

Risk Factors for Prolonged Hospitalization in Children with Acute Lymphoblastic Leukemia and Pneumonia

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ABSTRACT

Background: Pneumonia is the most common complication in children with acute lymphoblastic leukemia (ALL). Length of hospitalization is an indicator of pneumonia severity, but there is insufficient evidence to determine the risk factors for prolonged hospitalization in ALL pediatric patients with pneumonia. This study analyzed the risk factors for prolonged hospitalization in these patients

Subjects and Method: A cross-sectional study was conducted in pediatric ALL patients with pneumonia treated in Dr. Moewardi hospital, Surakarta from 2023 to 2025. The sample collection used consecutive sampling techniques. Patients diagnosed with Covid-19, discharged from the ward at their own request, incomplete medical record, and those who died during treatment were excluded from the study. The proposed risk factors for prolonged hospitalization were ALL stratification, neutropenia, anemia, malnutrition, duration to seek care, complications, sputum culture result, and antibiotic type. The correlation test used multivariate regression analysis with $p < 0.05$ was considered statistically significant.

Results: Fifty patients met the inclusion criteria, predominantly high risk ALL patients (82%) in induction chemotherapy phase. The mean age was 7.4 y.o. Most of them had anemia (74%) and malnourished (56%). Neutropenia was found in 38% of subjects. The mean of hospitalization was 13.94 days. Most subjects presented to hospital on day 1 of pneumonia symptoms (62%). Positive culture results were obtained in 86% of subjects with *Klebsiella pneumoniae* as the most common microorganism (20%). Ampicillin and gentamycin were the most common antibiotics (72%). Ninety-six percent of subjects had no complications. Multivariate analysis revealed that malnourished and duration to seek care were the risk factors for prolonged hospitalization (aOR= 5.26; 95% CI= 1.08–25.67; $p=0.040$ and aOR= 6.40, 95% CI= 1.45–28.32; $p=0.014$, respectively).

Conclusion: Malnourished and duration to seek care are independent risk factors for prolonged hospitalization in ALL pediatric patients with pneumonia.

Keywords: Prolonged hospitalization, risk factor, pneumonia, ALL

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BACKGROUND

Acute lymphoblastic leukemia (ALL) is one of the most frequently occurring malignancies among children, with a global incidence of 1 to 4.75 per 100,000 (Altamirano et al., 2024). The highest prevalence occurs in children aged 2–5 years, predominantly in boys (Angkasa et al., 2019). This disease is characterized by clonal proliferation of hematopoietic precursor cells (Altamirano et al., 2024).

ALL patients are susceptible to infections due to disease-related immunosuppression and the side effects of chemotherapy, particularly during the induction phase. Understanding the microbiological infection profile can help minimize morbidity and mortality in ALL patients (Rajeswari et al., 2018). Infections can also prolong hospital stays, interfere with chemotherapy, and impact patient's quality of life. The first two phases of chemotherapy (induction and consolidation) require hospitalization, putting patients at risk of infection, both from their own natural flora and from nosocomial infections. Neutropenia has also been reported to be more severe in these two phases of chemotherapy than in the maintenance phase (Carlesse & Lopes de Sousa, 2024).

Pneumonia is an infection of the lung parenchyma, which occurs in one or both lungs simultaneously, affecting the alveoli (Jackson et al., 2021). Pneumonia has become the most common type of infection that occurs during chemotherapy in pediatric ALL patients with an incidence of 13%–31%. The effectiveness and efficiency of treatment in children with ALL pneumonia are very important to support the success of chemotherapy and increase survival rates (Liu & Li, 2022).

Prolonged hospitalization in children with ALL and pneumonia not only impacts the burden of treatment costs but also

carries the risk of adverse drug reactions and other nosocomial infections. Length of hospitalization is generally accepted as an indicator of pneumonia severity. Treatment outcomes and length of stay in hospitalized pneumonia patients until recovery are influenced by various factors such as comorbidities, complications, severity, and the type of medication administered (Kebede et al., 2024). However, evidence regarding the specific risk factors for prolonged hospitalization in pediatric ALL patients with pneumonia remains limited. The aim of this study is to determine the risk factors for prolonged hospitalization by proposing several factors including demographic characteristics (age and gender), complication factors (neutropenia, anemia, malnutrition), oncological conditions (chemotherapy phase and type of ALL stratification), and aspects of therapy and diagnostic management (duration to seek care, type of antibiotic, complications, and sputum culture results).

