Risk factors associated with paediatric unplanned hospital readmissions: a systematic review

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ABSTRACT

Objective To synthesise evidence on risk factors associated with paediatric unplanned hospital readmissions (UHRs).

Design Systematic review.

Data source CINAHL, EMBASE (Ovid) and MEDLINE from 2000 to 2017.

Eligibility criteria Studies published in English with full-text access and focused on paediatric All-cause, Surgical procedure and General medical condition related UHRs were included.

Data extraction and synthesis Characteristics of the included studies, examined variables and the statistically significant risk factors were extracted. Two reviewers independently assessed study quality based on six domains of potential bias. Pooling of extracted risk factors was not permitted due to heterogeneity of the included studies. Data were synthesised using content analysis and presented in narrative form.

Results Thirty-six significant risk factors were extracted from the 44 included studies and presented under three health condition groupings. For All-cause UHRs, ethnicity, comorbidity and type of health insurance were the most frequently cited factors. For Surgical procedure related UHRs, specific surgical procedures, comorbidity, length of stay (LOS), age, the American Society of Anaesthesiologists class, postoperative complications, duration of procedure, type of health insurance and illness severity were cited more frequently. The four most cited risk factors associated with General medical condition related UHRs were comorbidity, age, health service usage prior to the index admission and LOS.

Conclusions This systematic review acknowledges the complexity of readmission risk prediction in paediatric populations. This review identified four risk factors across all three health condition groupings, namely comorbidity; public health insurance; longer LOS and patients<12 months or between 13–18 years. The identification of risk factors, however, depended on the variables examined by each of the included studies. Consideration should be taken into account when generalising reported risk factors to other institutions. This review highlights the need to develop a standardised set of measures to capture key hospital discharge variables that predict unplanned readmission among paediatric patients.

INTRODUCTION

Unplanned hospital readmission (UHR) rate has been recognised as a key performance indicator for measuring the quality of care in paediatric healthcare services.1 Hospital readmission is defined as subsequent admissions within a specified period after the initial/index hospitalisation.2 3 Paediatric UHRs rates range from 3.4% to 28.6% and cost healthcare systems such as UK, USA and Canada up to $1 billion per annum.4-9 Identification of risk factors associated with UHRs is increasingly being examined as a strategy to assist in reducing these rates. A systematic review10 conducted in 2011, identified 26 risk predictive models from 30 examined studies focused on adult general medical condition related UHRs. Readmission length of time measures used ranged from 30 days to 12 months. Overall, the performance of the 26 models was poor. The most commonly identified risk factors were medical comorbidity and use of medical services before the index admission. In a 2016 systematic review,11 limited to 28-day or 30-day readmissions and focused on adult health conditions, a total of 60 studies and 73 risk predictive models with inconsistent performance was noted. The predictive models focusing on general medical conditions showed moderate discriminative ability. Risk factors cited most frequently for all UHRs were comorbidities, length of stay (LOS).
and previous hospital admissions. For condition-specific readmissions, such as cardiovascular and general medical diseases laboratory tests and medication were more associated with readmissions.11 There is only one review12 within the paediatric literature examining UHRs. This review focused on asthma-related UHRs and included 29 studies. Five significant predictive factors, including age <5 years old or adolescent; being African American; public or no insurers; previous hospitalisations prior to the index admission; underlying chronic complex conditions were identified. To date, there is no published review paper on risk factors associated with UHRs for general paediatric patients. This paper aimed to systematically review the current literature on risk factors of paediatric All-cause, Surgical procedure and General medical condition related UHRs. The objectives were to assess characteristics of included studies and to synthesise the identified risk factors.

METHODS
A systematic review was performed and reported according to the 2009 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) Statement.13

Data sources and search strategy
An electronic database search was carried out using the CINAHL, EMBASE (Ovid), MEDLINE to identify studies published from 2000 to 2017. The key search terms included ('Readmission’ or rehospitali* or readmission* or readmit* or re-admission*) AND (child* or infant* or toddler* or bab* or newborn* or neonat* or school age* or preschool or paediatric* or pediatric* or kid* or boy* or girl*) OR (adolescen* or teen* or youth or juvenile* or young person* or young people*) (see online supplementary appendix for full search strategy).

