BMJ Open

Applicability of predictive models for 30-day unplanned hospital readmission risk in paediatrics: a systematic review

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To cite: Niehaus IM, Kansy N, Stock S, *et al*. Applicability of predictive models for 30-day unplanned hospital readmission risk in paediatrics: a systematic review. *BMJ Open* 2022;**12**:e055956. doi:10.1136/bmjopen-2021-055956

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-055956).

Received 28 July 2021
Accepted 09 February 2022

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ABSTRACT

Objectives To summarise multivariable predictive models for 30-day unplanned hospital readmissions (UHRs) in paediatrics, describe their performance and completeness in reporting, and determine their potential for application in practice.

Design Systematic review.

Data source CINAHL, Embase and PubMed up to 7 October 2021.

Eligibility criteria English or German language studies aiming to develop or validate a multivariable predictive model for 30-day paediatric UHRs related to all-cause, surgical conditions or general medical conditions were included.

Data extraction and synthesis Study characteristics, risk factors significant for predicting readmissions and information about performance measures (eg, c-statistic) were extracted. Reporting quality was addressed by the 'Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis' (TRIPOD) adherence form. The study quality was assessed by applying six domains of potential biases. Due to expected heterogeneity among the studies, the data were qualitatively synthesised.

Results Based on 28 studies, 37 predictive models were identified, which could potentially be used for determining individual 30-day UHR risk in paediatrics. The number of study participants ranged from 190 children to 1.4 million encounters. The two most common significant risk factors were comorbidity and (postoperative) length of stay. 23 models showed a c-statistic above 0.7 and are primarily applicable at discharge. The median TRIPOD adherence of the models was 59% (P_{25}–P_{75}, 55%–69%), ranging from a minimum of 33% to a maximum of 81%. Overall, the quality of many studies was moderate to low in all six domains.

Conclusion Predictive models may be useful in identifying paediatric patients at increased risk of readmission. To support the application of predictive models, more attention should be placed on completeness in reporting, particularly for those items that may be relevant for implementation in practice.

Strengths and limitations of this study

- ► Independent and standardised methodological approach for study selection, data extraction and risk of bias assessment.
- ► Comprehensive presentation of predictive models that provide information about applicability, performance and reporting quality at a model level, differentiated by 30-day all-cause, surgical conditions and general medical condition-related paediatric unplanned hospital readmissions.
- ► Due to study heterogeneity, the models were only narratively synthesised.

INTRODUCTION

Hospital readmissions (HRs) are becoming increasingly important as a quality indicator for paediatric inpatient care.[1 2] HR is often defined as a subsequent, unplanned admission within a period of 30 days after the index hospitalisation.[3] For paediatric populations, rates of all-cause 30-day unplanned hospital readmission (UHR) ranged from 3.4% to 18.7%.[3–5] In addition, taking 27 US states into account, it has been estimated that paediatric HRs can cost up to $2 billion annually, with approximately 40% of these occurring HRs being potentially preventable.[6]

Identifying the reasons for paediatric HRs is a major challenge, as the health of children is also affected by factors aside of inpatient care.[7] Predictive models can be applied as a tool for the identification of patients with a risk of HR higher than that of the average population and for the implementation of preventive interventions to reduce the risk of HR.[8] Especially in the context of the ongoing COVID-19 pandemic, where children and adolescents are also being hospitalised with a variety of symptoms,[9–11] the prevention of UHRs can be beneficial, as it would allow hospital resources to be used in a more target-orientated way.

This systematic review aimed to address two research gaps that have been identified:

1. Predictive models with good performance are useful in practice when clinicians and other stakeholders have all the necessary information for their application in

clinical practice and critical assessment.[12] However, previous systematic reviews discussed the shortcomings in reporting the quality of prediction models[13–15] and also for paediatric clinical prediction rules[16].

2. A previous systematic review has already identified 36 significant risk factors for UHRs in paediatric patients with different health conditions.[3] The largest number of risk factors was identified for surgical procedure-related UHRs. Among others, comorbidity was one of the most common risk factors across the 44 included studies.[3] The review[3] extends the findings of an earlier systematic review that focused on 29 paediatric studies targeting predictors for asthma-related UHRs[17].

