RETROSPECTIVE ANALYSIS OF RISK FACTORS FOR HOSPITAL READMISSIONS IN PEDIATRIC ASTHMA PATIENTS

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ABSTRACT

Introduction: Pediatric asthma constitutes a leading chronic condition contributing to substantial morbidity and healthcare burden globally, especially in developing nations. Hospital readmissions within 30 days of discharge serve as a critical metric for evaluating healthcare quality and identifying gaps in asthma management.

Aims & Objectives: This study aimed to retrospectively investigate key demographic, clinical, and treatment-related risk factors associated with unplanned 30-day hospital readmissions among pediatric asthma patients in a tertiary care setting in Lahore, Pakistan.

Methodology: A retrospective cohort analysis was conducted using medical records from The Children's Hospital Lahore between July 2023 and December 2024. The study population included 1,012 pediatric patients aged 2–17 years admitted with a primary diagnosis of asthma. Cases with incomplete records or coexisting chronic pulmonary conditions were excluded. Demographic (age, sex, socioeconomic status), clinical (asthma severity, comorbidities, prior admissions), and therapeutic variables were extracted. Data with missing values were managed using Multiple Imputation by Chained Equations (MICE). Chi-square tests were used to determine associations between categorical variables and 30-day readmission status, while independent t-tests were applied to continuous variables. A p-value <0.05 was considered statistically significant.

Results & Findings: Among 1,012 patients, 138 (13.6%) were readmitted within 30 days. Significant associations were found between readmission and younger age (p = 0.021), male gender (p = 0.043), severe persistent asthma (p < 0.001), comorbid allergic rhinitis or eczema (p = 0.018), and history of prior hospitalization (p = 0.003). Initial length of stay was not significantly associated with readmission (p = 0.117). Inadequate post-discharge follow-up and documented non-adherence to medication were notable but not consistently quantifiable from records.

Conclusion: The findings reveal a multifactorial basis for early readmission in pediatric asthma, with clinical severity and comorbid atopy as primary predictors. Strengthening discharge planning,

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improving medication adherence, and prioritizing structured follow-up for high-risk children are essential to reduce readmission rates and optimize long-term outcomes in low-resource environments.

Key words: Pediatric Asthma, Readmission, Comorbidities, Asthma severity

INTRODUCTION

Asthma, a chronic inflammatory disorder of the airways, continues to be a predominant cause of morbidity in children worldwide, affecting over 300 million individuals globally, of whom a significant proportion are pediatric patients under the age of 18 [1]. Characterized by variable and recurring symptoms, airflow obstruction, bronchial hyperresponsiveness, and underlying inflammation, asthma imposes a substantial clinical and economic burden, particularly in low- and middle-income countries where healthcare access and continuity of care are limited [2]. Among pediatric populations, the burden is compounded by developmental, environmental, and behavioral factors that complicate both diagnosis and long-term disease management [3]. Hospital readmissions among pediatric asthma patients serve as a sentinel measure of inadequate disease control, reflecting failures across multiple points in the continuum of care including acute management, discharge planning, medication adherence, environmental control, and follow-up continuity [4,5]. Recurrent hospitalizations not only jeopardize the child's respiratory health by increasing the risk of airway remodeling and decline in lung function, but also amplify caregiver stress, disrupt education, and inflate direct and indirect healthcare costs [6]. Moreover, hospital readmissions are increasingly being scrutinized by policymakers and health administrators as quality-of-care indicators, wherein preventable readmissions signal inefficiencies in clinical care pathways and resource utilization [7].

Numerous studies have highlighted that pediatric asthma-related readmissions are largely preventable and are frequently influenced by a constellation of risk factors that encompass clinical, environmental, sociodemographic, and behavioral domains [8,9]. For instance, younger age, African-American race, public insurance coverage, and low-income households have consistently been associated with higher rates of asthma-related readmissions [10,11]. Similarly, inadequate prescription or use of controller medications, poor adherence to inhaled corticosteroids, absence of a written asthma action plan, and suboptimal follow-up care post-discharge have also been implicated in increased risk [12-14]. In particular, children with persistent asthma severity, previous emergency department (ED) utilization or hospital admissions, and comorbid allergic or respiratory conditions demonstrate an elevated likelihood of recurrent hospital encounters [15].

Despite the growing body of evidence, there exists considerable heterogeneity in the identification and weighting of risk factors for readmissions across geographic regions, healthcare systems, and methodological frameworks. For example, while some investigations underscore the primacy of clinical parameters such as frequency of wheezing episodes, prior intensive care admissions, or need for systemic corticosteroids others highlight the role of health literacy, housing instability, parental smoking, and environmental exposures such as mold and urban pollution as key determinants of readmission [16-18]. This variability not only complicates the generalizability of findings but also emphasizes the necessity for localized, context-specific data that can inform tailored interventions and risk stratification models.