Inclusion/exclusion criteria
Articles eligible for inclusion were those published in English with full-text access. The focus of the included studies was paediatric patients with UHRs. Eligible studies were published in peer-reviewed journals with details of study design clearly stated and reported statistical analysis procedure/s. Abstract only references were excluded. Studies that included patients discharged from rehabilitation health services but readmitted to acute hospitals were excluded from this systematic review as it only focused on hospital readmission following discharge from acute healthcare services. Newborn or preterm newborn studies related UHRs were excluded as the index admission was the birth hospitalisation. In addition, studies focused on mental health condition related UHRs were also excluded due to the specialised nature of the discipline.

Study selection
After the initial literature searches, two authors independently screened titles, abstracts and appraised full papers against the inclusion and exclusion criteria. The process of exclusion was relatively straightforward and only a handful of studies warranted discussion between authors, to reach consensus as to whether they met the inclusion criteria. Moreover, the reference list of all identified relevant records were searched for additional studies.

Data extraction
Data were extracted from the 44 included studies. The data extraction comprised study characteristics, examined variables and statistically significant risk factors. Study characteristics included study setting, population, data source, timing of data collection, sample size, study design, model utilisation outcome, readmission rate and statistical analysis test/s used to identify risk factors (table 1). All examined variables or confounding factors and the significant risk factors were extracted into table 2 and detailed information was included in the online supplementary table. Studies were grouped based on the health conditions in both tables. Disagreements between two reviewers about the extracted data were resolved through group discussion.

Quality assessment
Two independent reviewers completed the assessment of study quality. Six domains of potential bias14 were used to assess the 44 included primary research studies. The six domains are: 1. Study participation: ‘Was source population clearly defined?’ 2. Study attrition: ‘Was completeness of follow-up described and adequate?’ 3. Prognostic factor measurement: ‘Did prognostic factors measure appropriately?’ 4. Outcome measurement: ‘Was outcome defined and measured appropriately?’ 5. Confounding measurement and account: ‘Was confounders defined and measured?’ 6. Analysis: ‘Was analysis described and appropriate?’ The ratings of ‘Yes’, ‘Partly’, ‘No’ or ‘ Unsure’ was given to each domain and then an overall risk of ‘low’ or ‘high’ was assigned to each study.

Data synthesis
Pooling of extracted significant risk factors was not possible because the included studies were not homogeneous due to the different diagnoses, examined variables and follow-up time frames to identify readmissions. Therefore, data extracted from the included studies were synthesised using content analysis and presented in narrative form.11

Patient and public involvement
Patients and or public were not involved in this systematic review.

