

## Research Article

# Identifying the Prevalence and Causes of 30-Day Hospital Readmission in Children: A Case Study from a Tertiary Pediatric Hospital

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## ABSTRACT

**Introduction:** The objectives of this study were to determine the prevalence of unplanned readmissions in the pediatric population within 30 days of discharge, identify the possible reasons behind them, and develop a predictive model for unplanned admissions. **Methods:** A retrospective chart review study of 25,211 patients was conducted to identify the prevalence of readmissions occurring within 30 days of discharge from the King Abdullah Specialized Children's Hospital (KASCH) in Riyadh, Saudi Arabia, between Jan 1, 2019, and Dec 31, 2021. The data were collected using the BestCare electronic health records system and analyzed using Jamovi statistical software version 1.6. **Results:** Among the 25,211 patients admitted to the hospital during the study period, the prevalence of unplanned readmission within 30 days was 1291 (5.12%). Of the 1291 patients, 1.91% had subsequent unplanned readmissions. In 57.8% of the cases, the cause of the first unplanned readmission was related to the cause of the first admission, and in 90.64% of the cases, the cause of the subsequent unplanned readmission was related to the cause of the first unplanned readmission. The most common reason for the first unplanned readmission was postoperative complications (18.75%), whereas pneumonia (10.81%) was the most common reason for subsequent unplanned readmissions. Most patients with subsequent unplanned readmissions were also found to have either isolated central nervous system pathology or chronic complex medical conditions. **Conclusion:** Internationally, the rate of unplanned readmissions in pediatric patients has been estimated to be 6.5% within 30 days, which is comparable to the results of our study (5.12%). Most of the causes of first and subsequent unplanned readmission were found to be related to primary admission. The diagnosis/causes of readmission vary depending on the patient's age. A predictive model for pediatric readmission should be established so that preventive measures can be implemented.

**Keywords:** pediatric population, predictive model, predisposing factors, unplanned hospital readmission

## INTRODUCTION

Unplanned hospital readmission is considered one of the most important key performance indicators in prominent and well-developed pediatric healthcare facilities.<sup>[1]</sup> Regardless of its cause, unplanned pediatric

readmissions pose a huge financial burden on the healthcare system. In addition, it causes unnecessary disruption to patients and their caregivers and inhibits the ideal patient experience. According to several scholarly papers, many pediatric readmissions are preventable.<sup>[2]</sup>

Many definitions of unplanned hospital readmission exist in the literature. However, the most widely used quality indicator definition is the unpredictable presence of a patient in any acute healthcare setting within 30 days of hospital discharge.<sup>[2]</sup>

The rate of unplanned pediatric readmission varies across pediatric institutions<sup>[3,4]</sup>; however, it has been estimated that 6.5% of pediatric patients experience unplanned readmission to acute care children's hospitals within 30 days of discharge.<sup>[4]</sup> The differences in the rates of unplanned readmissions among pediatric healthcare facilities are not necessarily a direct reflection of care quality but might be a result of variations in the underlying regional hospitalization rates.<sup>[5]</sup>

The proportion of preventable readmissions is debatable in the literature. Many factors need to be considered when predicting the preventability of readmission, particularly in the pediatric population, including patient age, socioeconomic status, complexity of the patient's condition, and other variables. Simple interventions are needed to control the rate of asthma readmission cases; for instance, complex chronic medical conditions require major healthcare system reforms to achieve this goal. This explains the wide variability in the literature regarding the percentage of preventable readmissions in the pediatric population (between 30% and 79%).<sup>[6,7]</sup> Known factors for preventing or decreasing recurrent readmission rates in chronic complex patients include continuity of care provided by a multidisciplinary team, easy access to care for emerging concerns, connection with home healthcare, close post-discharge follow-up, and health coaching activities for caregivers.<sup>[8]</sup> Despite the lack of prediction models for these admissions, some researchers have developed prediction models that help identify patients at high risk of readmission.<sup>[9,10]</sup>

To the best of our knowledge, no studies on pediatric readmissions in the Arab Gulf region have been published. Most international studies have addressed the rate and risk factors associated with hospital readmission; however, only a few have explored the reasons for these readmissions.<sup>[5]</sup> Therefore, this research project aimed to serve as a local reference for any quality project in the region that intends to study the factors contributing to pediatric readmissions in a local context. Hospital readmission data, based on medical records from a tertiary children's specialist hospital in Riyadh from January 2019 to December 2021 were analyzed. The analysis was used to estimate the prevalence and structure of rehospitalization, explore the reasons for readmission, and scrutinize patient-related risk factors of readmission. This study aimed to determine the prevalence of unplanned readmissions in the pediatric population within 30 days of discharge, recognize the possible reasons behind them, and develop a predictive model for unplanned admissions.