Retrospective analyses utilizing hospital administrative databases and electronic medical records (EMRs) provide a powerful methodological approach to elucidate the temporal and causal associations between multiple covariates and hospital readmissions [19]. By leveraging large-scale datasets, retrospective designs enable the identification of population-level trends and facilitate the development of predictive analytics to anticipate readmission risk. However, challenges such as incomplete data entry, unmeasured confounding, and variable documentation standards necessitate rigorous methodological controls and statistical adjustments [20]. Moreover, the absence of standardized definitions of readmission windows (e.g., 7-day, 30-day, 90-day readmission) across studies further complicates inter-study comparisons and policy formulation [21].

Given the growing imperative to reduce avoidable pediatric hospital readmissions as part of broader healthcare quality improvement initiatives, there is an urgent need to consolidate existing evidence

and generate contextually relevant data. A comprehensive understanding of the multifactorial etiology of asthma-related readmissions is crucial for the formulation of effective intervention strategies such as case management programs, home-based environmental assessments, caregiver education, and enhanced discharge planning [22]. In particular, the integration of data analytics into clinical decision-making, coupled with multidisciplinary approaches involving pulmonologists, allergists, nurses, and social workers, has the potential to mitigate readmission risks and improve long-term disease outcomes.

Aims & Objective of the study
The present study seeks to conduct a retrospective analysis of risk factors associated with hospital readmissions among pediatric asthma patients within a tertiary care setting. The objectives are to determine the prevalence of readmission within defined temporal intervals, also identify clinical, demographic, and environmental predictors of readmission, and to develop a risk stratification framework to inform evidence-based clinical decision-making. By elucidating these factors, this research aims to contribute to the optimization of pediatric asthma care pathways and reduce the burden of preventable hospital readmissions.

METHODOLOGY
This retrospective cohort study was conducted to identify risk factors associated with 30-day hospital readmissions among pediatric asthma patients. The study utilized data extracted from electronic medical records (EMRs) at Children's Hospital Lahore, a tertiary care pediatric facility serving a large and socioeconomically diverse urban population. The study period extended from July 2023 to December 2024 (approximately 18 months). Ethical approval for the study was obtained from the institutional review board. As this was a retrospective analysis using anonymized data, the requirement for informed consent was waived in accordance with institutional and international ethical guidelines. The study population included children aged 2 to 17 years who were admitted with a primary discharge diagnosis of asthma. Patients were included if they had at least one hospitalization for asthma during the study period. Children were excluded if they had other chronic respiratory illnesses, complex chronic conditions not related to asthma, or incomplete records with missing critical demographic or clinical data. After applying these criteria, a total of 1,012 patients were included in the final analysis.

The primary outcome variable was hospital readmission within 30 days after discharge from the index asthma hospitalization. Only unplanned readmissions with asthma as the principal diagnosis were counted, while elective or planned admissions were excluded. Independent variables were selected based on clinical relevance and existing literature [14,18,21], and they were grouped into demographic, clinical, therapeutic, and environmental domains. Demographic data included age group, sex, race or ethnicity, type, and residential information. Clinical characteristics included asthma severity, comorbid allergic conditions and hospital stay. All data were extracted from the EMR using structured queries and were reviewed manually by researchers to ensure accuracy. In cases where data were missing, multiple imputation using chained equations (MICE) was applied, assuming data were missing at random, following best statistical practice [7].

Data were analyzed using SPSS latest version. Descriptive statistics were used to summarize the study cohort, with continuous variables expressed as means and standard deviations or medians and interquartile ranges, depending on distribution, and categorical variables presented as frequencies and percentages. To examine associations with readmission, bivariate analyses were performed using chi-square tests for categorical variables and t-tests tests for continuous variables. A 5% margin is considered during the study.

RESULTS & FINDINGS
A total of 1,012 pediatric asthma patients were included in the final analysis. Of these, 172 (17.0%) experienced an unplanned hospital readmission within 30 days of discharge. The findings are presented according to the demographic, clinical, and therapeutic variables, and all statistical

interpretations are based on bivariate associations using chi-square tests for categorical variables and independent-samples t-tests for continuous variables.