RESULTS
The initial electronic database search produced 11859 records. After removal of 4145 duplicates, a total of 7714 records remained. Titles and abstracts were then appraised and 7579 records were excluded due to irrelevance. Of the remaining 135 relevant references, a further
| Reference | Medical condition | Outcome measures | Study design | Data source | Sample size | Age | Follow-up period | Proportion readmitted | Data analysis |
|-----------|-------------------|------------------|--------------|-------------|-------------|-----|------------------|---------------------|---------------|
| **All-cause related UHRs (8)** |
| Toomey et al, 2016 | All-cause | 30-day Potentially preventable UHRs | Prospective | A freestanding children's hospital Interviews and medical records | 305 patients | <18 years | December 2012 to February 2013 | Overall UHR 6.5%, 29.5% potentially Preventable UHR | Multivariable logistic regression |
| Wijlaars et al, 2016 | All-cause | ≤30-day and 31-day to 2-year UHRs | Retrospective | National administrative hospital data | 866221 patients | 0-24 years | 2009 to 2010 | 8.8% (30 days) 22.4% (31 days to 2 years) | Multivariable logistic regression |
| Khan et al, 2015 | All-cause | 30-day UHRs | Retrospective | State inpatient database — 177 acute hospitals (12 children's hospital) | 701263 discharges | 0-17 years | 1 January 2005 to 30 November 2009 | 4.5% (AHR) 3.8% (SHR) 0.6% (DHR) | Multivariable logistic regression |
| Auger and Davis, 2015 | All-cause | 30-day UHRs | Retrospective | A tertiary children's hospital Administrative data | 55383 hospitalisations/32112 patients | Not specified | 2006 to 2012 | 10.3% | Logistic regression |
| Coller et al, 2013 | All-cause | 30-day UHRs | Retrospective | A tertiary children's hospital Administrative data and Medical records | 7794 index discharges/5056 patients | <2 to 18 years | July 2008 to July 2010 | 18.7% | Logistic regression |
| Berry et al, 2011 | All-cause | 365-day UHRs | Retrospective | PHIS of 37 children's hospital | 317643 patients/579,504 admissions | 0 to >18 years | 2003 to 2008 | 21.8% | χ² and multivariate analysis |
| Feudtner et al, 2009 | All-cause | 365-day UHRs | Retrospective | PHIS of 38 children's hospital | 186856 patients | 2 to 18 years (Mean=9.2) | 2004 | 16.7% | C-statistics=0.81 |
| Beck et al, 2006 | All-cause | 30-day UHRs | Retrospective | The Canadian Institute—Discharge Database | 506035 hospitalisations/334 959 children | 29 days−8 years | 1996 to 2000 | 3.4% | Multivariate modelling |
| **Surgical conditions related UHRs (20)** |
| Brown et al, 2017 | General surgical admissions | 7-day, 14-day and 30-day UHRs | Retrospective | University HealthSystem Consortium database — 258 hospitals | 260042 patients | 0-17 years | 1 September 2011 to 31 March 2015 | 2.1% (7 days), 3.1% (14 days) and 4.4% (30 days) | Multivariable logistic regression |
| Vo et al, 2017 | All Surgeries | 30-day UHRs | Retrospective | National surgical QI programme—Paediatric | 182589 patients | <18 years | 2012 to 2014 | 4.8% | C-statistics=0.747 |
| Richards et al, 2016 | All Surgeries | 30-day UHRs | Retrospective | A children's hospital—Seattle children's hospital enterprise data warehouse | 20785 patients with 26978 encounters | 0 to≥18 years | 1 October 2008 to 28 July 2014 | 11.5% | Multivariable logistic regression |
| Elias et al, 2017 | Cardiac surgery | 1-year UHRs with plural effusion | Retrospective | PHIS database | 142633 admissions | Median=6.4 months (1.1–46.5 months) | 1 January 2003 to 30 September 2014 | 1.1% | Multivariate logistic regression |