## MATERIALS AND METHODS

### Design and Setting

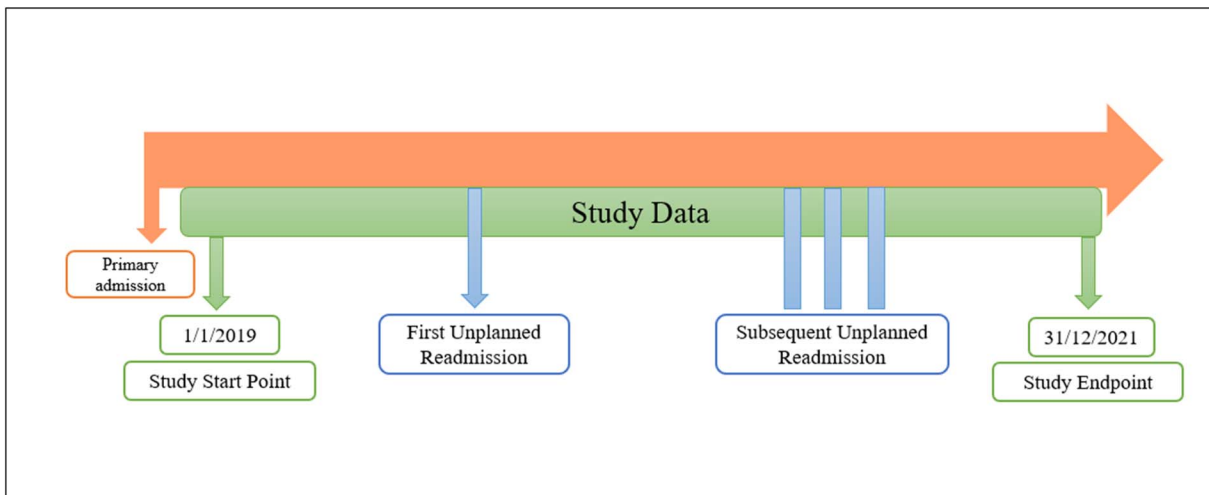
This was a single-center retrospective cohort study (chart review) that investigated hospital readmissions at King Abdullah Specialized Children's Hospital (KASCH) in Riyadh, Kingdom of Saudi Arabia, from Jan 1, 2019, to Dec 31, 2021. KASCH is a tertiary (referral) center with highly specialized pediatric professionals. The hospital capacity is almost 350 beds, divided into 25 pediatric intensive care unit (PICU) beds, 24 high-dependency unit (HDU) beds, and 75 neonatal intensive care unit beds, and the rest are for general and subspecialty wards. On average, the number of annual admissions to KASCH was nearly 8386. This study was approved by the Research and Ethics Committee of King Abdullah International Medical Research Center (KAIMRC). Data were accessed only by the principal investigator and co-investigators and secured using a password. Data were managed and stored within the KAIMRC facilities according to institutional policies.

### Participants

The study sample included all patients admitted to KASCH during the study period. Patients who met the criteria for readmission, including all pediatric patients aged 14 years or younger who had a history of unplanned readmission within 30 days of hospital discharge, were included for the analysis of unplanned readmissions. Patients with planned hospital readmissions were excluded from the study, specifically those who met the following criteria: (1) patients admitted for elective surgical procedures, (2) patients admitted for imaging studies, and (3) patients admitted for chemotherapy or recurrent infusion therapy.

### Data Collection Methods

All unplanned readmissions that met the inclusion criteria were followed from the first readmission until discharge. First readmission in our study refers to the first unplanned readmission within 30 days of a recent hospital stay of the patient. We have also reported on further unplanned readmissions following the first readmission during the study period and we referred to these as subsequent unplanned readmissions (Fig. 1). The association between readmission and primary admission was categorized into three categories: (1) immediately related, in which the cause of readmission was exactly the same as the cause of admission; (2) partially related, in which the cause of readmission was a consequence of the cause of admission or related to a procedure that was performed during the primary admission; and (3) unrelated, in which there was no association between the cause of readmission and primary admission. A retrospective chart review was conducted, in which four well-trained interns reviewed electronic charts and then extracted data into a data collection form (see the Supplemental Material,



**Figure 1.** Study chronological flow chart.

available online). The principal investigator also reviewed the data for accuracy. The data included both the independent and dependent variables. The independent variables included demographic data (sex, nationality, age), first unplanned readmission (day of admission, date of admission, date of discharge, interval [in days], total days of hospital stay, PICU stay, total PICU stay days, history of chronic disease, complexity of the medical condition), and subsequent readmissions. The dependent variable was unplanned readmission(s).

**Statistical Analysis**

Data were recorded using Microsoft Excel and are presented as tables and graphs. The Jamovi program (version 1.6) was used for data analysis. Continuous variables are presented as median (25<sup>th</sup> percentile, 75<sup>th</sup> percentile) and compared using the Mann-Whitney *U* test (nonparametric data). Categorical variables were presented as frequencies and percentages and were compared using Pearson’s chi-square test. The odds ratio (95% CI) and between-group differences (95% CI) were calculated. A multiple linear regression model with a beta coefficient (95% CI) was built to correlate the different factors with readmission. Statistical significance was considered when the two-tailed *p*-value was less than 0.05.

