Title: Survival Outcomes and Associated Factors in Critically Ill Pediatric Patients: Insights from a Single-Center Retrospective Study

Abstract

This single-center retrospective study evaluated survival outcomes and associated factors among critically ill pediatric patients admitted to the intensive care unit (PICU). The study analyzed patient data to identify key demographic, clinical, and physiological variables influencing survival. Diagnoses were categorized into cardiac, endocrine, gastrointestinal, infection, trauma, respiratory, and hematologic conditions to assess their impact on survival rates. The results revealed that survival was highest among patients with cardiac, endocrine, gastrointestinal, infection, and trauma diagnoses, while respiratory and hematologic conditions were associated with lower survival rates. Female patients demonstrated slightly higher survival frequencies compared to males. Factors linked to improved odds of survival included older age, larger body size, and higher oxygen saturations at admission. These findings underscore the importance of age, body size, and oxygen saturation as critical markers for survival in critically ill pediatric patients. Future research, including multicenter studies and randomized controlled trials, is needed to validate these findings and further investigate interventions to improve survival outcomes in this vulnerable population.

Introduction

Critically ill pediatric patients admitted to the pediatric intensive care unit (PICU) represent a vulnerable population with unique physiological and clinical challenges. Despite advances in pediatric critical care, mortality and morbidity rates in this population remain a significant concern. Understanding the factors influencing survival outcomes is essential for clinicians to identify high-risk patients, optimize interventions, and improve prognosis (Sperotto et al., 2023).

Identifying factors that impact survivability in critically ill pediatric patients is a complex but vital endeavor. By pinpointing these key determinants, clinicians can intervene more effectively, potentially enhancing survival rates and improving the long-term quality of life for children admitted to the PICU. Understanding and addressing these factors can help tailor treatment strategies that better support each patient's unique needs, offering an evidence-based approach to critical care in pediatrics (Odetola & Pappachan, 2022).

Previous studies have often focused on specific diseases or interventions, neglecting a broader view of survival predictors in diverse clinical contexts. Moreover, many investigations have been limited by small sample sizes, single-center data, or incomplete variable assessments, leaving critical gaps in understanding (Shen & Jiang, 2021).

This study aims to build on existing literature by evaluating survival outcomes across a range of diagnoses, including cardiac, respiratory, infection, trauma, hematologic, endocrine, and gastrointestinal conditions. Special attention is given to demographic factors (e.g., age, sex, body size) and physiological measures (e.g., oxygen saturation) to uncover potential survival predictors.

The findings of this retrospective analysis will provide a foundation for future studies and highlight areas requiring further investigation. The ultimate goal is to improve survival outcomes for critically ill pediatric patients through evidence-based care strategies tailored to their unique needs. By identifying key predictors of survival, this research aims to contribute to the broader effort of enhancing pediatric critical care practices and patient outcomes.

Data and Methods

This study utilized a publicly available dataset containing information on critically ill pediatric patients admitted to a PICU. The dataset was sourced from Kaggle (https://www.kaggle.com/datasets/ledysmai5/critically-ill-pediatric-patients-in-picucsv) and comprised observational units representing individual patients. Variables in the dataset included demographic data (e.g., age, sex, and body size), physiological measurements (e.g., oxygen saturation and vital signs), and clinical diagnoses. Diagnoses were initially presented as diverse unique entries, which were subsequently grouped into broader categories based on related body systems to facilitate meaningful statistical analysis. The primary outcome variable was survival (0 = survived, 1 = deceased), with additional variables representing potential predictors of survival.

The data analysis was conducted using R (version 4.4.1, "Race for Your Life," released on 2024-06-14, ucrt), developed by The R Foundation for Statistical Computing, Platform: x86_64-w64-mingw32/x64. Descriptive statistics summarized categorical data (e.g., frequency counts and percentages), while summary statistics described continuous variables (Table 1).

Correlation analyses were performed to evaluate relationships between predictor variables and survival outcomes. Techniques included Pearson and Spearman correlations for continuous data, Point-Biserial correlations for binary data, and Chi-Square tests of independence for categorical data relative to survival. Standardized residuals were examined to highlight categories with significant deviations from expected values, identifying specific diagnoses or demographics associated with survival outcomes.