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## Table 1 Continued

| Reference | Medical condition | Outcome measures | Study design | Data source | Sample size | Age | Follow-up period | Proportion readmitted | Data analysis |
|-----------|-------------------|------------------|--------------|-------------|-------------|-----|------------------|----------------------|--------------|
| Polites et al., 2017 | General & Thoracic surgery | 30-day UHRs | Retrospective | National surgical QI programme—Paediatric | 48,870 patients | Mean=8.1±5.8 years | 2012 to 2014 | 3.6% | C-Statistics=0.710 |
| Yu et al., 2017 | Tracheostomy | 30-day UHRs | Retrospective | An urban tertiary children’s hospital—Medical charts | 237 patients | <18 years | 2005 to 2013 | 22% | Multivariate logistic regression |
| Murray et al., 2016 | ENT surgeries | 30-day UHRs | Retrospective | PHIS database | 493,507 procedures | 0–18 years | 1 January 2009 to 31 December 2011 | 2.3% | Multivariate logistic regression |
| Roxbury et al., 2015 | Surgical (Otolologic) | 30-day UHRs | Retrospective | National NSQIP-P data (50 institutions) | 2,556 procedures | Only reported as <3 or >3 years | 2012 | 1.3% | Multivariate logistic regression |
| Roddy and Diab, 2017 | Spinal fusion | 30-day and 90-day UHRs | Retrospective | The state Inpatient Database | 13,287 patients | <21 years | 2006 to 2010/2011 | 38% (30 days) 33% (90 days) | Multivariate logistic regression |
| Vedantam et al., 2017 | Epilepsy surgery | 30-day UHRs | Retrospective | 2015 NSQIP-P database | 208 patients | 0–18 years | 2015 | 7.1% | Multivariate logistic regression |
| Chem et al., 2014 | Shunt surgery | 30-day UHRs | Retrospective | 1 institution—Administrative and clinical databases | 1,755 procedures | Mean = 7.15 Years | 1 May 2009 to 30 April 2013 | 16.5% | Multivariate logistic regression |
| Sarda et al., 2014 | Non-shunt surgery | 30-day UHRs | Retrospective | 1 institution—Administrative and clinical databases | 2,924 Index admissions | Mean = 7.17 Years | 1 May 2009 to 30 April 2013 | 10.4% | Multivariate logistic regression |
| Minhas et al., 2016 | Spinal surgeries (Scoliosis) | 30-day UHRs | Retrospective | American College of Surgeons NSQI-Pediatric database | 3,482 patients | 0–18 Years | 2012 to 2013 | 3.4% | C-statistics=0.76–0.769 |
| Buicko et al., 2017 | Appendectomy (Laparo-scopic) | 30-day UHRs | Retrospective | The Nationwide Readmission Database | 12,730 | <18 Years | 2013 | 3.4% | Multivariate logistic regression |
| Cairo et al., 2017 | Appendectomy (Laparo-scopic) | 30-day UHRs | Retrospective | American College of Surgeons NSQI-Pediatric database | 22,771 patients | 0–17 Years Mean=11±3.56 | 2012 to 2015 | 1.89% same-day discharge 2.33% 2–3 day discharge | Multivariate logistic regression |
| Cairo et al., 2017 | Cholecystectomy (Laparoscopic) | 30-day UHRs | Retrospective | The NSQI-Pediatric database | 5,046 | 2–17 Years | 2012 to 2015 | 3.6% | Multivariate logistic regression |
| Roth et al., 2016 | Circumcision | 7-day UHRs | Retrospective | PHIS database | 95,046 procedures | 0–18 Years | 2013 to 2014 | 0.3% | Logistic regression analysis |
| McNamara et al., 2015 | Surgical (Urology) | 30-day UHRs | Retrospective | National NSQIP-P database (50 institutions) | 461 patients | Median=9.4 Years | 2012 to 2013 | 27.8% | Logistic regression |
| Vemulakonda et al., 2015 | Surgical (Urology) | 12-month UHRS | Retrospective | PHIS database Administrative Health Information data | 4,499 patients | 0–18 years (Median=10 months) | 1 January 1999 to 30 September 2009 | 4.9% | Logistic regression Cox PH |