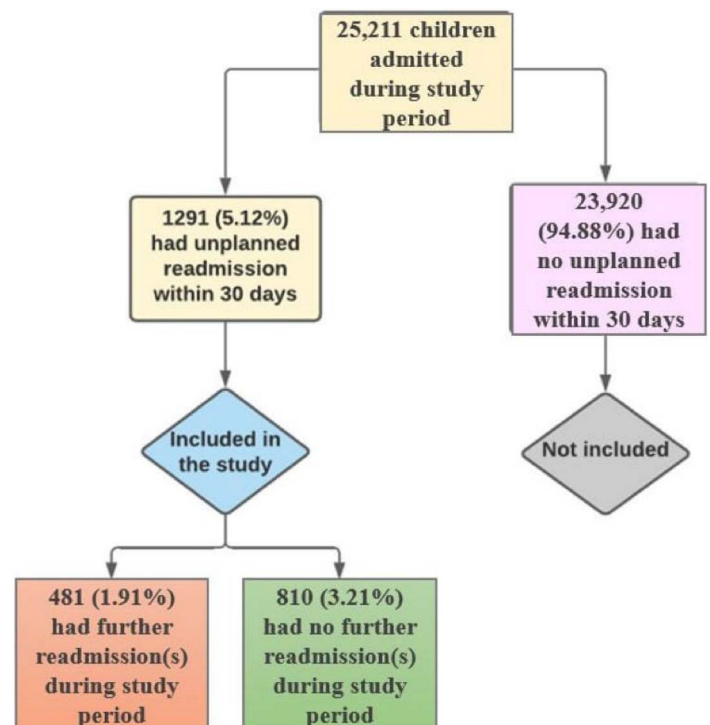
**RESULTS**

During the study period, 25,211 children were admitted to KASCH. The prevalence of unplanned readmissions within 30 days was 5.12% (1291 patients). The prevalence of subsequent unplanned readmissions during the study period was 1.91% (481 patients; Fig. 2).

As shown in Table 1, most of the patients were male (57.4%). The median age was 3 (0.7, 6) years; 50 (3.9%) were neonates, 349 (27%) were infants, 152 (11.8%) were toddlers, 429 (24.1%) were preschool children, and 311 (24.1%) were school children.

For most children (57.8%), the first unplanned readmission (within 30 days of discharge) was directly related to the primary admission, 32.3% were readmitted due to different unrelated conditions, and for 9.9% of the cases, the causes of readmission were partially related to primary admission. The conditions affecting 5% or more of patients are listed in Table 1. The most common causes of readmission were postoperative complications (18.75%), bronchiolitis (9.99%), pneumonia (8.06%), and gastroenteritis (7.51%).

The most common associated chronic conditions were genetics/syndromes (13.48%), asthma (12.39%), isolated



**Figure 2.** Prevalence of unplanned hospital readmissions.

**Table 1.** Patients' admission characteristics

Characteristic	Value
No. of patients	1291
Sex	
Male	741 (57.4)
Female	550 (42.6)
Age (y)	
Mean (SD)	4.0 (3.8)
Median (Q1, Q3)	3 (0.7, 6)
Age group	
Neonate ( $\leq 28$ d)	50 (3.9)
Infant (1 mo–1 y)	349 (27.0)
Toddler (1–2 y)	152 (11.8)
Preschool child (2–6 y)	429 (33.2)
School child (6–14 y)	311 (24.1)
Related to primary admission	
Unrelated	417 (32.3)
Immediately related	746 (57.8)
Partially related	128 (9.9)
Primary cause for first readmission*	
Postoperative	242 (18.75)
Bronchiolitis	129 (9.99)
Pneumonia	104 (8.06)
Gastroenteritis	97 (7.51)
URTI	71 (5.5)
Associated chronic disease/condition*	
Genetic/syndromes	174 (13.48)
Asthma	160 (12.39)
Isolated CNS problem	137 (10.61)
Isolated congenital heart disease	122 (9.45)
Malignancy	120 (9.3)
Medical complexity**	
No	1194 (92.5)
Yes	97 (7.5)
Time of admission per week***	
Weekday	845 (65.5)
Weekend	446 (34.5)
Interval between discharge and first readmission	
<10 days	821 (63.6)
10–20 days	331 (25.6)
21–30 days	134 (10.8)
Initial place of readmission	
PICU	67 (5.2)
General ward	1173 (90.9)
HDU	51 (4.0)
Total days of hospital stay	
Mean (SD)	6.3 (16.0)
Median (Q1, Q3)	3 (1, 6)
PICU stay	
No	1164 (90.2)
Yes	127 (9.8)
Total PICU stay days	
Mean (SD)	0.5 (2.6)
Median (Q1, Q3)	0 (0, 0)
No. of repeated readmission(s) during study period	
0	810 (62.74)
1	251 (19.44)
2–5	172 (13.32)
>5	58 (4.49)
Diagnosis of further readmissions* (n = 481)	
Pneumonia	52 (10.81)
PUO	42 (8.73)
Gastrointestinal problems other than gastroenteritis	33 (6.86)
Isolated CNS problem	33 (6.86)

*Table 1 continues on next Column*

**Table 1.** Continued

Characteristic	Value
URTI	33 (6.86)
Metabolic disorder	29 (6.03)
Bronchiolitis	28 (5.82)
Related to first readmission (n = 481)	
No	45 (9.36)
Yes	436 (90.64)

Data are presented as n (%), mean (SD), or median (Q1, Q3).

\*Only causes/conditions with a percentage  $\geq 5\%$  are listed.

\*\*Criteria for a complex medical condition are (1) technology dependency, (2) at least four major body systems involved, (3) having  $\geq 2$  admissions per year, and (4) requiring 12 outpatient clinic visits per year.

\*\*\*Weekend: from Thursday at 5 p.m. to Sunday at 8 a.m.