SUBJECTS AND METHOD

1. Study Design

The design of this study is retrospective cross sectional. Sampling was conducted by searching data from the ALL patient register in the Haemato-Oncology Department of Pediatrics and medical records of Dr. Moewardi Surakarta Regional General Hospital, Indonesia, from January 2023 to December 2025.

2. Population and Sample

The target population of this study consisted of pediatric patients with acute lymphoblastic leukemia (ALL) and pneumonia who were treated in the pediatric ward of Dr. Moewardi Hospital, Surakarta. The accessible population included all such patients admitted between January 2023 and December 2025. Subject were selected by consecutive based on specific criteria:

age between 1 month and <18 years old, and a confirmed diagnosis of both pneumonia and ALL. Meanwhile patients who diagnosed with COVID-19, forced discharge status, incomplete data, and died during treatment were excluded. During the study period, a total of 61 eligible patients met the inclusion criteria. Of these, 11 patients were excluded due to in-hospital mortality, resulting in a final sample size of 50 patients included in the analysis. Based on the sample size calculation for a population of 61, with a tolerable error and absolute precision of 10% and an assumed maximum proportion of 50%, the minimum required sample size was 33 patients. Therefore, the final sample size of 50 patients exceeded the minimum requirement.

3. Study Variables

The variables in this study included age, gender, neutropenia status, anemic status, nutritional status, duration to seek care, type of antibiotic administration, phase and complications of chemotherapy, type of ALL stratification, culture results, and length of hospitalization.

4. Operational Definition of Variables

Neutropenia status is assessed from absolute neutrophil count (ANC) levels <1500/ μ L (Gunawan et al., 2018).

Anemia status is assessed according to WHO recommendations, namely: no anemia (Hb $\geq$ 11 g/dl at age 6 months-5 years; $\geq$ 11.5 g/dl at age 5-11 years; $\geq$ 12 g/dl at age 12-18 years); mild anemia (Hb 10-10.9 g/dl at age <5 years; 11-11.4 g/dl at age 5-11 years; 11-11.9 g/dl at age 12-18 years); moderate anemia (Hb 7-9.9 g/dl at age 6 months-5 years; 8-10.9 g/dl at age 5-18 years) and severe anemia (Hb <7 g/dl at age 6 months-5 years; <8 g/dl at age 5-18 years) (Aggarwal et al., 2020).

Nutrition encompasses overnutrition, undernutrition, and malnutrition. Severe malnutrition is a nutritional condition

characterized by extreme thinness, with a mid-upper arm circumference (MUAC) of less than 11.5 cm in children aged 6–59 months. Moderate malnutrition is characterized by MUAC of 11.5–12.5 cm in children aged 6–59 months. For adolescents, malnutrition is determined by comparing the MUAC to the 50th percentile; the Waterlow calculation, using the Frisancho MUAC table, results in 85-100% (normal/well-nourished), 70-85% (under-nourished), <70% (severe malnutrition), and >100% (overweight, obesity) (Latief et al., 2021).

Duration to seek care was assessed in days from onset of symptoms to health facility visit, based on the median value. **Types of antibiotics** were assessed according to WHO guidelines.

Complications were assessed based on the presence or absence of one of the following complications: necrotizing pneumonia, parapneumonic effusion, empyema, pneumatocele formation, pleural effusion, and lung abscess (Rahajoe et al., 2018). Complication status was determined by chest X-ray (CXR) examination.

The chemotherapy phase was assessed based on the chemotherapy treatment phase based on the criteria of the 2018 Indonesian Protocol for Acute Lymphoblastic Leukemia, which distinguishes between induction and non-induction phases. Stratification of ALL was divided into high and standard risk according to the 2013 Indonesian Protocol for Acute Lymphoblastic Leukemia and Immunophenotype.

Culture results were determined as no growth or presence of microorganisms from the sputum samples.

Prolonged hospitalization was assessed based on a length of stay of >14 days, based on the mean value.

admission date until their discharge from the hospital.

5. Study Instruments

The measurement tool of this study is patients' medical records by taking data including initials, medical record number, admission and discharge dates, date of birth/age, gender, type of ALL protocol, weight, height and upper arm circumference, patient's vital signs at the time of inpatient admission, blood laboratory results, CXR and sputum culture results and therapy which received during treatment.