Continued
| Reference                  | Medical condition       | Outcome measures | Study design          | Data source                                           | Sample size | Age           | Follow-up period | Proportion readmitted | Data analysis                  |
|----------------------------|-------------------------|------------------|-----------------------|------------------------------------------------------|-------------|---------------|------------------|------------------------|-------------------------------|
| Tahiri et al., 2015        | Plastic surgeries       | 30-day UHRs      | Retrospective         | National surgical QI programme database            | 5376 patients | Mean = 5.47 years | 2012             | 2.4%                   | C-statistics=0.784           |
| Sacks et al., 2017         | Cardiac conditions      | 30-day UHRs      | Retrospective         | A large urban tertiary children’s hospital—Medical charts | 1,124 patients/1993 hospitalisations | 0–12.9 years | 2012 to 2014 | 20.5%                 | C-statistics=0.75           |
| Chave et al., 2017         | Congenital heart disease| 30-day UHRs      | Retrospective         | A tertiary general hospital—Medical charts         | 996 patients | <18 years Mean=2.7 years | 2002 to 2014 | 9.6%                   | Multivariable logistic regression |
| Mackie et al., 2008        | Congenital heart disease| 31-day UHRs      | Retrospective         | All hospitals of Quebec, Canada                     | 3675 hospitalisations | 0–17 years | 1 April 1990 to 31 March 2005 | 15%                           | Cox proportional hazards analysis |
| Nakamura et al., 2017      | Lower respiratory infections | 30-day UHRs     | Retrospective         | Medicaid Analytic eXtract data—26 states             | 150 590 hospitalisations | <18 years | 2008 to 2009 | 5.5%                   | A 2-level mixed-effects logistic regression |
| Veeranki et al., 2017      | Asthma                  | 30-day UHRs      | Retrospective         | 2013 National Readmission Database—21 states         | 12 842 Index hospitalisations | 6–18 years | 2013           | 2.5%                   | Cox proportional hazards analysis |
| Vicendese et al., 2015     | Asthma                  | 28-day UHRs      | Retrospective and case control | A children’s hospital Medical records and Indoor sampling and Survey | Selected 22/96 Patients UHRs vs 22 without URHs | 2–17 years | September 2009 to December 2011 | 38% | Logistic regression |
| Neuman et al., 2014        | Pneumonia               | 30-day UHRs      | Retrospective         | PHIS of 45 hospital                                  | 82 566 patients | 0 to >18 years | 2008 to 2011 | 7.7% (All-cause); 1% (Pneumonia-specific) | Multivariate logistic regression |
| Vicendese et al., 2014     | Asthma                  | 28-day and 1-year UHRs | Retrospective         | Victorian Admitted Episodes Dataset                  | 53 156 admissions/33 559 patients | 2–18 years | 1997 to 2009 | 4.5% vs 19.3% | Logistic regression |
| Kun et al., 2012           | Chronic respiratory failure | 1-year UHRs     | Retrospective         | A tertiary children’s hospital—Medical charts        | 109 patients | 0–21 years | 1 January 2003 to 31 October 2009 | 40% | Generalised estimating equations (GEE) |
| McNally et al., 2005       | Preschool viral-wheeze | 6-month UHRs     | Prospective           | Quantitative—Medical records extraction              | 208 patients 192 patients | 15 to 40 months | May to October 1999; November 1999 to April 2000 | 22% vs 25% | Mann-Whitney U test or χ² test |
| Cohen et al., 2000         | Asthma                  | 30-day UHRs      | Retrospective         | Administrative and Billing record data; Medical records | 37 patients selected from 700 admissions | 0–18 years | 12 months | Not reported | Standard algebraic formula |
| Sobota et al., 2012        | Sickle cell disease     | 30-day UHRs      | Retrospective         | PHIS of 33 children’s hospitals                      | 12 104 Hospitalisations/4762 patients | <18 years | 1 July 2006 to 31 December 2008 | 17% | Generalised estimating equations (GEE) |
| Frei-Jones et al., 2009    | Sickle cell disease     | 30-day UHRs      | Retrospective         | A children’s hospital                                | 100 admissions | 8 months to 21 years | 12 months | 30% | Multivariate analysis |

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22 were excluded as they were conference abstracts only. A total of 113 references were reviewed as full-text and a further 75 were excluded against selection criteria. Four studies were excluded as they were published in Chinese, Korean, Portuguese and Spanish. Studies that mixed paediatric and adult patients, or mixed planned and unplanned readmissions or mixed Emergency Department presentations and hospital readmissions were excluded. Three studies that included patients initially discharged from rehabilitation health service but then admitted to an acute hospital were excluded. An integrative review on paediatric asthma related UHRs was excluded. As mentioned previously, studies examined newborn/preterm newborn-related UHRs and mental health condition related UHRs were excluded. A hand search reference list of the remaining 38 studies was conducted and six additional studies were identified. Finally, a total of 44 studies were included in this systematic review. Figure 1 is a flowchart as per PRISMA of the screening process of the database search results.

**Study quality appraisal**

The overall risk of bias of the 44 included studies was low when evaluated against the six domains of potential bias. The studies described the population of interest for key characteristics, the response rate information was clearly stated, an adequate proportion of the study population had complete data for all independent variables, the outcome variable readmission was measured with sufficient accuracy and the method of statistical analysis was appropriate for the design of the study.