Both reviews[3 17] were primarily addressed to predictor finding studies[14],while to date, there is no published review of existing 30-day UHR predictive models in paediatrics.

The objective of this systematic review was to determine the potential application of multivariable predictive models for individualised risk prediction of 30-day UHR in the paediatric population by evaluating the models' discriminative ability, completeness in reporting and the risk factors shown to be significant for prediction of 30-day UHR.

METHOD

The 2020 Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement was adhered to for conducting and reporting of this systematic review.[18] Screening of the titles and abstracts, data extraction, quality assessment and analyses (eg, completeness in reporting) were performed by two independent reviewers, while disagreements were discussed with a third author. A protocol for this non-registered systematic review was prespecified and is available from the corresponding author. Based on expert recommendation, the analysis was subsequently focused on 30-day UHRs instead of 30-day HRs (ie, planned HRs and UHRs), deviating from the prespecified protocol.

Data source and search strategy

CINAHL, Embase and PubMed were used for an electronic database search to identify studies published up to 7 October 2021. The key search terms include the outcome variables used for the model (ie, readmission/rehospitalisation), elements of the study design (ie, prediction/c-statistic) and the population of interest (ie, paediatrics/children) (see online supplemental material for full search strategies—online supplemental tables A1–A3). The reference lists of the included studies and of comparable systematic reviews[3 17] were examined for further potential studies.

Inclusion criteria

Studies addressing multivariable predictive models for children and adolescents (except newborns/preterm newborns, as the index admission is the birth hospitalisation) were included if they were published in English or German and available as full texts in peer-reviewed original journal articles. Studies aiming to develop a new model or to validate an existing model were included (1) if the model was potentially appropriate for the individual prediction of 30-day UHR from acute healthcare service after discharge or after index procedure in paediatrics and (2) if the model provided at least one discrimination measure (eg, c-statistic). Discriminative ability is a key factor in evaluating predictive models[19] and a necessary information to make well-founded conclusions about the performance of a model. In addition, (3) predictive model studies that developed a new model (ie, development design) or determined the incremental or added value of a predictor for an existing model (ie, incremental value design) had to be based on a regression modelling approach. This inclusion criterion enables us to identify significant risk factors and to apply the Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis (TRIPOD) adherence form, which was originally developed for regression models.[20] This implies that predictive models using machine-learning (ML) techniques (eg, least absolute selection and shrinkage operator[21] or random forest[22]) are excluded and coded as non-regression models. Studies that aimed to identify 30-day UHR predictors and did not provide a discrimination measure are classified as prognostic factor studies and are thus excluded from the analysis (so as not to bias them adversely in TRIPOD adherence). Prognostic factor studies, for example, are not required to present a simplified scoring rule (cf. TRIPOD item 15b[23]). Due to specific requirements of mental diseases, studies were only included (4) if they addressed non-mental health condition-related 30-day UHRs.[3]

Data extraction

Just as in previous systematic reviews,[3 24] studies were categorised by health conditions in all tables. Basic study characteristics were extracted according to criteria in tables 1 and 2. To assess the applicability of the predictive models, significant risk factors (ie, odds ratio (OR) or hazard ratio>1 with a p value of <0.05) were assigned to established and revised variable categories[3] in table 3. If all variables of a predictive model are available for a patient at the time of index admission (eg, previous health service usage before index admission), the model is applicable at admission. Applicability of predictive models at discharge is given if all variables are available at this point for a patient (eg, length of stay and operative time).

Reporting quality and performance

Predictive models can just be used in practice when clinicians and other stakeholders have access to all information required for their application in clinical practice.[12] The newly developed 'Critical Appraisal of Models that Predict Readmission (CAMPR)' contains 15 expert recommendations for predictive model development

Table 1 Summary of study characteristics for all-cause 30-day UHR predictive models