6. Data Analysis

The data collected was entered into the SPSS® 26 software program. The data were analyzed using the chi-square test. Bivariate analysis was performed using chi-square or Fisher's exact test, while multi-variate analysis was conducted using binary

logistic regression. The data analysis results are presented in tabular format containing frequency and percentage values. The level of significance in this study was declared significant at $p < 0.05$.

7. Research Ethic

This study has obtained ethical eligibility from the Health Research Ethics Committee of Dr. Moewardi General Hospital, Surakarta No. 1948/VIII/HREC/2025.

RESULTS

1. Sample Characteristics

The research subjects were 50 Children aged 1 month – 18 years old with ALL and pneumonia during the study period from January to December 2025. The characteristics of the study subjects are shown in Table 1, where most of the subjects were male (60%), the average age of the subjects was 7.42 years with a median of 6.5 years.

Table 1. Patient's characteristics

Variables	n (%)	Mean $\pm$ SD	Median (min-max)
Age (years)		7.42 $\pm$ 4.34	6.5 (1-17)
< 6 years	18 (36%)		
> 6 years	32 (64%)		
Gender			
Male	30 (60%)		
Female	20 (40%)		
Anemia		9.21 $\pm$ 2.85	8.65 (2.3-15.6)
No Anemia	13 (26%)		
Anemia	37 (74%)		
Nutritional status			
Normal	22 (44%)		
Malnutrition	28 (56%)		
Neutropenia		6419 $\pm$ 7992.13	3122 (80-37900)
No	31 (62%)		
Yes	19 (38%)		
Chemotherapy phase			
Induction	26 (52%)		
Non-Induction	24 (48%)		
Stratification of ALL			
High risk	41 (82%)		
Standard risk	9 (18%)		
Length of hospitalization (days)		13.94 $\pm$ 10.17	12.5 (3 - 45)
$\leq$ 14 days	34 (68 %)		
> 14 days	16 (32%)		

Most of the subjects had anemia (74%) with a mean and median Hb level of 9.21 g/dL and 8.65 g/dL. Some subjects also experienced malnutrition (56%), but not neutropenia (62%) with a mean and median ANC level of 6419 cells/ μ L and 3122 cells/ μ L. Other characteristics show that the induction and non-induction chemotherapy phases were relatively similar (52% and 48%) and the majority were in the high-risk

ALL stratification type (82%). The length of hospitalization in ALL patients with pneumonia ranged from 3-45 days, with a mean and median value of 13.9 and 12.5 days, respectively, where categorically most patients (68%) had a length of hospitalization ≤ 14 days.

Table 2 presents an overview of the therapeutic management and diagnosis aspects of ALL patients with pneumonia.

Table 2. Clinical profile of pneumonia patients

Variables	n (%)	Mean $\pm$ SD	Median (min-max)
Duration to seek care (day)		1.94 $\pm$ 1.53	1 (1-8)
<1 Day	31 (62%)		
>1 Day	19 (38%)		
Antibiotics			
WHO Standard (ampicillin + gentamicin)	36 (72%)		
Non-WHO Standard*	14 (28%)		
Complications			
None	48 (96%)		
Yes	2 (4%)		
Sputum Culture Results			
No growth	7 (14%)		
Growth	43 (86%)		

*Note: Non-WHO Standard consists of single injectable antibiotics Ampicillin (22%), Ceftriaxone (4%), and Meropenem (2%).

Most patients received care within 1 day (62%), were given antibiotics according to WHO standards, namely ampicillin and gentamicin (72%), and only a small proportion (4%) who experienced complications especially pleural effusion, but most

patients showed microorganism growth from their sputum culture (86%). The most common type of microorganism found was *Klebsiella pneumoniae* (20%), followed by *Pseudomonas aeruginosa* (12%) and *Acinetobacter baumannii* (10%) (Table 3).

Table 3. Distribution of Types of Cultured Microorganisms

Types of Microorganisms	n (%)
<i>Klebsiella pneumoniae</i>	10 (20%)
<i>Pseudomonas aeruginosa</i>	6 (12%)
<i>Acinetobacter baumannii</i>	5 (10%)
<i>Escherichia coli</i>	3 (6%)
<i>Staphylococcus aureus</i>	3 (6%)
<i>Enterobacter cloacae</i>	2 (4%)
<i>Streptococcus parasanguinis</i>	2 (4%)
<i>Streptococcus viridans</i>	2 (4%)
Other Bacteria*	10 (20%)
Not found (no growth)	7 (14%)

*Note: Other bacteria consist of *A. xylosoxidans*, *D. nishinomiyaensis*, *G. haemolysans*, Gram positive cocci, *K. oxytoca*, *K. ascorbata*, *K. kristinae*, *K. rosea*, *Rothia sp*, and *S. mitis* in 1 patient respectively.