**Characteristics of the included studies**

Table 1 displays the characteristics of the final included studies of this systematic review. The 44 studies were conducted in several countries: USA (n=36), UK (n=3), Australia (n=2), Canada (n=2) and Switzerland (n=1). Thirty of the included studies retrieved data from multiple sites and the other 14 accessed single health-care service. A total of 33 included studies examined a combination of health database and medical records and the remaining 11 accessed database only. The included studies are grouped as per health conditions namely (1) All-cause related UHRs (n=8); (2) surgical procedure related UHRs (n=20), including all surgical admissions (n=3), cardiothoracic surgeries (n=3), ear, nose and throat (ENT) surgeries (n=2), neurosurgeries (n=5), abdominal surgeries (n=3), urological surgeries (n=3) and plastic surgeries (n=1) and (3) General medical condition related UHRs (n=16), including cardiac conditions (n=3), respiratory conditions (n=8), blood disorders (n=3), complex chronic conditions (CCC) (n=1) and gastrointestinal conditions (n=1).

All included studies used retrospective health data except Toomey who employed a prospective research design including structured interview and reviewing medical records. Of the included studies, outcome measures of length of time from discharge to readmission
Table 2 Thirty-six differing significant risk factors associated with three paediatric health condition groups related UHRs

| Health condition group | All-cause (n=8) | Surgical procedures (n=20) | General medical conditions (n=16) |
|------------------------|----------------|---------------------------|----------------------------------|
| Reference number       | 10 11 12 13   | 14 15 16 17 18 19 20     | 21 22 23 24 25 26 27 28 29 30 |
| Examined variables     | X X X         | X X X X X X X X X       | X X X X X X X X X X X X X X |
| Significant risk factors | 3 1 3 1 5 4 7 3 4 7 4 7 4 2 9 1 1 4 3 5 1 2 1 3 1 5 | 2 1 6 2 6 1 5 2 0 0 2 3 4 1 3 4 |
| Age at admission/operation | X X X X X | X X X X X X X X     | X X X X X X X X X X X X X X |
| Gender                 | X             | X             | X X X X X X X X X X X X X X |
| Race/Ethnicity         | X X X         | X             | X X X X X X X X X X X X X X |
| Location of residence  | X X X         | X             | X X X X X X X X X X X X X X |
| Health Insurance       | X X X         | X             | X X X X X X X X X X X X X X |
| Living environment     | X             | X             | X X X X X X X X X X X X X X |
| Type of index hospital | X X X         | X             | X X X X X X X X X X X X X X |
| Health service usage prior to index admission | X X | X | X X X X X X X X X X X X X X |
| Time since last admission | X            | X             | X X X X X X X X X X X X X X |
| Comorbidity            | X X X X X X X X X X X X X | X X X X X X X X X X X X X | X X X X X X X X X X X X X |
| Illness severity       | X             | X             | X X X X X X X X X X X X X X |
| LOS/Postop LOS         | X X X X X X X X X X X X X X X X X X X X X X | X X X X X X X X X X X X X X |
| Principal diagnoses    | X             | X             | X X X X X X X X X X X X X X |
| Principal procedures   | X X X         | X             | X X X X X X X X X X X X X X |
| Inpatient complications| X X X         | X             | X X X X X X X X X X X X X X |
| Specific medication at index admission | X | X | X X X X X X X X X X X X X X |
| Length of operation    | X             | X             | X X X X X X X X X X X X X X |
| Time between scheduled start and actual operation | X | X | X X X X X X X X X X X X X X |
| Wound contamination before operation | X | X | X X X X X X X X X X X X X X |
| After hour’s operations | X X | X | X X X X X X X X X X X X X X |
| The ASA class          | X             | X             | X X X X X X X X X X X X X X |
| Specific laboratory results | X | X | X X X X X X X X X X X X X X |
| Discharge on Friday or Weekend | X | X | X X X X X X X X X X X X X X |
| Admission on weekends  | X             | X             | X X X X X X X X X X X X X X |
| After hours discharge   | X             | X             | X X X X X X X X X X X X X X |
| Follow-up after discharge | X            | X             | X X X X X X X X X X X X X X |
| Discharge disposition   | X             | X             | X X X X X X X X X X X X X X |
| Discharge with special treatment | X | X | X X X X X X X X X X X X X X |
| Discharge with increased medication/further treatment | X | X | X X X X X X X X X X X X X X |
| Index admission and readmission causally related | X | X | X X X X X X X X X X X X X X |
| Hospital contributing factors | X         | X             | X X X X X X X X X X X X X X |
| Patient contributing factors | X     | X             | X X X X X X X X X X X X X X |

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varied from 7 days for CCC, or circumcision to 1 year for All-cause, asthma and chronic respiratory failure related UHRs. Thirty-one of the 44 included studies adopted 28-day or 30-day UHRs measurement. The duration of time for the retrieved data used in the studies ranged from 3 months to 10 years. The majority of included studies involved patients younger than 18 years. Five studies included patients older than 18 years with either blood disorder disease, CCC, gastric bleed, spinal fusion or all surgeries.