CNS: central nervous system; HDU, high-dependency unit; PICU: pediatric intensive care unit; PUO: pyrexia of unknown origin; URTI: upper respiratory tract infection.

central nervous system (CNS) problems (10.61%), isolated congenital heart diseases (9.45%), and malignancy (9.3%). Furthermore, 7.5% of the first unplanned readmission patients are known to have complex medical conditions. According to local hospital guidelines, a complex medical disease is defined as any condition with the following criteria: (1) technology dependency, (2) involvement of at least four major body systems, (3) having two or more admissions per year, and (4) requiring 12 outpatient clinic visits per year.

Most admissions were carried out on weekdays (65.5%) rather than on weekends (34.5%); 63.6% of the children were readmitted within 10 days of discharge, 25.6% were readmitted 10–20 days post-discharge, and 10.8% were readmitted 21–30 days after discharge. Most patients (90.9%) were initially readmitted to the general ward, 5.2% were admitted to the PICU, and 4% were admitted to the HDU. Of the patients, 9.8% were admitted to the PICU during admission. The average duration of hospital stay for all children was 3 (1, 6) days. The mean duration of PICU stay was 0.5 ( $\pm 2.6$  SD) days (median = 0).

During the study period, 481 of the 1291 children (1.91%) had one or more subsequent unplanned readmissions after the first unplanned readmission; 19.44% were readmitted once, 13.32% were readmitted two to five times, and 4.49% were readmitted more than five times. In 90.64% of cases, such subsequent unplanned readmission was related to the first readmission (same condition or sequelae). The most common causes of readmission were pneumonia (10.81%), gastrointestinal problems other than gastroenteritis (6.86%), pyrexia of unknown origin (8.73%), isolated CNS problems (6.86%), upper respiratory tract infections (URTI) (6.86%), metabolic disorders (6.03%), and bronchiolitis (5.82%).

Among all age groups, most readmissions were found to be related to the primary admission. The highest percentage of readmissions was observed among neonates (60%), and the lowest was among toddlers (54.6%),

**Table 2.** Patients' age-specific admission characteristics

	Neonate (0–28 d) (n = 50)	Infant (1 mo–1 y) (n = 349)	Toddler (1–2 y) (n = 152)	Preschool child (2–6 y) (n = 429)	School child (6–14 y) (n = 311)	Total (N = 1291)	p-value*
Relation of first readmission to primary admission							0.391
No	14.0 (28.0)	116.0 (33.2)	56.0 (36.8)	143.0 (33.3)	88.0 (28.3)	417.0 (32.3)	
Yes	30.0 (60.0)	201.0 (57.6)	83.0 (54.6)	250.0 (58.3)	182.0 (58.5)	746.0 (57.8)	
Partially related	6.0 (12.0)	32.0 (9.2)	13.0 (8.6)	36.0 (8.4)	41.0 (13.2)	128.0 (9.9)	
Medical Complexity**							<0.001
No	50.0 (100.0)	304.0 (87.1)	137.0 (90.1)	410.0 (95.6)	293.0 (94.2)	1194.0 (92.5)	
Yes	0.0 (0.0)	45.0 (12.9)	15.0 (9.9)	19.0 (4.4)	18.0 (5.8)	97.0 (7.5)	
Interval between discharge and first readmission, days							0.018
<10	41.0 (82.0)	224.0 (64.2)	86.0 (56.6)	274.0 (63.9)	196.0 (63.0)	821.0 (63.6)	
10–20	7.0 (14.0)	94.0 (26.9)	42.0 (27.6)	106.0 (24.7)	82.0 (26.4)	331.0 (25.6)	
21–30	2.0 (4.0)	30.0 (8.9)	24.0 (15.8)	49.0 (11.4)	29.0 (10.6)	134.0 (10.8)	
Relation of subsequent readmissions to first readmission	(n = 24)	(n = 115)	(n = 54)	(n = 173)	(n = 115)	(N = 481)	0.035
No	2.0 (8.3)	16.0 (13.9)	9.0 (16.7)	13.0 (7.5)	5.0 (4.3)	45.0 (9.4)	
Yes	22.0 (91.7)	99.0 (86.1)	45.0 (83.3)	160.0 (92.5)	110.0 (95.7)	436.0 (90.6)	

Data are presented as *n* (%).

\*Pearson's chi-squared test.

\*\*Criteria for medical complexity: technology dependency, four major body systems involvement,  $\geq 2$  admissions per year, and 12 outpatient clinic visits per year.

although no significant difference was observed (Table 2). Complex conditions (7.5%) were the most common among infants (12.9%) and toddlers (9.9%;  $p < 0.001$ ). There was a significant difference in the interval between primary admission and first readmission among the different age groups ( $p = 0.018$ ). The admission rate within 10 days of discharge (63.6%) was the highest among the neonates. In contrast, readmissions 11–20 days (25.6%) and 21–30 days after discharge (10.8%) were the lowest among the neonates (14% and 4%, respectively). Admission related to the first unplanned readmission was lowest among toddlers (83.3%) and highest among school children (95.7%;  $p = 0.035$ ). The common morbidities among the different age groups are shown in Table 3.

The causes of the first unplanned readmission, subsequent readmissions, and chronic conditions associated with readmissions varied depending on the age category, as shown in Table 3. During the neonatal period, the most common causes of both first and subsequent readmissions were neonatal jaundice and bronchiolitis, with a chronic medical history of renal disease (10%). In infancy (1 month–1 year), bronchiolitis was the most common cause of both first and subsequent readmissions. The most common cause of readmission in toddlers, preschool-age, and school-age children was postoperative complications followed by pneumonia; however, the causes of subsequent readmissions for the three categories were pneumonia, pyrexia of unknown origin, and gastrointestinal tract problems other than gastroenteritis.