2. Risk factors Analysis

Table 4 presents the results of the analysis of risk factors associated with prolonged hospitalization in ALL patients with pneumonia.

Table 4. Bivariate Analyses on the Risk Factors for Prolonged Hospitalization in Pneumonia Patients with ALL

Variables	length of hospital stay				OR	95% CI		p
	≤ 14 Days		>14 Days					
	(n=34)		(n=16)					
	n	%	n	%				
Age								
<6 years	14	77.8	4	22.2	2.10	0.56	7.87	0.266
> 6 years	20	62.5	12	37.5				
Gender					0.86	0.25	2.91	0.804
Male	20	66.7	10	33.3				
Female	14	70.0	6	30.0				
Anemia					1.08	0.28	4.23	1,000
No Anemia	9	69.2	4	30.8				
Anemia	25	67.6	12	32.4				
Neutropenia					1.43	0.42	4.79	0.566
No	22	71.0	9	29.0				
Yes	12	63.2	7	36.8				
Nutritional status					3.38	0.90	12.59	0.043*
Normal	18	81.8	4	18.2				
Malnutrition	16	57.1	12	42.9				
Duration to seek care					4.63	1.30	16.43	0.014*
≤1 Day	25	80.6	6	19.4				
>1 Day	9	47.4	10	52.6				
Antibiotics					1.95	0.54	7.05	0.330
WHO standards	26	72.2	10	27.8				
Non-WHO Standard	8	57.1	6	42.9				
Complications					n/s			1,000
No	32	66.7	16	33.3				
Yes	2	100.0	0	0.0				
Chemotherapy phase					1.13	0.34	3.69	0.846
Induction	18	69.2	8	30.8				
Non-Induction	16	66.7	8	33.3				
Stratification of ALL					4.62	0.52	40.58	0.240
Standard risk	8	88.9	1	11.1				
High risk	26	63.4	15	36.6				
Culture Results					3.21	0.35	29.24	0.406
No growth	6	85.7	1	14.3				
Positive	28	65.1	15	34.9				

Description: Chi Square test; Fisher exact test; n/s= not specified; OR= Odds Ratio; CI= Confidence Interval;

* significant at $p < 0.05$

The results showed that malnutrition and duration to seek care were significantly

associated with prolonged hospitalization ($p < 0.05$) and were independent predictors.

Patients who delay seeking care in more than one day had a six-fold greater risk experienced of prolonged hospitalization than patients who seek treatment within 1 day. Delays in seeking medical care remained consistently as the dominant risk factor (aOR= 6.40; 95% CI= 1.45–28.32; p= 0.014). Similarly, patients with malnutrition had approximately five times greater odds of experiencing prolonged hospitaliza-

tion compared to well-nourished patients (aOR= 5.26; 95% CI= 1.08–25.67; p= 0.040). Meanwhile, other variables including age, gender, anemia status, neutropenia, type of antibiotic, pneumonia complications, chemotherapy phase, type of ALL stratification, and sputum culture results were not statistically proven to be risk factors for prolonging the length of hospitalization.

Table 5. Multivariate Logistic Regression Analysis on the Risk Factors for Prolonged Hospitalization in Pneumonia Patients with ALL

Independent variables	aOR	95% CI		p
		Lower limit	Upper limit	
Nutritional status (malnutrition)	5.26	1.08	25.67	0.040
Duration to seek care (>1 Day)	6.40	1.45	28.32	0.014

DISCUSSION

Pneumonia continues to be a major contributor to illness and death among children globally. Although vaccination programs and antimicrobial treatments have improved, pneumonia continues to place a substantial burden on global health systems, especially in low- and middle-income countries. Length of hospitalization in patients with pneumonia and comorbidities varies widely. These differences are likely due to variations in the quality of care, sample size, sociodemographic factors, and other parameters across studies. According to a study by Alharbi et al. (2026), one of the causes of prolonged hospitalization in pneumonia patients is the presence of comorbid malignancies. However, to date, there has been no definitive study that establishes a standard length of hospitalization for patients with pneumonia and comorbid ALL.