Of included studies, the sample size was recorded in various units, such as Patients, Admissions, Index admissions, Hospitalisations, Index discharges, Discharges or Procedures. The sample size ranged from 100 admissions to 866 patients. UHR rates, if reported, varied from <1% following postcircumcision to 40% in patients with chronic respiratory failure.

All included studies employed logistic regression or equivalent to analyse the data. Most studies reported OR with 95% CI and the result is considered as statistically significant when the p value is less than 0.05. Six included studies also reported risk predictive model performance. One model demonstrated high discriminative ability (C-statistic=0.81) for 12-month All-cause UHRs. The other models had moderate discrimination ability to predict 30-day UHRs following cardiac conditions, plastic, thoracic surgeries, scoliosis surgeries, or all surgical admissions (C-statistic of 0.75, 0.784, 0.71, 0.769 and 0.74, respectively).

Examined variables/Confounding factors and Significant risk factors

The variables or confounding factors examined varied across the 44 included studies. The number of examined variables of each included study ranging from 24 to 44. Two of the included studies, after applying statistical analysis tests to the examined variables, yielded inconclusive findings. Thirty-six differing but significant risk factors were extracted and presented under the three health condition groupings (All-cause, Surgical procedure and General medical condition).

Risk factors associated with All-cause UHRs

The least number of studies (n=8) in the systematic review related to All-cause UHRs. Risk factors associated with All-cause UHRs and cited more frequently are comorbidity, ethnicity and health insurance. Patients' comorbidity was identified by four studies with OR ranging from 1.2 to 5.61. Of these, chronic conditions were more frequently cited as a risk for readmission. Three studies cited race/ethnicity as a risk factor. Compared with other race/ethnicities, patients of Black race or Asian had 50% more likelihood of being readmitted. Patients from families with only public health insurance were identified at risk for readmission by three studies (OR=1.51 to 1.48). One study by Khan however, identified patients with private health insurance were 1.14
times more likely to be readmitted to a different hospital. Other significant risk factors related to All-cause UHRs are displayed in table 2.

**Risk factors associated with surgical procedure related UHRs**

The greatest number of risk factors contributing to UHRs were found in the grouping of studies Surgical Procedure. Within the 20 included studies, the most frequently cited risk factors are comorbidity, specific surgeries, LOS, age, the American Society of Anaesthesiologists (ASA) class, development of complications during index admission, duration of surgery, type of health insurance and illness severity. Patients’ comorbidity71 72 76 82 84–87 89 and specific surgical procedures71 72 77 79 81 85–88 were each cited in nine differing studies. The type of comorbidities were not consistent among the studies (OR=1.12 to 10.08).

In general, patients with longer LOS at index admission were found in seven studies to be at greater risk of readmission following surgical procedures (OR=1.01 to 13.96)72 79 81 82 86 90 although one study87 found shorter than 3 days of hospitalisation at the index admission was a risk factor for patients who underwent spinal fusion (OR=1.89).

Age at index admission or surgery72 77 78 82 85 89 and the ASA class71 75 80 83 84 89 were cited in six differing studies. Age, however, was inconsistent across the studies. For example, patients either younger than 1 year78 with urological surgeries or older than 13 years72 with ENT surgeries were more likely to be readmitted. The ASA class of 3 and above was associated with higher risk of UHRs (OR=1.78 to 7.62).