Reference	Model name	Medical condition	Model outcome	Study design/data source	Sample size	Age group	Period of data collection	Readmission rate	Model type/validation method
All-cause related UHRs									
Brittan *et al.*, USA[64]	Composite score	All-cause	30-day UHRs	Retrospective/1 children's hospital	29 542 patients	0–21 years	2014–2015	4.0%	Development study/ internal: cross
Sills *et al.*, USA[68]	PACR+SDH	All-cause	30-day UHRs	Retrospective/PHIS database, US Census's American Community Survey data, 47 hospitals	458 686 index discharges	<18 years	2014	6.1%	Incremental value study/ apparent
Ehwerhemuepha *et al.*, USA[65]	Unnamed	All-cause	30-day UHRs	Retrospective/US Census's American Community Survey data, one tertiary paediatric hospital	38 143 inpatient clinical encounters (DC: 19 072, VC: 19 071)	Between 28 days and 17 years	July 2013–June 2017	10.4%	Development study/ internal: random–split sample
	LACE (validation)				VC: 19 071 inpatient clinical encounters			NR	External validation study
Bradshaw *et al.*, USA[63]	HARRPS tool	All-cause	30-day UHRs	Retrospective/1 paediatric hospital	5306 patients	<18 years	May 2017–June 2018	25.3%	Development study/ internal: cross
Zhou *et al.*, Australia[61]	Unnamed	All-cause	30-day UHRs	Retrospective/Australian Census data, 1 tertiary paediatric hospital	73 132 patients	Age limit for admission: 15 years, special permissions by hospital executives possible	2010–2014	4.6%	Development study/ apparent
Ehwerhemuepha *et al.*, USA[69]	LACE (validation)	All-cause	30-day UHRs	Retrospective/Cerner Health Facts Database, 48 hospitals	1.4 million encounters	<18 years	2000–2017	12.6% (DC)	External validation study
Zhou *et al.*, Australia[22]	Model 1: GLM	All-cause	30-day UHRs	Retrospective matched case–control/1 tertiary paediatric facility, administrative inpatient data	940 patients	Different paediatric age groups*	2010–2014	4.55%†	Development study/ internal: cross
	Model 1: G-S								Development study/ internal: cross
	Model 2: GLM			Retrospective matched case–control/1 tertiary paediatric facility, administrative inpatient data, medical records					Development study/ internal: cross
	Model 2: G-S								Development study/ internal: cross
	Model 3: GLM			Retrospective matched case-control /1 tertiary paediatric facility, administrative inpatient data, medical records, written discharge documentation					Development study/ internal: cross
	Model 3: G-S								Development study/ internal: cross

*Mean age (years): 5.2 with HR, 5.3 without HR.
†Based on 3330 patients from the initial data set.
DC, derivation cohort; GLM, logistic regression; G-S, stepwise logistic regression; HARRPS, High-Acuity Readmission Risk Pediatric Screen; HR, hospital readmission; LACE, Length of stay, Acuity of admission, Comorbidity of the patient, Emergency department use; NR, not reported; PACR, paediatric all-condition readmission; PHIS, Paediatric Health Information Systems; SDH, social determinants of health; UHR, unplanned hospital readmission; VC, validation cohort.

Table 2 Summary of study characteristics for surgical and general medical conditions-related 30-day UHR predictive models