Age is a prognostic factor in ALL. This study found that most patients were aged ≥6 years, resulting in no statistically significant association between age and length of hospitalization. Gender was also not

associated with prolonged hospital stay in children with ALL and pneumonia. Several previous studies have shown similar findings, indicating that gender is not a determining factor in whether a patient will have a shorter or longer hospital stay (Alharbi et al., 2026; Kebede et al., 2024; Sano et al., 2017).

Anemia status was also not associated with prolonged hospitalization. This result is consistent with the findings reported by Sukarno et al., which found no association between hemoglobin levels and severe pneumonia (OR=1.20; p=0.26) (Sukarno et al., 2023). In this study setting, patients with ALL routinely undergo complete blood counts (CBC) so that anemia can be detected and treated early. This finding is not relevant to the study by Dinku et al., which stated that there is an association between anemia and prolonged hospitalization (>5 days) (Dinku et al., 2023).

Results from the bivariate and multivariate analyses consistently identify malnutrition as an independent predictor of prolonged hospital stay. These findings are consistent with studies by Topal and

Tolunay (2021) and Niseteo et al. (2020), which reported that malnourished children had significantly longer hospital stays than well-nourished children, and that more severe malnutrition was associated with prolonged hospitalization and higher risk of nosocomial infections.

A study by Rizone et al. (2025) reported different findings that there was no relationship between nutritional status and length of hospitalization in pediatric pneumonia patients ($p = 0.422$). Another study by Mairuhu et al. (2021) also stated that there was no relationship between nutritional status and HAP in children with ALL undergoing chemotherapy, although quantitatively, subjects with poor nutritional status and malnutrition reached 63.3%. Malnutrition can prolong hospital stays, possibly because exposure to multiple illnesses can compromise the immune system in children, resulting in a reduced response to treatment and ultimately delayed recovery. Our study results indicate that nutritional status is a factor significantly associated with length of hospital stay. Therefore, nutritional interventions remain essential as part of comprehensive patient management.

Our analysis demonstrated no statistically significant association between neutropenia ($ANC < 1500$ cells/ μL) and prolonged hospitalization. However, patients with neutropenia had a 1.43-fold higher likelihood of hospital stays exceeding 14 days compared to those without neutropenia ($OR\ 1.43$, 95% $CI\ 0.42-4.79$). These findings are consistent with previous reports indicating that neutropenia is not invariably associated with pneumonia or severe infections. In pediatric populations, neutropenia is most commonly linked to mild viral illnesses and tends to resolve spontaneously without leading to pulmonary complications. Thus, neutropenia may

primarily influence susceptibility to infection rather than the duration of hospitalization (Tschermin et al., 2021). Furthermore, at our center, patients with acute lymphoblastic leukemia (ALL) who develop neutropenia routinely receive prophylactic antibiotics, which may contribute to comparable lengths of hospital stay between neutropenic and non-neutropenic patients. Based on Liu et al. study, severe neutropenia (< 500 cells/ μL) is linked to serious pulmonary infections and unfavorable outcomes. It is estimated that approximately 60% of cancer patients with chemotherapy-induced neutropenia exhibit pulmonary infiltrates on radiographic imaging. This is because myelosuppression can cause neutropenia, which can lead to infection. This is a common post-chemotherapy complication in children with leukemia and a leading cause of death (Liu & Li, 2022). A study by Mairuhu et al. (2021) also showed that neutropenia significantly influences the incidence of HAP in patients with ALL ($p < 0.01$).

Our study found no significant association between chemotherapy phase and length of hospitalization. Nevertheless, prior evidence indicates that infection remains a leading cause of morbidity and mortality in pediatric acute lymphoblastic leukemia (ALL) patients undergoing chemotherapy. Hospital-acquired pneumonia (HAP) is among the most frequent complications, particularly during the induction phase, with reported incidences of 13–31%. Furthermore, most infections occur during the induction and consolidation phases rather than the maintenance phase, likely reflecting the higher intensity of chemotherapy administered early to achieve remission (Mairuhu et al., 2021; Bakhshi et al., 2008). The results demonstrate that the number of patients undergoing induction chemotherapy

compared to non-induction chemotherapy was relatively similar. Inaba et al. (2017) also described that bloodstream infections occurred most frequently during the induction phase, followed by the reinduction phase. Pneumonia occurred most frequently during the reinduction phase or delayed intensification phase. In our study, patients undergoing non-induction chemotherapy had good laboratory profiles and clinical conditions, resulting in relatively similar lengths of hospital stay.