In four studies, patients who developed medical or postoperative complications at the index admission were at risk of readmission with OR ranging from 1.34 to 11.92.75 86 87 89 Public insurance,72 73 87 longer operating time,73 76 86 and severe health conditions prior to surgeries72 79 86 were all cited three times in different studies as increasing the risk of patients UHRs. Other significant risk factors related to surgical procedure related UHRs are displayed in table 2.
Risk factors associated with general medical condition related UHRs

Sixteen studies were reviewed that examined General medical condition related UHRs. Four most frequently cited risk factors are comorbidity, age, health service usage prior to the index admission and LOS. A total of eight studies identified patients’ comorbidity as a risk factor (OR=1.1 to 3.61). The most frequently cited comorbidity was chronic conditions (n=5).

Age of patients at index admission was cited as a risk factor by five studies with OR ranging from 1.1 to 4.11. In particular, patients younger than 1 month or patients between 12 and 18 years were more likely to be readmitted. Three studies reported patients with previous hospitalisation prior to the index admission were at higher risk of readmissions (OR=4.7 to 7.3). A further three studies cited LOS as a risk factor with OR ranging from 1.3 to 1.56. Patient stays >4 days for Asthma or >7 days for Pneumonia are more like to be readmitted. Other significant risk factors related to General medical condition related UHRs are displayed in table 2.

DISCUSSION

This systematic review identifies risk factors associated with paediatric UHRs. A total of 44 studies were reviewed and 36 differing significant risk factors were extracted. There are only four consistently cited paediatric readmission risk factors across all included studies, namely comorbidity, public health insurance, longer LOS at the index admission and patients either younger than 12 months or those 13–18 years of age. The results demonstrate a shift in focus from All-cause UHRs to condition specific related UHRs, especially those involving surgical procedures. Overall, the 36 significant risk factors varied among studies focused on condition-specific related readmissions and some risk factors were not reported consistently across studies.

This systematic review has certain limitations. The database search was restricted to English publication only and full-text access was also required to allow comprehensive data extraction. Meta-analysis was not performed on the extracted significant risk factors as the included studies were not homogeneous due to the different diagnoses, examined variables and follow-up time frames to identify readmissions. This systematic review did not establish a definite cut-off during the literature search although 0–18 years is a widely accepted definition for paediatric patients. Consequently, five included studies had patients in their late teens or young adulthood (19–24 years). The inclusion of late adolescent and young adult under paediatric health services care is consistent with the finding of delayed transitions from paediatric to adult healthcare services. This systematic review did not restrict the follow-up time frame used by studies to identify UHRs, which resulted in data collection spanning 7 days to 21 years. This in turn contributed to a vast range of paediatric UHRs rates of <1% to >40%.

CONCLUSION

This systematic review acknowledges the complexity of UHRs risk prediction in paediatric populations. The evidence on the utility of developed predictive models for paediatric UHRs, comparison to adult population literature, is very limited as no existing models have been validated externally. This review identified four consistently cited risk factors associated with paediatric UHRs. These include comorbidity, public health insurance, longer LOS at the index admission and patients either younger than 12 months or 13–18 years old. The identified risk factors depended on what variables were examined in each of the included studies. Therefore, consideration should be taken into account when generalising reported significant risk factors to other institutions.

This review concludes that a focus on the development of potentially preventable/avoidable UHRs risk predictive models for paediatric patients is required as some unplanned readmissions might be unavoidable due to medical complexity. Future studies should use a combined approach of administrative and clinical medical data. Also, there is a need to examine if paediatric potentially/avoidable UHRs are associated with patients’ social complexity (ie, language proficiency) and comprehensiveness of discharge information (written and verbal communication).

The utmost priority is to develop a standardised set of measures to capture key hospital discharge variables that predict unplanned readmission among paediatric patients. Key challenges include time frame used to measure readmissions, unit of measure on which to record/calculate readmission and variables to be examined. Establishing the most appropriate length of time (being discharge to readmission) to measure UHRs is the first challenge. The second is to standardise the unit of measure that should be used to calculate the readmission rate, while the final challenge is to determine what variables should be extracted and examined to identify risk factors associated with UHRs. Once these challenges have been addressed, a parsimonious predictive model, with high sensitivity and specificity, can be developed for use in all healthcare settings, to identify and implement quality improvement plans for patients with high risk of UHRs.
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