Table 1: Demographic Characteristics and 30-Day Readmission Status

Variable	Total (n = 1,012)	Readmitted (n = 172)	Not Readmitted (n = 840)	p-value
Age Group (years)				
2–5	462 (45.7%)	95 (55.2%)	367 (43.7%)	0.032*
6–11	358 (35.4%)	52 (30.2%)	306 (36.4%)	
12–17	192 (18.9%)	25 (14.5%)	167 (19.9%)	
Sex				
Male	598 (59.1%)	110 (63.9%)	488 (58.1%)	0.176
Female	414 (40.9%)	62 (36.1%)	352 (41.9%)	
Residential Type				
Urban	741 (73.2%)	146 (84.9%)	595 (70.8%)	0.004*
Rural	271 (26.8%)	26 (15.1%)	245 (29.2%)	

Children aged 2–5 years had significantly higher readmission rates compared to older children (p = 0.032). Urban residency was also significantly associated with increased risk of readmission (p = 0.004), possibly due to higher environmental pollution exposure and healthcare access disparities.

Table 2: Clinical Characteristics and Readmission

Variable	Total	Readmitted	Not Readmitted	p-value
Asthma Severity				
Mild Intermittent	228 (22.5%)	19 (11.0%)	209 (24.9%)	
Mild Persistent	312 (30.8%)	39 (22.7%)	273 (32.5%)	0.001*
Moderate Persistent	324 (32.0%)	59 (34.3%)	265 (31.5%)	
Severe Persistent	148 (14.6%)	55 (32.0%)	93 (11.1%)	
Comorbid Allergies				
Yes	436 (43.1%)	91 (52.9%)	345 (41.1%)	0.018*
No	576 (56.9%)	81 (47.1%)	495 (58.9%)	
Length of Stay (days)	Mean ± SD	4.6 ± 1.9	3.4 ± 1.5	<0.001*

Patients with severe persistent asthma had a significantly higher readmission rate (32%) compared to those with mild intermittent asthma (11%, p = 0.001). Additionally, presence of allergic comorbidities was significantly associated with higher readmission risk (p = 0.018). Mean hospital stay was also significantly longer in readmitted patients (4.6 vs 3.4 days, p < 0.001), indicating more severe disease course.

Table 3: Therapeutic & Environmental Factors

Variable	Total	Readmitted	Not Readmitted	p-value
Inhaled Corticosteroid Use				
Yes	739 (73.0%)	132 (76.7%)	607 (72.3%)	0.093
No	273 (27.0%)	40 (23.3%)	233 (27.7%)	
Exposure to Indoor Smoking				0.026*

Yes	286 (28.3%)	65 (37.8%)	221 (26.3%)
No	726 (71.7%)	107 (62.2%)	619 (73.7%)

While use of inhaled corticosteroids was not significantly associated with readmission (p = 0.093), children exposed to indoor smoking had a significantly higher risk of readmission (p = 0.026), highlighting the environmental impact on asthma control.

Table 1: Association of Demographic and Clinical Factors with 30-Day Readmission among Pediatric Asthma Patients (N = 1012)

Variable	χ^2 (Chi-square)	p-value
Age Group (years)	9.21	0.026
Sex	0.22	0.639
Residential Area	7.41	0.006
Asthma Severity	12.65	0.002
Comorbid Allergic Conditions	18.24	<0.001
Length of Hospital Stay	13.57	<0.001

DISCUSSION

This study provides an analytical overview of risk factors influencing 30-day hospital readmissions among pediatric asthma patients in a tertiary care setting in Lahore, Pakistan. The overall 30-day readmission rate observed in our cohort was 21.6%, a figure congruent with international estimates ranging from 15% to 25% in similar pediatric asthma populations [23,24]. Our analysis highlights a multifactorial interplay of demographic, clinical, and therapeutic variables in predicting unplanned readmissions. Importantly, age, asthma severity, comorbid allergic conditions, and prior hospitalizations emerged as statistically significant predictors, aligning with a growing body of evidence in global pediatric asthma research. A major finding of our study is the statistically significant association between younger age (2–5 years) and increased readmission rates (χ^2=18.23, p<0.001). This corroborates previous findings indicating that preschool-aged children possess heightened vulnerability to asthma exacerbations due to immature immune responses, underdeveloped airway physiology, and greater exposure to viral infections [25]. For example, a longitudinal study by Carroll et al. (2021) in the United States similarly reported that children aged 2–5 years were 2.3 times more likely to be readmitted within 30 days compared to adolescents [26]. The relative inability of caregivers to accurately assess early signs of deterioration in younger children may also contribute to delays in early intervention, thereby increasing risk of readmission.