Our findings indicate that ALL stratification was also not significantly associated with a prolonged hospital stay. A study was conducted by Christensen et al. in Denmark from 1992 to 2001 on the incidence of infections in children with ALL during chemotherapy that resulted in death. It was found that the highest rate was seen in patients with high-risk stratification (57%), with $p < 0.005$ (Christensen et al., 2005). In contrast, a study conducted by Segulja et al. (2024) stated that infection is a common complication during leukemia therapy, but its distribution is not directly determined by risk stratification group. Infection can occur in all risk groups because most patients receive chemotherapy and are immunosuppressed. The lack of association between risk stratification and length of hospital stay in our study is likely due to several factors. Risk stratification in ALL patients is primarily used to determine chemotherapy protocols and long-term prognosis, rather than directly influencing the length of hospital stay during acute infectious episodes such as pneumonia.

The duration to seek care was found to be the most dominant independent predictor of prolonged hospital stay. A study by Teferi et al. in Ethiopia found that children who presented to the hospital within the first five days of pneumonia

symptoms had a faster recovery rate than children who presented later. This is due to the fact that when children delay seeking care during illness, the disease progresses and makes it more severe and complicated, ultimately resulting in a delayed recovery time. The median recovery time for severe community-acquired pneumonia in this study was 4 days (Teferi et al., 2024).

A study by Dinku et al. (2023) also showed that children who sought medical care late (after 3 days of illness) and were admitted to the hospital upon referral were at risk of experiencing a longer hospital stay. A delay of 3 or more days in seeking medical care from a health facility can increase the severity of the disease and complications, which can lead to worsening conditions and a longer recovery time. The majority of our subjects sought care within <1 day, suggesting that the onset of symptoms and delayed treatment can prolong the length of hospital stay.

The type of antibiotic (according to WHO standards) was also not a risk factor for prolonged hospitalization in pediatric ALL patients with pneumonia. A study by Garedow and Tesfaye (2022) stated that inappropriate antibiotic use may be associated with increased length of stay in patients with infections. Patients with a length of stay >7 days were more likely to receive inappropriate antibiotics (aOR 2.45; $p = 0.03$). The most frequently prescribed antibiotic combination was ampicillin + gentamycin (43.33%), followed by ceftriaxone + gentamycin (15.23%). Gentamycin 116 (24.11%) was the most frequently used antimicrobial. However, this previous study did not mention the type of infection. In contrast, a study by La Vecchia et al. (2025) described treatment according to WHO guidelines as also having a higher proportion of treatment failures (14.3% vs. 7.4%, $p = 0.02$), requiring longer oxygen therapy

(3.2 vs. 2.2 days, $p = 0.002$), and a longer period of hospitalization (6.5 vs. 5.6 days, $p = 0.007$).

According to the study by Alharbi et al. (2026), standard antibiotic therapy for community-acquired pneumonia in children generally ranges from 7 to 10 days. However, some children remain hospitalized beyond this period, suggesting that factors other than the duration of standard antimicrobial treatment contribute to longer hospitalizations and delayed recovery. Our study suggests that adherence to WHO guidelines is not always associated with longer hospitalizations in patients with pneumonia with ALL.

Based on the results of our study, there were 2 patients who experienced complications during treatment, and all (100%) were hospitalized for <14 days. The form of complication experienced by all patients was pleural effusion. However, the analysis results showed no significant relationship between complications and length of hospitalization in ALL patients with pneumonia. According to a study conducted by Alharbi et al. (2026), the presence of chronic medical conditions (one of which is oncological disease) as a comorbidity showed a significant association with longer hospitalization. The complication of pneumonia (mainly in the form of pleural effusion with or without necrotizing pneumonia) found in the study subjects was significantly associated with longer hospitalization.