Reference	Model name	Medical condition	Model outcome	Study design/data source	Sample size	Age group	Period of data collection	Readmission rate	Model type/validation method
Surgical conditions related UHRs									
Vo *et al.*, USA[57]	Unnamed	All surgical specialties without cardiac surgery	30-day unplanned postsurgical HRs relating to non-cardiac surgery	Retrospective/ACS NSQIP-P database	182 589 patients	<18 years	2012–2014	4.8%	Development study/internal: bootstrap
Polites *et al.*, USA[56]	Unnamed	General and thoracic surgery	30-day UHRs related to the index surgical procedure	Retrospective/ACS NSQIP-P database	54 870 patients (DC: 38 397, VC: 16 473)	29 days–<18 years	2012–2014	3.6%	Development study/internal: random–split sample
Delaplain *et al.*, USA[70]	30-day readmission model	Trauma-related conditions	30-day unplanned trauma HRs	Retrospective/Cerner Health Facts database, 28 hospitals	82 532 patients (DC: 75%, VC: 25%)	<18 years	2000–2017	8.8%	Development study/internal: random–split sample*
Chotai *et al.*, USA[67]	Unnamed	Neurosurgery	30-day UHRs following index surgery for neurosurgical diagnoses	Retrospective/1 paediatric hospital	536 children	<18 years	January 2012–March 2015	11.9%	Development study/apparent
Davidson *et al.*, USA[73]	Unnamed	Ureteroscopy	30-day UHRs after ureteroscopy	Retrospective/NSQIP-P database	2510 patients	≤18 years	2015–2018	6.5%	Development study/apparent
Garcia *et al.*, USA[74]	Unnamed	Kasai procedure	30-day UHRs related to Kasai procedure	Retrospective/ NSQIP-P database	190 children	<1 year	2012–2015	15.3%	Development study/apparent
Lee *et al.*, USA[75]	Unnamed	Adolescent idiopathic scoliosis surgery	30-day UHRs after adolescent idiopathic scoliosis surgery	Retrospective/nationwide readmissions database	30 677 patients	10–18 years	2012–2015	2.9%	Development study/apparent
Minhas *et al.*, USA[58]	Idiopathic scoliosis	Spinal surgeries (scoliosis)	30-day UHRs	Retrospective/NSQIP-P database	3482 children	≤18 years	2012–2013	3.4%	Development study/apparent
	Progressive infantile scoliosis								Development study/apparent
	Scoliosis due to other conditions								Development study/apparent
Roddy and Diab, USA[59]	Unnamed	Spine fusion	30-day UHRs	Retrospective/state inpatient database	13 287 patients	<21 years	2006–2010 (New York, Utah, Nebraska, Florida and North Carolina), 2006–2011 (California)	4.7%	Development study/apparent
Sherrod *et al.*, USA[77]	Unnamed	Neurosurgery	30-day UHRs after neurosurgery	Retrospective/NSQIP-P database	9799 cases	<18 years	2012–2013	11.2%	Development study/apparent
Tahiri *et al.*, USA[60]	Unnamed	Plastic surgery	30-day UHRs following paediatric plastic surgery procedures	Retrospective/NSQIP database	5376 patients	≤18 years	2012	2.4%	Development study/apparent
Wheeler *et al.*, USA[78]	Unnamed	Burn diagnosis	30-day UHRs	Retrospective/nationwide readmissions database	11 940 patients	1–17 years	January–November 2013, January–November 2014	2.7%	Development study/apparent
Vedantam *et al.*, USA[31]	Unnamed	Epilepsy surgery	30-day UHRs after epilepsy surgery	Retrospective/NSQIP-P database	280 surgeries	≤18 years	2015	7.1%	Development study/apparent

Continued

Table 2 Continued

Reference	Model name	Medical condition	Model outcome	Study design/data source	Sample size	Age group	Period of data collection	Readmission rate	Model type/validation method
Basques *et al.*, USA[53]	Unnamed	Posterior spinal fusion	30-day UHRs after posterior spinal fusion	Retrospective/NSQIP-P database	733 patients	11–18 years	2012	1.5%	Development study/apparent
Martin *et al.*, USA[54]	Unnamed	Spinal deformity surgery	30-day UHRs after spinal deformity surgery	Retrospective/NSQIP-P database	1890 patients	<18 years	2012	3.96%	Development study/apparent
General medical conditions related UHRs									
Leary *et al.*, USA[66]	Prediction at admission	Complex chronic conditions	30-day UHRs	Retrospective /US Census Bureau data, 1 academic medical centre	2296 index admissions	6 months–18 years	October 2010–July 2016	8.2%	Development study/internal: bootstrap
	Prediction at discharge								Incremental value study/internal: bootstrap
Ryan *et al.*, USA[62]	PASS (validation)	Asthma	30-day UHRs	Retrospective/1 university-affiliated, tertiary paediatric referral centre	328 patients	5–18 years	May 2015–October 2017	3.0%	External validation study
O'Connell *et al.*, USA[72]	Unnamed	Nervous system condition	30-day UHRs	Retrospective/Cerner Health Facts database, 18 hospitals	105 834 index admissions (DC: 80%, VC: 20%)	<18 years	2000–2017	12.0%	Development study/internal: random–split sample
Hoenk *et al.*, USA[71]	Unnamed	Oncology	30-day UHRs	Retrospective/Cerner Health Facts database, 16 hospitals	10 418 patients (DC: 7814, VC: 2604)	<21 years	2000–2017	41.2%	Development study/internal: random–split sample
Sanchez-Luna *et al.*, Spain[76]	Unnamed	Acute bronchiolitis due to respiratory syncytial virus	30-day UHRs	Retrospective/Spanish National Health Service records	63 948 discharges	<1 year	2004–2012	7.5%	Development study/apparent
Sacks *et al.*, USA[55]	Unnamed	Cardiac conditions	30-day UHRs	Retrospective/1 academic children's hospital	1993 hospitalisations	0–12.9 years	2012–2014	20.5%	Development study/apparent