Logistic regression was used to model the relationship between independent variables and survival, with post hoc evaluations assessing model goodness of fit using Null Deviance, Residual Deviance, and the Akaike Information Criterion (AIC). Statistical significance for all tests was defined as an alpha level of 0.05 or lower.

Results

This study analyzed data from 90 critically ill pediatric patients admitted to the PICU. The cohort included a predominance of male patients (60%), with an overall survival rate of 72.22%. Diagnostic categories were diverse, with respiratory conditions being the most common, followed by cardiac and gastrointestinal (GI) conditions.

Summary Statistics

The median age was 0.92 years, with a mean of 4.16 years, and the distribution was moderately right-skewed (1.25), indicating a younger cohort. Weight and height also showed right-skewed distributions, with median values of 8 kg and 66 cm, respectively, and a broad range reflecting diverse patient sizes. Heart rate had a median of 138 bpm and a mean of 131.5 bpm, with minimal skewness (0.65), while oxygen saturation was tightly distributed around a median of 95% and exhibited slight left skewness (-0.15). Respiratory rate was highly right-skewed (2.5) with a median of 30 breaths/min (extreme outliers were present). Blood pressure variables, including systolic, diastolic, and mean arterial pressure, had medians of 100 mmHg, 60 mmHg, and 73 mmHg, respectively, with low skewness, suggesting a relatively stable distribution in this population.

Survival Outcomes by Diagnosis

Analysis revealed significant variability in survival outcomes across diagnostic categories. Cardiac, endocrine, GI, infection, and trauma diagnoses were associated with the highest survival rates. In contrast, hematologic, neurological, and respiratory conditions were linked to lower survival rates (Table 2).

Sex and Survival

Females exhibited a higher survival rate (87.5%) compared to males (72.71%), a statistically significant difference (Table 3).

Correlations and Regression Analysis

Correlations between predictor variables and survival were largely significant; however, many associations explained only a small proportion of the variation in survival outcomes. Logistic regression models identified key predictors of survival, including older age, larger body size, and higher oxygen saturation levels. These factors were significantly associated with improved odds of survival, highlighting their potential as critical markers in assessing patient prognosis (Table 4, Figure 1).

Diagnostic and Demographic Insights

Chi-Square tests of independence and standardized residuals provided additional insights into the relationship between categorical variables and survival outcomes. For example, diagnoses within the cardiac and endocrine categories showed higher-than-expected survival frequencies, while respiratory and hematologic conditions demonstrated the opposite trend.

Limitations and Proportional Analysis

While the proportional analysis provided a detailed breakdown of survival within each diagnostic category, the limited sample-size imposed constraints on the generalizability of findings. This study highlights several critical factors influencing survival in critically ill pediatric patients, offering a foundation for future research in broader and more diverse populations (Figure 2).

Discussion and Conclusions

This study highlights several important factors associated with survival outcomes among critically ill pediatric patients in the PICU. While certain variables, such as age and body size, are commonly recognized as influencing survival, this study provides deeper insights into the interactions between these factors and others, such as physiological and diagnostic variables.

A key finding was the significant association between diagnostic categories and survival rates. Cardiac, endocrine, GI, infection, and trauma diagnoses were linked to the highest survival rates, while hematologic, neurological, and respiratory conditions were associated with the lowest. These findings suggest that diagnostic categories play a crucial role in patient outcomes and should be a focus for tailored treatment strategies. Additionally, female patients exhibited slightly higher survival rates compared to males, raising questions about potential biological or care-related factors contributing to this disparity.

Physiological variables, including HR and MAP, were also critical predictors of survival. This study observed that higher HRs were associated with decreased odds of survival, aligning with findings by King et al. (2022), who reported that HR monitoring is linked to improved survival without neurocognitive impairment (King et al., 2022). Similarly, a higher MAP was associated with decreased odds of death, consistent with established guidelines recommending careful blood pressure management to avoid deleterious consequences (Pearson & Halbach, 2023).

Despite these findings, the study has several limitations. Its retrospective design introduces potential biases, such as incomplete or missing data for certain variables. Additionally, the dataset lacked other potentially relevant variables, such as genetic markers or detailed treatment histories, which could further inform survival outcomes. Furthermore, the study was limited to a single-center dataset, reducing its generalizability to other healthcare settings or populations.