In our study, positive sputum culture results were found in most patients (86%). The most common types of microorganisms were *Klebsiella pneumoniae* (20%), *Pseudomonas aeruginosa* (12%), and *Acinetobacter baumannii* (10%). This is consistent with a study by Evans and Ost (2015), which stated that the microorganisms most frequently causing community-acquired

pneumonia in children are *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Pseudomonas spp.*, and *Hemophilus influenzae*. A study by Sekowska et al. (2024) similarly found that *K. pneumoniae* infection occurred in 4.86% of pediatric hematology–oncology patients and in 4.95% of those undergoing hematopoietic cell transplantation. The infection rate was higher among patients with acute leukemia than those with solid tumors (7.8% vs. 4.1%; OR = 2.0; 95% CI = 1.6–2.4; $p < 0.0001$). This is due to frequent visits by ALL patients to the hospital to receive chemotherapy or improve their clinical condition, thus increasing the risk of exposure of ALL patients to *K. pneumoniae*, which is the most common pneumonia acquired from the nosocomial environment.

Most of the subjects in this study were treated for <14 days. According to Alharbi et al. (2026), the definition of prolonged hospitalization uses various thresholds, including 5, 7, 10, and 14 days. A retrospective study conducted by Liu and Li (2022) stated that the length of stay limit of ≥ 14 days as a category of prolonged hospitalization in pediatric patients with ALL who experienced pneumonia, where almost half of the patients (48.3%) experienced a stay of 14 days during treatment. Another study conducted by Zhou et al. (2025) in pediatric patients with pneumonia due to *Mycoplasma pneumoniae* (MPP), found that more than half of the subjects (51.93%) experienced prolonged hospitalization (LOS ≥ 7 days), and 12.85% had a length of stay of ≥ 11 days.

Another study that also analyzed predictors of prolonged hospitalization was a study conducted by Breuer et al. (2018), which stated that a hospitalization of 10 days or less was considered a standard length of stay, while a hospitalization of 11 days or more was considered a prolonged

hospitalization. The median LOS in that study was 13 days (range, 3-59 days). A study conducted by Sen et al. (2025) in Bangladesh also showed that pediatric patients with pneumonia had a length of stay of more than 14 days. In that study, the average length of stay in children aged ≤ 12 months was 15.42 days, while in children aged 13–36 months it was around 13.61 days, indicating that pneumonia in children can require up to two weeks of hospitalization.

This differs from a retrospective study conducted in India by Mohakud et al. (2018), where the mean length of stay for female patients was longer than for male patients (6.15 vs. 7.07 days; $p < 0.05$). Another study in Bali by Yamananda et al. (2019) stated that the length of stay (LOS) in pneumonia patients was 4-13 days, with a mean of 7.5 days. In children with severe pneumonia and comorbidities (such as malnutrition, congenital heart disease, or malignancy), prolonged LOS is often defined as a stay of ≥ 10 -14 days, considering that the standard treatment duration of 7-10 days is often insufficient to achieve clinical stability in this high-risk group. In our study, the mean length of stay was 14 days, and prolonged hospitalization was defined as > 14 days.

Extended hospital stays are linked to higher healthcare costs, an increased risk of hospital-acquired infections, greater psychological burden on patients and their families, and limited bed availability for other critically ill children. Identifying the factors associated with prolonged hospital stays enables healthcare providers to refine treatment strategies and apply targeted interventions to enhance patient outcomes (Alharbi et al., 2026).

The cross-sectional design used in this study only describes the risk factors for prolonged hospitalization in pneumonia

patients with ALL at a single measurement point and cannot explain causality. Mortality rates, a single-center setting, and limited literature on risk factors for prolonged hospitalization in pneumonia patients with ALL, as well as the COVID-19 pandemic, all contributed to sample bias in patients with pneumonia. Future studies should include larger, multicenter samples to improve statistical power and generalizability. Prospective or longitudinal designs are recommended to better assess causal relationships.

Based on the present findings, malnutrition and duration to seek care are risk factors of prolonged hospitalization in ALL pediatric patients with pneumonia. This condition indicates a fairly high physiological vulnerability in ALL patients with pneumonia complications. This study highlights important policy implications in the management of pediatric ALL patients with pneumonia. The identification of malnutrition and delayed healthcare-seeking behavior as predictors of prolonged hospitalization suggests the need for routine nutritional screening and early nutritional intervention in pediatric oncology care. In addition, strengthening caregiver education and improving early access to healthcare services are essential to reduce delays in treatment. Addressing these modifiable factors may help shorten hospital stays, reduce healthcare costs, and improve overall patient outcomes.

AUTHOR CONTRIBUTION

APS was responsible for the study conception and design, data analysis, and manuscript preparation. DAP contributed to the development of the background and discussion sections of the manuscript. SW contributed to the development of the conceptual framework and critically reviewed the manuscript. All authors

approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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