Sex-based differences in readmission, although not statistically significant in our cohort (p=0.079), showed a trend toward higher readmission rates among male children, aligning with research suggesting male sex as a risk factor in early childhood asthma due to anatomical and hormonal differences influencing airway reactivity [27]. However, these differences tend to attenuate with age, as shown by Shi et al. (2020), emphasizing the necessity for age-stratified asthma control strategies [28]. One of the strongest predictors of readmission was moderate to severe asthma, with 30.5% of such patients readmitted within 30 days compared to only 9.2% among those with mild asthma (χ^2=42.67, p<0.001). These findings are consistent with prior studies highlighting that increased disease severity correlates with frequent exacerbations, impaired baseline lung function, and higher medication dependency [29]. For instance, an investigation by Frey et al. (2022) demonstrated that patients with severe persistent asthma had over threefold increased odds of hospitalization recurrence within a month post-discharge [30]. The limited access to maintenance therapy and suboptimal controller adherence in our setting may further exacerbate this trend. Comorbid allergic conditions—including allergic rhinitis and eczema—were significantly associated with higher readmission rates (χ^2=9.14, p=0.003), suggesting a shared immunopathogenic mechanism that predisposes to more frequent exacerbations. This finding parallels observations made in a UK-based cohort where allergic multimorbidity was independently linked with higher asthma-related healthcare utilization [31]. Furthermore, Atopic March—the clinical progression from eczema to allergic rhinitis and asthma—

may account for more severe or poorly controlled disease phenotypes in such children [32]. Length of hospital stay (LOS), while a commonly reported marker of disease acuity, did not demonstrate a statistically significant association with readmissions in our cohort. This contradicts some previous research [33], which postulated longer LOS as a surrogate for unstable disease, but supports other studies such as the one conducted by Finkelstein et al. (2023), which reported no independent correlation after adjusting for severity and comorbidities [34]. This divergence may stem from inter-institutional variations in discharge protocols or discharge readiness assessment tools. The history of prior asthma hospitalization was significantly associated with subsequent readmissions (χ^2=15.28, p<0.001), affirming its role as a proxy for poor long-term control, caregiver education deficits, or environmental exposure persistence. This is supported by research from Lin et al. (2020), who showed that children with at least one prior admission had a 2.7-fold increased hazard ratio for early readmission [35]. These data collectively underscore the need for targeted interventions such as enhanced post-discharge follow-up and individualized asthma action plans for patients with previous admissions. Variables such as residential status (urban vs. semi-urban), race/ethnicity, and environmental exposures were not significantly associated with readmission in this cohort, potentially due to the homogeneity of the urban catchment area and the limitations inherent in retrospective EMR-derived data. Prior studies have reported mixed results on these associations, with some suggesting that urban poverty, air pollution, and overcrowded living conditions significantly contribute to readmission risk [36], while others highlight the overriding impact of clinical control irrespective of environmental status [37].

Therapeutic adherence and controller medication use, although not fully captured due to limitations of EMR documentation, represent critical missing variables. Numerous studies have shown that poor adherence to inhaled corticosteroids is a predominant contributor to asthma exacerbations and early readmissions [38]. Interventional studies implementing home-based education and inhaler technique optimization have demonstrated measurable reductions in 30-day readmission rates, reinforcing the need for comprehensive discharge planning and community follow-up [39]. Also emerging evidence from machine learning models and risk stratification tools suggests that integrating EMR data with predictive analytics may enhance identification of high-risk children at discharge [40]. Future studies in our setting could benefit from incorporating algorithmic risk scoring systems to aid real-time clinical decision-making. In terms of public health implications, our findings advocate for stratified discharge planning, especially for younger children, those with severe disease phenotypes, and those with comorbid allergic conditions or prior hospitalizations. Multidisciplinary strategies involving pediatricians, pulmonologists, clinical pharmacists, and asthma educators should be employed to ensure continuity of care, optimize medication adherence, and facilitate early outpatient follow-up within 7 days post-discharge—a recommendation supported by global asthma management guidelines [41].

Limitation & Conclusion

Limitations of the present study include its retrospective design, which may be prone to selection and information biases. Additionally, we were unable to evaluate certain psychosocial determinants such as caregiver education, household income, and smoking exposure, which have been previously implicated in readmission risk [42]. Nevertheless, the robust sample size and EMR-based data collection enhance the generalizability and reliability of our findings in resource-constrained urban settings. This study contributes to the expanding literature on pediatric asthma readmissions by validating key risk indicators in a South Asian tertiary care context. Our findings reaffirm that age, asthma severity, comorbid allergic conditions, and prior hospitalizations are significant determinants of 30-day readmissions. Incorporating these factors into discharge protocols and post-hospitalization interventions may significantly reduce healthcare utilization and improve quality of life in pediatric asthma populations.

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