Asthma was the most common chronic condition associated with readmission in the preschool children age group and the second most common in the school-age group after malignancy, whereas syndromes were the most

common associated condition for toddlers who had frequent readmissions.

As shown in Table 4, patients whose reasons for primary admission and first readmission were the same were less likely to have subsequent readmission.

Patients with subsequent readmissions had greater odds of developing pneumonia, neutropenia, and gastrointestinal tract (GIT) problems other than gastroenteritis. They had a lower likelihood of admissions due to postoperative complications and bleeding from any cause. The two groups were comparable in terms of the odds of gastroenteritis, isolated CNS problems, and URTI.

Regarding history of chronic conditions, patients with subsequent readmissions had higher odds of isolated CNS problems, malignancy, metabolic disorders, and syndromes. Patients with subsequent readmissions were more likely to have complex conditions than those who did not.

### Predictive Model for Unplanned Pediatric Hospital Readmissions

Based on the data available from this study, several predictive models for the risk factors of unplanned readmissions in pediatric hospitals have been examined.<sup>[11]</sup> The most practical and statistically constant models are listed in Table 5. This model was constructed using a multiple linear regression analysis. This predictive model was established based on different variables that influence the readmission rate in the pediatric population. The model fit using the F-test was statistically significant ( $F = 18.95$ ,  $p < 0.001$ ). Unfortunately, the  $R^2$  was 0.16, which means that this model may account for only 16% of the variations in the dependent variable (subsequent readmissions).

**Table 3.** Common morbidities among different age groups of pediatric hospital admissions

	<b>Most Common Causes for First Readmission</b>	<b>Most Common Causes for Subsequent Readmissions</b>	<b>Most Common Associated Chronic Diseases/Conditions</b>
Neonate (0–28 d)	<ul style="list-style-type: none"> <li>• Jaundice: 18/50 (36.0%)</li> <li>• Bronchiolitis: 10/50 (20.0%)</li> <li>• Abnormal labs: 4/50 (8.0%)</li> <li>• Other: 18/50 (36%)</li> </ul>	<ul style="list-style-type: none"> <li>• Jaundice: 8/24 (33.3%)</li> <li>• Bronchiolitis: 5/24 (20.8%)</li> <li>• GIT problem other than GA: 2/24 (8.3%)</li> <li>• Other: 9/24 (37.5%)</li> </ul>	<ul style="list-style-type: none"> <li>• Renal problem: 5/50 (10.0%)</li> <li>• Blood disorder: 4/50 (8.0%)</li> <li>• Isolated congenital heart disease: 3/50 (6.0%)</li> <li>• Other: 38/50 (76%)</li> </ul>
Infant (1 m–1 y)	<ul style="list-style-type: none"> <li>• Bronchiolitis: 97/349 (27.8%)</li> <li>• Gastroenteritis: 41/349 (11.7%)</li> <li>• Isolated CNS problem: 32/349 (9.17%)</li> <li>• Other: 179/349 (51.3%)</li> </ul>	<ul style="list-style-type: none"> <li>• Bronchiolitis: 19/115 (16.5%)</li> <li>• Pneumonia: 15/115 (13.0%)</li> <li>• URTI: 13/115 (11.3%)</li> <li>• Other: 68/115 (59.13%)</li> </ul>	<ul style="list-style-type: none"> <li>• Isolated congenital heart disease: 71/349 (20.3%)</li> <li>• Syndromic: 49/349 (14.0%)</li> <li>• Isolated CNS problem: 33/349 (9.64%)</li> <li>• Others: 196/349 (56.16%)</li> </ul>
Toddler (1–2 y)	<ul style="list-style-type: none"> <li>• Postoperative: 24/152 (15.8%)</li> <li>• Pneumonia 18/152 (11.8%)</li> <li>• Bronchiolitis: 17/152 (11.2%)</li> <li>• Other: 93/152 (61.18%)</li> </ul>	<ul style="list-style-type: none"> <li>• Pneumonia: 8/54 (14.8%)</li> <li>• Respiratory/lung problem: 7/54 (13.0%)</li> <li>• Metabolic disorder: 5/54 (9.3%)</li> <li>• Other: 34/54 (63%)</li> </ul>	<ul style="list-style-type: none"> <li>• Syndromic: 20/152 (13.2%)</li> <li>• Isolated CNS problem: 19/152 (12.5%)</li> <li>• Isolated congenital heart disease: 17/152 (11.2%)</li> <li>• Other: 96/152 (63.17%)</li> </ul>
Preschool child (2–6 y)	<ul style="list-style-type: none"> <li>• Postoperative: 120/429 (28.0%)</li> <li>• Pneumonia: 38/429 (8.9%)</li> <li>• Neutropenia: 32/429 (7.5%)</li> <li>• Other: 239/429 (55.71%)</li> </ul>	<ul style="list-style-type: none"> <li>• PUO: 25/173 (14.5%)</li> <li>• Pneumonia: 22/173 (12.7%)</li> <li>• Isolated CNS problem: 14/173 (8.1%)</li> <li>• Other: 122/173 (70.52%)</li> </ul>	<ul style="list-style-type: none"> <li>• Asthma: 77/429 (17.9%)</li> <li>• Syndromic: 73/429 (17.0%)</li> <li>• Isolated CNS problem: 63/429 (14.67%)</li> <li>• Other: 216/429 (50.4%)</li> </ul>
School child (6–14 y)	<ul style="list-style-type: none"> <li>• Postoperative: 80/311 (25.7%)</li> <li>• GIT problem other than GA: 21 (6.8%)</li> <li>• Pneumonia: 20/311 (6.4%)</li> <li>• Other: 19/311 (60.1%)</li> </ul>	<ul style="list-style-type: none"> <li>• GIT problem other than GA: 13/115 (11.3%)</li> <li>• Malignancy: 10/115 (8.7%)</li> <li>• PUO: 10/115 (8.7%)</li> <li>• Other: 80 (69.67%)</li> </ul>	<ul style="list-style-type: none"> <li>• Malignancy: 46/311 (14.8%)</li> <li>• Asthma: 44/311 (14.1%)</li> <li>• Isolated CNS problem: 43/311 (13.83%)</li> <li>• Other: 178/311 (57.23%)</li> </ul>