*Assumption for validation method: ORs for 30-day UHRs are displayed in a table that is part of the DC from the 7-day UHR predictive model.[70]
ACS, American College of Surgeons; DC, derivation cohort; HR, hospital readmission; NR, not reported; NSQIP-P, National Surgical Quality Improvement Programme Paediatric; PASS, Paediatric Asthma Severity Score; PHIS, Paediatric Health Information Systems; UHR, unplanned hospital readmission; VC, validation cohort.

Table 3 Significant risk factors for 30-day unplanned hospital readmission predictive models with a development or incremental value design

Health condition group	All-cause (n=5*)					Surgical conditions related (n=17)																General medical conditions related (n=6)					
Reference	64	68	65	63	61	57	56	70	67	73	74	75	58†	58‡	58§	59	77	60	78	31	53	54	66¶	66**	72	71	76	55
Location of residence††		x			x														x									
Health insurance				x	x											x												
Type of index hospital						x				x						x		x							x			
Living environment				x																								
Characteristics of primary care provider	x																											
Age at admission/ operation					x																						x	x
Sex										x						x												
Race/ethnicity		x							x								x								x			
Health service usage prior to index admission‡‡			x	x				x									x						x	x	x	x		
Prematurity											x																x	
Comorbidity		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			
LOS/postoperative LOS			x		x		x	x				x				x			x					x	x	x		
Principal diagnoses			x					x								x									x	x		
Principal procedures							x						x		x	x	x		x	x		x				x		
Inpatient complications						x	x				x	x				x	x	x			x							
(Specific) medication at index admission								x																	x	x		
Length of operation							x										x	x										
Wound contamination before operation							x											x										
The ASA class						x									x			x				x						
Discharge on Friday or weekend					x																							
Discharge disposition																x	x							x				

Continued

Table 3 Continued

Health condition group	All-cause (n=5*)				Surgical conditions related (n=17)												General medical conditions related (n=6)				
Reference	**64**	**68**	**65**	**63**	**61**	**57**	**56**	**70**	**67**	**73**	**74**	**75**	**58†**	**58‡**	**58§**	**59**	**77**	**60**	**78**	**31**	**53**	**54**	**66¶**	**66****	**72**	**71**	**76**	**55**
Discharge with increased medication/further treatment	x																											
Admission on Friday					x																							
Surgical location										x																		

x=risk factor (OR/hazard ratio>1).
*The six predictive models of Zhou *et al*[22] are not included in this analysis due to missing information about ORs. See online supplemental table A6 in the online supplemental material for a list of included variables.
†Model for idiopathic scoliosis.
‡Model for progressive infantile scoliosis.
§Model for scoliosis due to other conditions.
¶Admission model.
**Discharge model.
††Social determinants of health are included (eg, median household income).
‡‡Risk factor category includes, for example, the number of previous emergency department visits or hospitalisations.
§§The risk factor category also captures the urgency of the index admission. The risk factor category includes, for example, PICU or emergency department admission.
ASA, American Society of Anesthesiologists; LOS, length of stay; PICU, paediatric intensive care unit; postoperative LOS, postoperative length of stay.

relating to HRs. However, CAMPR should not be used as a reporting standard so far and relates to aspects that are out of the scope of this systematic review (eg, considering different time frames for UHRs).[25] Due to the importance of high-quality information about predictive models, we decided to assess the completeness of reporting by using the TRIPOD adherence form and scoring rules.[12 23 26] The TRIPOD adherence form consists of 22 main criteria based on the TRIPOD statement,[20] resulting in 37 items that are applicable to varying degrees to the development, validation and incremental value studies.[23] We decided to apply the TRIPOD adherence form at predictive model level. Therefore, publications that report the development and validation of the same predictive model, for example, are assessed separately. According to previous research, our analysis concentrates on items that could be reported in the main text or supplements[27].

