.49 (n=117)	0.488*
MPV (pre, fL)	104.95 (n=87)	100.68 (n=117)	0.609*
Lymphocyte count (pre, $\times 10^9/L$)	76.95 (n=87)	121.50 (n=117)	<0.001*
Lymphocyte % (pre)	82.86 (n=87)	117.11 (n=117)	<0.001*
Creatinine (post, mg/dL)	57.80 (n=65)	46.68 (n=41)	0.069*
RBC (post, $\times 10^6/\mu L$)	75.71 (n=82)	107.53 (n=104)	<0.001*
Hemoglobin (post, g/dL)	90.36 (n=82)	95.98 (n=104)	0.480*
Hematocrit (post, %)	85.73 (n=82)	99.63 (n=104)	0.081*
Platelet count (post, $\times 10^3/\mu L$)	89.54 (n=82)	96.62 (n=104)	0.373*
MPV (post, fL)	94.87 (n=81)	91.54 (n=104)	0.675*
Lymphocyte count (post, $\times 10^9/L$)	68.24 (n=80)	111.16 (n=104)	<0.001*
Lymphocyte% (post)	80.59 (n=80)	101.66 (n=104)	0.008*

Statistical comparisons were performed using the Mann–Whitney U test (*) for non-parametric data and the independent t-test (**) for normally distributed variables. Abbreviations: RBC, red blood cell count; MPV, mean platelet volume; Lymphocyte %, lymphocyte percentage; pre, pre-transfusion; post, post-transfusion.

Table 5. Chi-Square Analysis of Demographic and Clinical Variables Associated with Survival

Variable	Category Distribution (Deceased vs Survived)	χ^2 (df)	p-value
Sex	Female: 51.1% vs 78.0%	16.492 (1)	<0.001
Blood Group	A: 43.3% vs 39.0%	1.863 (3)	0.601
Rh Factor	Rh+: 91.1% vs 92.4%	0.280 (1)	0.597
Transfusion Department	ICU: 40.0% vs 2.5%; Palliative: 27.8% vs 4.2%	131.323 (19)	<0.001
Critical Care Setting	Critical: 75.6% vs 16.9%	71.848 (1)	<0.001
Transfusions in First 3 Months	≥3 units: 12.2% vs 3.4%	20.427 (10)	0.025
≥5 Transfusions in First 3 Months	Yes: 13.3% vs 5.1%	4.395 (1)	0.036
Final Transfusion Count	2 units: 42.2% vs 56.8%	9.976 (4)	0.041
Final Transfusion ≥2 Units	Yes: 50.0% vs 59.3%	1.795 (1)	0.180
Final Transfusion ≥3 Units	Yes: 7.8% vs 2.5%	3.058 (1)	0.080
Transfusion Indication	Chronic disease: 93.3% vs 36.4%	73.367 (4)	<0.001
Comorbidity Status	Cancer: 48.3% vs 9.4%	68.388 (2)	<0.001

Categorical variables were compared between deceased and surviving patients using Pearson's chi-square test. Degrees of freedom (df) are shown in parentheses. p-values < 0.05 were considered statistically significant. Abbreviations: ICU, intensive care unit; df, degrees of freedom; ≥, greater than or equal to

Table 6. Comparison of Hematological and Clinical Parameters Between Critical and Non-Critical Care Patients

Variable	Critical (n) Mean Rank / %	Noncritical (n) Mean Rank / % (noncritical)	Statistic	p-value
Age (years)	123.24 (n=88)	90.75 (n=120)	Z = –3.847	<0.001*
Survival follow-up (days)	73.51(n=88)	127.23 (n=120)	Z = –6.360	<0.001*
Pre-transfusion RBC (×10⁶/µL)	82.92 (n=86)	116.77 (n=118)	t = –4.02 / Z = –4.045	<0.001**
Pre-transfusion HCT (%)	90.01 (n=86)	112.39 (n=119)	Z = –2.665	0.008*
Post-transfusion HCT (%)	90.14 (n=76)	95.82 (n=110)	Z = –0.707	0.480*
Pre-transfusion hemoglobin (g/dL)	95.66 (n=86)	108.31 (n=119)	Z = –1.507	0.132*
Post-transfusion hemoglobin (g/dL)	94.08 (n=76)	93.10 (n=110)	Z = –0.122	0.903*
Pre-transfusion lymphocyte (×10³/µL)	83.78 (n=85)	115.87 (n=119)	Z = –3.828	<0.001*
Post-transfusion lymphocyte (×10³/µL)	72.69 (n=75)	106.13 (n=109)	Z = –4.185	<0.001*
Pre-transfusion platelet (×10³/µL)	98.55 (n=86)	106.22 (n=119)	Z = –0.914	0.361*
Post-transfusion platelet	88.88 (n=76)	96.69 (n=110)	Z = –0.972	0.331*
Pre-transfusion MPV (fL)	105.54 (n=85)	100.33(n=119)	Z = –0.622	0.534*
Post-transfusion MPV (fL)	96.31 (n=75)	90.75 (n=110)	Z = –0.694	0.488*