Data are presented as *n* (%).

CNS: central nervous system; GA: gastroenteritis; GIT: gastrointestinal tract; PUO: pyrexia of unknown origin; URTI: upper respiratory tract infection.

**Table 4.** First readmission disease characteristics among patients with and without subsequent readmissions

	Subsequent Readmission(s)		Total (N = 1291)	Difference Between Groups (95% CI)	Odds Ratio (95% CI)	p-value*
	No (n = 810)	Yes (n = 481)				
Related to primary admission						<0.001
No	218.0 (26.9)	199.0 (41.4)	417.0 (32.3)			
Yes	532.0 (65.7)	214.0 (44.5)	746.0 (57.8)			
Partially related	60.0 (7.4)	68.0 (14.1)	128.0 (9.9)			
Primary cause for first readmission**						
Pneumonia	53.0 (6.5)	51.0 (10.6)	104.0 (8.1)	4 (1 to 7)	1.69 (1.13–2.53)	0.010
Neutropenia	21.0 (2.6)	32.0 (6.7)	53.0 (4.1)	4 (2 to 7)	2.68 (1.53–4.7)	<0.001
Postoperative	209.0 (25.8)	33.0 (6.9)	242.0 (18.7)	-19 (-20 to -15)	0.21 (0.14–0.3)	<0.001
Gastroenteritis	71.0 (8.8)	26.0 (5.4)	97.0 (7.5)	-3 (-6 to -1)	0.6 (0.4–0.9)	0.027
Isolated CNS problem	44 (5)	36 (7)	80 (6)	2 (-1 to 5)	1.41 (0.89–2.22)	0.139
Bleeding	35.0 (4.3)	4.0 (0.8)	39.0 (3.0)	-3 (-5 to -1)	0.19 (0.07–0.5)	<0.001
GIT problem	23.0 (2.8)	26.0 (5.4)	49.0 (3.8)	3 (0.2 to 5)	1.96 (1.1–3.47)	0.020
URTI	41.0 (5.1)	30.0 (6.2)	71.0 (5.5)	1 (-1 to 4)	1.25 (0.077–2.03)	0.370
UTI	19.0 (2.3)	29.0 (6.0)	48.0 (3.7)	4 (1 to 6)	2.67 (1.48–4.82)	<0.001
Associated chronic disease/condition**						
Asthma	95.0 (11.7)	65.0 (13.5)	160.0 (12.4)	2 (-2 to 6)	1.18 (0.83–1.65)	0.347
Isolated congenital heart disease	66.0 (8.1)	56.0 (11.6)	122.0 (9.5)	3 (0.06 to 7)	1.49 (1.02–2.16)	0.038
Isolated CNS problem	60 (7.41)	77 (16.01)	137 (10.61)	9 (5 to 12)	2.38 (1.66–3.41)	<0.001
Malignancy	51.0 (6.3)	69.0 (14.3)	120.0 (9.3)	8 (5 to 12)	2.49 (1.7–3.65)	<0.001
Metabolic disorder	11.0 (1.4)	34.0 (7.1)	45.0 (3.5)	6 (4 to 8)	5.52 (2.77–11)	<0.001
Syndromic	68.0 (8.4)	106.0 (22.0)	174.0 (13.5)	13 (10 to 17)	3.08 (2.22–4.29)	<0.001
Complex or not (Yes)***	24.0 (3.0)	73.0 (15.2)	97.0 (7.5)	12 (9 to 16)	5.86 (3.64–9.44)	<0.001

Data are presented as n (%).

\*Pearson's chi-squared test.

\*\*Diagnoses with a percentage  $\geq 5\%$  in any age group are listed.

\*\*\*Criteria for a complex condition: use of any machine, four systems involved,  $\geq 2$  admissions per year, or 12 outpatient clinic visits per year.

CNS: central nervous system; GIT: gastrointestinal tract; URTI: upper respiratory tract infection; UTI: urinary tract infection.

In this model, when age increased by 1 year, the number of readmissions increased by 0.05 cases/patient ( $p = 0.008$ ), provided that other factors were constant (*ceteris paribus*). Patients who were initially admitted to the PICU experienced a decreased frequency of subsequent readmissions by 1.2 ( $p = 0.007$ ); however, overall PICU admission was associated with an increased frequency of subsequent readmissions by 1.22 ( $p < 0.001$ ). The initial admission to the HDU was not related to the number of subsequent readmissions when compared with general ward admissions ( $p = 0.97$ ).