This study's findings reinforce the necessity of exploring survival predictors within a broader, multicenter context. Similar research has shown that integrating diagnostic-specific approaches with physiological markers like HR and MAP can significantly enhance survival outcomes (Haque et al., 2015). For instance, studies on PICU populations have linked lower MAP to poorer survival rates, underscoring the critical need for careful blood pressure management (Alten et al., 2022). Additionally, disparities in survival outcomes between male and female patients, as highlighted by Schlapbach (Schlapbach et al., 2019), suggest avenues for further investigation into biological and care-related factors. Future research should leverage these insights through advanced analytics and cross-center collaborations to improve survival predictions and therapeutic interventions for pediatric patients.

In conclusion, this study provides valuable insights into the factors influencing survival among critically ill pediatric patients. By identifying key determinants, such as diagnostic categories, physiological markers, and demographic variables, this research contributes to the foundation for developing evidence-based interventions to enhance survival and quality of care in pediatric critical care settings.

Table 1

SUMMARY STATISTICS OF CONTINUOUS VARIABLES

VARIABLE	Min	1st Quartile	Median	Mean	3rd Quartile	Max	Skewness
AGE	0.1667	0.3333	0.9167	4.1587	5	26	1.25
WT	4	5.5	8	15.16	13	65	0.75
HT	45	55	66	86.61	100	170	1.8
HR	0	118	138	131.5	151	205	0.65
O2	0	90	95	91.85	97	100	-0.15
RR	0	23	30	30.25	34	400	2.5
SBP	0	87	100	98.1	110	163	0.55
DBP	0	49	60	59.85	72	112	0.45
MAP	0	61	73	72.62	85	124	0.1

* WT = weight, HT = height, MAP = mean arterial pressure, DBP = diastolic blood pressure, SBP = systolic blood pressure, RR = respiratory rate, O2 = oxygen saturation, HR = hear rate

Table 2

SURVIVAL BY DIAGNOSIS

DIAGNOSIS	Survival Rate	Non-Survival Rate	Key Observation
CARDIAC (1)	0.940989	0.059011	High Survival
ENDOCRINE (2)	1	0	High survival
GI (2)	1	0	High survival
HEMATOLOGIC (4)	0.330119	0.669881	Low survival
IMMUNE (5)	1	0	High survival
INFECTION (6)	1	0	High survival
NEUROLOGICAL (7)	0.742091	0.257909	Moderate survival
RENAL (8)	1	0	High survival
RESPIRATORY (9)	0.703109	0.296891	Moderate survival
TRAUMA (10)	1	0	High survival