TRIPOD adherence at model level was merged with the performance results (ie, discrimination and calibration measures) and the applicability assignment in table 4. The discrimination of a predictive model is often evaluated by the c-statistic or area under the receiver operating characteristic curve. The c-statistic can take a value between 0.5 and 1. A value of 0.5 indicates that the model is not superior to a random prediction of outcome, while values between 0.7 and 0.8 indicate that the model is appropriate. A value of 0.8 or greater indicates a strong discrimination of a model.[28]

Quality assessment

Following previous systematic reviews,[3 24 29] the refined version of the quality in prognosis studies (QUIPS) tool with its prompting items[30] was used to appraise the studies critically with regard to the included predictive models based on six domains. Each domain was rated with a 'high', 'moderate' or 'low' risk of bias.

The six domains are[30] 'study participation', 'study attrition', 'prognostic factor measurement', 'outcome measurement', 'study confounding' and 'statistical analysis and reporting'.

Data synthesis

Because a quantitative evaluation in the form of a meta-analysis was not possible due to the high heterogeneity among the studies, the studies were qualitatively synthesised; that is, the results for performance, completeness in reporting and significant risk factors were presented in a narrative and simplified quantitative form.

Patient and public involvement

Due to the study design, we did not involve patients or the public.

RESULTS

Search result

From the electronic database search, 10076 records were obtained. After duplicates had been removed, the titles

Table 4 Performance, application and TRIPOD adherence of 30-day UHR predictive models in paediatrics (n=37)

Reference	Model name	Performance		TRIPOD score	Potentially applicable…
		Discrimination (c-statistic)	Calibration		
All-cause related UHRs					
Brittan *et al*.[64]	Composite Score	0.62		73.33%	At discharge
Sills *et al*.[68]	PACR+SDH	0.708		64.71%	At discharge
Ehwerhemuepha *et al*.[65]	Unnamed	VC: 0.79		63.33%	At discharge
	LACE (validation)	0.68		44.44%	At discharge
Bradshaw *et al*.[63]	HARRPS-tool	Score: 0.65		73.33%	At admission
Zhou *et al*.[61]	Unnamed	0.645		62.07%	At discharge
Ehwerhemuepha *et al*.[69]	LACE (validation)	0.7014		33.33%	At discharge
Zhou *et al*.[22]	Model 1: GLM	0.487		68.97%	At admission
	Model 1: G-S	0.477		68.97%	At discharge
	Model 2: GLM	0.585		68.97%	At discharge
	Model 2: G-S	0.593		68.97%	At discharge
	Model 3: GLM	0.609		68.97%	At discharge
	Model 3: G-S	0.617		68.97%	At discharge
Surgical condition-related UHRs					
Vo *et al*.[57]	Unnamed	0.747	Slope: 1, intercept: 0.002	68.97%	At discharge
Polites *et al*.[56]	Unnamed	DC: 0.71; VC: 0.701	DC: p=0.95, O:E ratio=1.03; VC: p=0.36, O:E ratio=1.07	62.07%	At discharge
Delaplain *et al*.[70]	30-day readmission model	VC: 0.799		51.72%	At discharge
Chotai *et al*.[67]	Unnamed	0.72		42.86%	At discharge
Davidson *et al*.[73]	Unnamed	0.73	H&L χ^2: 7.5 (p=0.4474)	58.62%	At discharge
Garcia *et al*.[74]	Unnamed	0.703		51.72%	At discharge
Lee *et al*.[75]	Unnamed	0.712	H&L: 0.0974	58.62%	At discharge
Minhas *et al*.[58]	Idiopathic scoliosis	0.760–0.769		55.17%	At discharge*
	Progressive infantile scoliosis			55.17%	At discharge*
	Scoliosis due to other conditions			55.17%	At discharge*
Roddy and Diab[59]	Unnamed	0.75	H&L (p value): 0.46	55.17%	At discharge
Sherrod *et al*.[77]	Unnamed	0.759		55.17%	At discharge
Tahiri *et al*.[60]	Unnamed	0.784		55.17%	At discharge
Wheeler *et al*.[78]	Unnamed	0.72		55.17%	At discharge
Vedantam *et al*.[31]	Unnamed	0.71	H&L (p value): 0.94	41.38%	At discharge
Basques *et al*.[53]	Unnamed	0.87	H&L: value not reported†	68.97%	At discharge
Martin *et al*.[54]	Unnamed	0.77		62.07%	At discharge
General medical condition-related UHRs					
Leary *et al*.[66]	Prediction at admission	0.65, score: 0.65	Calibration plot	79.31%	At admission
	Prediction at discharge	0.67, score: 0.67	Calibration plot	81.25%	At discharge
Ryan *et al*.[62]	PASS (validation)	0.28		55.17%	At discharge
O'Connell *et al*.[72]	Unnamed	VC: 0.733		51.72%	At discharge
Hoenk *et al*.[71]	Unnamed	VC: 0.714		55.17%	At discharge