Regarding the primary cause of the first readmission, postoperative complications were associated with a decrease in the number of subsequent readmissions by 0.82 [-1.21, -0.42] ( $p < 0.001$ ). Gastroenteritis was associated with a decrease in subsequent readmissions of 0.56 [-1.11, -0.01] ( $p = 0.047$ ), and isolated CNS problems were associated with a decrease in subsequent readmissions of 1.01 [-1.65, -0.37] ( $p = 0.002$ ).

Regarding the associated chronic conditions, asthma was associated with an increase in the number of subsequent readmissions by 0.49 [0.05, 0.93] ( $p = 0.029$ ). Isolated CNS problems were associated with an increase of 0.98 [0.48, 1.49] ( $p < 0.001$ ). Metabolic disorders were associated with an increase in subsequent readmissions by 4.04 [3.24, 4.83] ( $p < 0.001$ ). Syndromes were associated with an increase of 0.71 [0.26, 1.15] ( $p = 0.002$ ). Malignancy was associated with an increase of 0.52

[0, 1.04] ( $p = 0.048$ ). Complicated conditions were associated with an increase of 1.48 [0.90, 2.05] ( $p < 0.001$ ).

## DISCUSSION

This study investigated hospital readmissions in KASCH, Riyadh, Saudi Arabia, between January 2019 and December 2021. The prevalence of unplanned readmissions within 30 days was 5.12% (1291/25,211). Most of the participants were male (54.4%), and the highest rate of readmission was among newborns (27%); however, a study conducted in Australia found that readmission rates were higher in patients aged 16 years or older.<sup>[12]</sup>

Our study included the first unplanned readmissions and subsequent readmissions. Most of the first unplanned readmissions were related to the primary diagnosis at admission. A study by Berry et al<sup>[4]</sup> supports the aforementioned finding, as 48.3% of readmissions were for a diagnosis involving the same organ system or a related etiology as the original admission. In our study, the most common causes of readmission were postoperative complications, bronchiolitis, pneumonia, and gastroenteritis. Our top causes of readmission are consistent with an Australian study in which procedural complications ranked as the reason for the most readmissions.<sup>[12]</sup>

**Table 5.** Predictive model for unplanned pediatric hospital readmissions

Predictor	Estimate	SE	95% CI		t	P
			Lower	Upper		
Intercept <sup>a</sup>	0.49	0.13	0.23	0.75	3.73	< 0.001
Age year	0.05	0.02	0.01	0.09	2.64	0.008
Place of initial admission:						
PICU – General ward <sup>a</sup>	-1.20	0.44	-2.06	-0.33	-2.71	0.007
HDU – General ward <sup>a</sup>	0.01	0.38	-0.73	0.76	0.03	0.974
PICU stay (Yes/No <sup>a</sup> )	1.22	0.33	0.57	1.87	3.68	< 0.001
Primary cause for first readmission:						
Postoperative (Yes/No <sup>a</sup> )	-0.82	0.20	-1.21	-0.42	-4.07	< 0.001
Gastroenteritis (Yes/No <sup>a</sup> )	-0.56	0.28	-1.11	-0.01	-1.99	0.047
Isolated CNS problem (Yes/No <sup>a</sup> )	-1.01	0.33	-1.65	-0.37	-3.10	0.002
Associated chronic disease/condition:						
Asthma (Yes/No <sup>a</sup> )	0.49	0.22	0.05	0.93	2.19	0.029
Isolated CNS problem (Yes/No <sup>a</sup> )	0.98	0.26	0.48	1.49	3.81	< 0.001
Malignancy (Yes/No <sup>a</sup> )	0.52	0.26	0.00	1.04	1.98	0.048
Metabolic disorder (Yes/No <sup>a</sup> )	4.04	0.40	3.24	4.83	10.00	< 0.001
Syndromic (Yes/No <sup>a</sup> )	0.60	0.23	0.15	1.05	2.64	0.008
Complex or not (Yes/No <sup>a</sup> )**	1.48	0.29	0.90	2.05	5.04	< 0.001

<sup>a</sup>Represents reference level.

\* $R^2 = 0.16$ , F-test = 18.95;  $p < 0.001$ .

\*\*Criteria for a complex condition: use of any machine, four systems involved,  $\geq 2$  admissions per year, or 12 outpatient clinic visits per year.

CNS: central nervous system; HDU: high-dependency unit; PICU: pediatric intensive care unit.

Most children (63.6%) were readmitted within the first 10 days after discharge. Most patients (90.9%) were initially readmitted to the general wards, and only 5.2% were readmitted to the PICU. The apparent causes of readmission could be attributed to differences in care during hospitalization and pre-discharge instructions, such as discharge-provided information, medication prescriptions, and outpatient follow-up.<sup>[13,14]</sup> Other factors include post-discharge interventions (e.g., hotlines for patient inquiries, home visits, or follow-up phone calls).<sup>[15]</sup>

Social factors can play a role in the number of readmissions (e.g., working parents who cannot provide care for their children at home, paternal concerns, or inability to provide care to their children at home).<sup>[16]</sup> Other factors affecting readmission include patient characteristics and underlying chronic illnesses that can exacerbate the acute illness that the patient initially presents with. We examined the associated comorbidities of readmitted patients, and the most common conditions were syndromes, followed by asthma and CNS problems.