Table 3

SURVIVAL BY SEX

SEX	Survival	Non-Survival
MALE	0.727097	0.272904
FEMALE	0.874983	0.125017

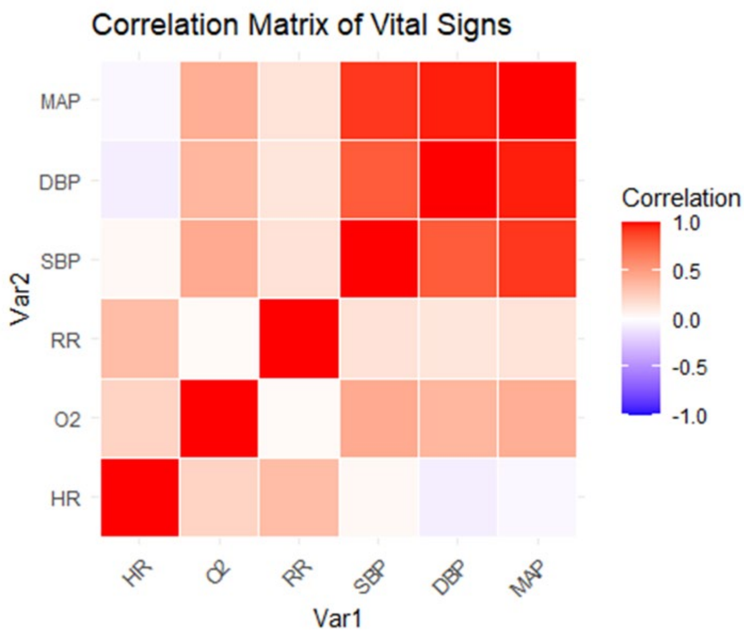
Table 4

SURVIVAL LOGISTIC REGRESSION

VARIABLE	Estimate	Std. Error	z value	P Value	Odds Ratio
(INTERCEPT)	-0.95151	0.147258	-6.462	1.04E-10	0.386157
AGE	-0.03928	0.007248	-5.419	5.98E-08	0.96148
WT	-0.14263	0.003295	-43.282	< 2e-16	0.867078
HT_	0.052719	0.001153	45.741	< 2e-16	1.054134
HR	-0.03297	0.000683	-48.274	< 2e-16	0.967572
O2	-0.01119	0.001479	-7.568	3.78e-14	0.988869
RR	0.057961	0.00107	54.192	< 2e-16	1.059674
SBP	0.350804	0.01717	20.431	< 2e-16	1.420209
DBP	0.834599	0.034344	24.301	< 2e-16	2.303889
MAP	-1.14806	0.05137	-22.349	< 2e-16	0.317253
SEX	-2.24761	0.040287	-55.79	< 2e-16	0.105652
DIAGNOSIS	0.341947	0.005463	62.595	< 2e-16	1.407686

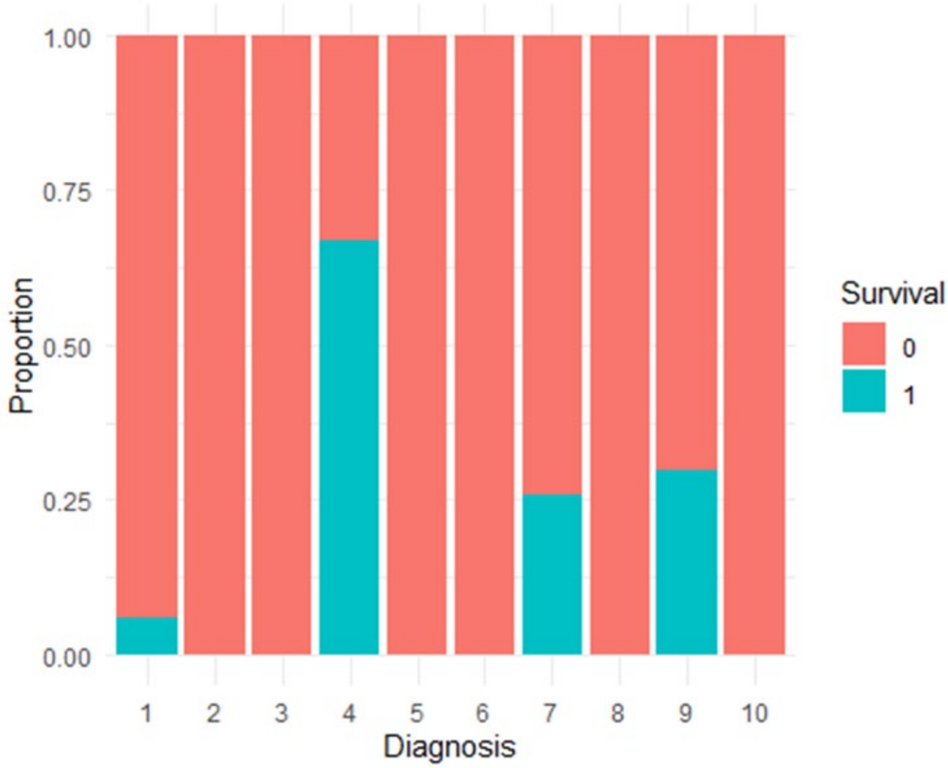
* WT = weight, HT = height, MAP = mean arterial pressure, DBP = diastolic blood pressure, SBP = systolic blood pressure, RR = respiratory rate, O2 = oxygen saturation, HR = hear rate

Figure 1



* MAP = mean arterial pressure, DBP = diastolic blood pressure, SBP = systolic blood pressure, RR = respiratory rate, O2 = oxygen saturation, HR = hear rate.

Figure 2



* The survival key is 0 = survived, 1 = non-survived. Diagnosis numbers 1 = Cardiac, 2 = Endocrine, 3 = GI, 4 = Hematologic, 5 = Immune, 6 = Infection, 7 = neurologic, 8 = Renal, 9 = Respiratory, 10 = Trauma

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