Variable	Critical (n) Mean Rank / %	Noncritical (n) Mean Rank / % (noncritical)	Statistic	p-value
Pre-transfusion lymphocyte (%)	98.62 (n=85)	105.27(n=119)	Z = –0.794	0.427*
Post-transfusion lymphocyte (%)	90.03 (n=75)	94.20 (n=109)	Z = –0.521	0.602*
Mortality (Exitus)	68/88 (77.3%) (n=88)	22/120 (18.3%) (n=120)	χ^2 = 71.8	<0.001***
Malignancy	39/87 (44.8%) (n=87)	15/119 (12.6%) (n=119)	χ^2 = 48.9	<0.001***
Chronic disease anemia	81/88 (92.0%) (n=88)	46/120 (38.3%) (n=120)	χ^2 = 65.3	<0.001**
≥5 units transfused (3 month)	13/88 (14.8%) (n=88)	5/120 (4.2%) (n=120)	χ^2 = 7.2	0.007***
No comorbidity	7/87 (8.0%) (n=87)	60/119 (50.4%) (n=119)	χ^2 = 48.9	<0.001***
ABO/Rh distribution	Similar	Similar	χ^2 = 0.2/0.1	>0.6***
Final transfusion volume	Median: 2 units	Median: 2 units	χ^2 = 2.9	>0.5***

Comparisons were made using: * Mann–Whitney U test; ** independent t-test; ** chi-square test. Z: standardized test statistic. $p < 0.05$ considered significant.

Abbreviations: RBC, red blood cell; HCT, hematocrit; Hb, hemoglobin; PLT, platelet count; MPV, mean platelet volume; LYM, lymphocyte count; LYM%, lymphocyte percentage; SD, standard deviation.

Table 7. Univariate Logistic Regression Analysis of Factors Associated with Survival

Predictor	**B**	**SE**	**Wald χ^2**	**p-value**	**OR (Exp(B))**	**95% CI for OR**
Age (years)	–0.065	0.009	47.95	<0.001	0.937	0.920 – 0.955
Creatinine (mg/dL)	–0.257	0.144	3.18	0.075	0.773	0.583 – 1.026
Hemoglobin (g/dL)	0.305	0.119	6.51	0.011	1.356	1.073 – 1.714
Red Blood Cells ($\times 10^6/\mu L$)	1.257	0.258	23.74	<0.001	3.514	2.120 – 5.825
Lymphocyte count ($\times 10^3/\mu L$)	0.620	0.215	8.32	0.004	1.859	1.220 – 2.833
Critical care admission (yes vs no)	–2.718	0.347	61.36	<0.001	0.066	0.033 – 0.130
Transfusion <5 units (vs ≥5 units)	1.055	0.521	4.10	0.043	2.872	1.034 – 7.978

Predictor	B	SE	Wald χ^2	p-value	OR (Exp(B))	95% CI for OR
Malignancy (vs other comorbidities)	–1.387	0.402	11.93	0.001	0.250	0.114 – 0.549

Table 8. Multivariate Logistic Regression Model Predicting Survival and Model Performance Metrics

Predictor	B	SE	Wald χ^2	p-value	OR (Exp(B))	95% CI for OR
Age (years)	–0.043	0.014	9.12	0.003	0.958	0.931 – 0.985
Creatinine (mg/dL)	0.162	0.174	0.87	0.352	1.176	0.836 – 1.655
Red Blood Cells ($\times 10^6/\mu L$)	0.067	0.654	0.01	0.919	1.069	0.297 – 3.850
Haemoglobin (g/dL)	–0.540	0.691	0.61	0.434	0.583	0.150 – 2.257
Haematocrit (%)	0.363	0.285	1.62	0.203	1.438	0.822 – 2.514
Lymphocyte count ($\times 10^3/\mu L$)	0.286	0.194	2.17	0.141	1.331	0.910 – 1.948
Critical care admission (yes vs no)	–1.873	0.509	13.55	<0.001	0.154	0.057 – 0.417
Transfusion <5 units (vs ≥5 units)	0.048	0.803	0.004	0.952	1.049	0.217 – 5.062
Malignancy (vs other comorbidities)	–1.292	0.542	5.68	0.017	0.275	0.095 – 0.795