Most readmissions occurred on weekdays (65.5%) rather than on weekends (34.5%). Our study did not examine the relationship between weekend discharge/admission and readmission, which requires further detailed studies to address the potential factors behind this variability. However, other studies have reported that most unplanned readmissions occur when admissions and discharges are on weekends.<sup>[17,18]</sup> This could be explained by a shortage of medical staff on weekends or by parents wishing to have their children discharged on weekends.

The opportunity to reduce pediatric readmissions depends on whether the readmission conditions are preventable. Based on our findings, the most common

causes of readmission are preventable with close follow-up and providing safety netting (safety precautions/adequate discharge information), as the patient is prepared for discharge.

The characteristics of the patients with and without subsequent readmissions were explored and reported in this study. By exploring the characteristics of patients in terms of the reasons for primary admission, it was found that patients with subsequent readmissions had greater odds of pneumonia, neutropenia, GIT problems other than gastroenteritis, and urinary tract infection. Similarly, pulmonary conditions resulted in the greatest number of readmissions, followed by cardiovascular and neurological conditions, according to a prospective study conducted between 2016 and 2017.<sup>[19]</sup>

In terms of history of chronic conditions, patients with subsequent readmissions had greater odds of isolated CNS problems, malignancy, metabolic disorders, and syndromes. A group of authors reported an increase from 22.3% to 89.0% in the number of readmissions associated with complex chronic conditions, including malignancies and metabolic diseases.<sup>[20]</sup> In our study, of 1291 patients, 97 were found to be complex care patients (7.5%), most of whom (73 patients) experienced frequent subsequent readmissions when compared with non-complex care patients. This result is comparable to that of another study that found that patients with medical complexity had significantly higher rates of readmission.<sup>[21]</sup> Several solutions have been suggested to decrease the readmission rate of complex care patients, including telehealth communication with healthcare providers, post-discharge close follow-up in clinics, home visits, health



coaching activities for caregivers regarding technology device use, and expanding home healthcare services.<sup>[8]</sup>

In this study, multiple factors were assessed to establish a predictive model for unplanned readmission in pediatric hospitals, including age. The readmission rate increases by 0.05 in response to a 1-year age increase. Similarly, Gay et al and Edmonson et al reported an 8.6–24.5% readmission rate that increased with age.<sup>[6,22,23]</sup>

Another predictive value is the admission to the PICU. General admission to the PICU, regardless of timing, was associated with an increase in the frequency of subsequent readmissions. However, on evaluating the initial admission location, it was found that admission to the PICU resulted in a significant decrease of 1.2 times in the subsequent readmission frequency. This can be attributed to the fact that admitting a patient to the PICU as the first location helps prevent underestimation of the severity of the patient's condition, which may occur if they were initially admitted to the HDU or a general ward. Moreover, the number of PICU admissions also influences the rate of readmissions, as reported in a cohort study conducted in Sweden.<sup>[24]</sup> In their study, patients with multiple PICU admissions were analyzed, and the number of PICU admissions demonstrated a readmission rate greater than that of patients with a single PICU admission.<sup>[24]</sup>

Our study showed a decrease in the number of subsequent readmissions when the primary causes of the first readmission were postoperative complications, gastroenteritis, or isolated CNS problems. Primary diagnosis of readmission can be used as a predictor of readmission; however, it could be challenging at times due to a lack of adequate diagnostic data or unclear diagnosis upon admission.<sup>[25]</sup> Symum and Zayas-Castro<sup>[25]</sup> compared multiple predictive models in their study and reported that the primary diagnosis changed in 53.2% of patients after additional clinical tests.

Associated chronic conditions were also incorporated into the predictive model for unplanned readmissions. Asthma, being a chronic condition, is associated with an increase in the frequency of readmissions. Similarly, one study reported that more than 50% of readmissions were due to asthma.<sup>[3]</sup> This valuable information can assist pediatricians in enhancing the management of chronic asthma and considering early specialist referrals as preventive measures against readmissions.

Our study identified several limitations that should be taken into consideration. First, the COVID-19 pandemic introduced a confounding factor, affecting the rate of both admissions and readmissions during the study period. To address this limitation, we extended the study period to include a timeframe before the onset of the COVID-19 pandemic, as well as 1 year post-pandemic. This served to provide a more comprehensive understanding of the readmission rates and allowed for a more accurate assessment of the impact of the pandemic on readmissions. Second, the data were collected

exclusively from a specialized tertiary hospital, which may limit the generalizability of our findings to other healthcare settings. Recognizing this limitation, we suggest that future studies incorporate multiple healthcare settings to enhance the external validity of the results. Last, our study identified the need for further investigation into the potential relationship between weekend discharge/admission and readmission rates, as well as the exploration of underlying psychosocial factors influencing this variability. Future research should explore these factors to gain a deeper understanding of the complexities surrounding readmissions.

## CONCLUSION

Our study is the first to explore the prevalence and causes of unplanned readmissions among pediatric patients in the Middle East. Our findings revealed a 5.12% prevalence rate of these readmissions within a span of 30 days. Notably, the causes behind readmission differed across different age groups. Furthermore, we successfully developed a prediction model that effectively identifies high-risk patients, allowing for the implementation of preventive measures targeting modifiable risk factors in pediatric readmission cases. This study contributes valuable insights toward improving the healthcare outcomes for this vulnerable population.

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