Continued

Table 4 Continued

Reference	Model name	Performance		TRIPOD score	Potentially applicable…
		Discrimination (c-statistic)	Calibration		
Sanchez-Luna *et al*.[76]	Unnamed	0.611		56.67%	At admission
Sacks *et al*.[55]	Unnamed	0.75		58.62%	At discharge

*Assumption for applicability based on variables included in the univariable analysis.
†H&L shows 'no evidence of a lack of fit' (Basques[53] p290).
DC, derivation cohort; GLM, logistic regression; G-S, stepwise logistic regression; HARRPS, High Acuity Readmission Risk Paediatric Screen; H&L, Hosmer-Lemeshow; LACE, Length of stay, Acuity of admission, Comorbidity of the patient, Emergency department use; NR, not reported; PACR, paediatric all-condition readmission; PASS, Paediatric Asthma Severity Score; SDH, social determinants of health; TRIPOD, Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis; UHR, unplanned hospital readmission; VC, validation cohort.

and abstracts were screened for 7694 records. Based on the predefined inclusion criteria, 7586 records were excluded. Adding one additional recommended article[31],we found that this results in 109 records being included in the full-text assessment. Among the 84 excluded records, 2 were predictive model studies for 30-day HRs (ie, UHRs and planned HRs) with discrimination metrics[32 33]; 12 studies analysed 30-day UHRs or 30-day HRs combined with another outcome (ie, emergency department return visits (n=5),[34–38] mortality (n=3)[39–41] and other complications (n=4)[42–45]); 3 were predictive model studies for 30-day UHRs or 30-day HRs with no discrimination metrics[46–48]; 5 were non-regression-based predictive model studies for 30-day UHRs or 30-day HRs in paediatrics[21 49–52]; and 59 were prognostic factor studies for 30-day UHRs or 30-day HRs. Based on the full-text assessments (n=25) and the hand search of reference lists (n=3[53–55]), 28 studies were included in the systematic review, with 6 of them[55–60] already presented in a previous systematic review[3] with a different focus. The results of the review process regarding the database search are provided in online supplemental figure A1 in the online supplemental material (see online supplemental table A4 in the online supplemental material for a summary of study characteristics of selected excluded models).

Quality assessment

Overall, the quality of many studies was moderate to low for several domains. For instance, the study quality had to be reduced due to a lack of sufficient information (eg, in the domain 'study participants' or 'study attrition'), while all studies were rated as 'low' for the domain 'study confounding' (see online supplemental table A5 in the online supplemental material for the results of the risk of bias assessment).

Study characteristics

All studies were based on retrospective data, with 9 studies based on tertiary or paediatric hospital data,[22 55 61–67] and 19 studies based on centralised databases[31 53 54 56–60 68–78]. Four of 28 studies additionally included census data in the analysis.[61 65 66 68] The period of data collection ranged from 1 year[31 53 54 60 63 68] to 17 years[69 70]. The majority of studies included patients up to an age of <18 or ≤18 years. Only 5 studies considered patients up to 21 years of age[59 64 71] or younger than 1 year[74 76]. The sample size was specified with different units in the individual studies (eg, encounters and admissions) and varies between 190 children[74] and 1.4 million encounters[69].

The 28 included studies resulted in 37 predictive models for 30-day UHRs in paediatrics. 10 of 28 studies developed or validated more than one predictive model for UHRs,[22 58 59 65–70 75] which were in part excluded due to non-agreement with the inclusion criteria. The models included were grouped into three health conditions: (1) all-cause UHR (n=13),[22 61 63–65 68 69] (2) surgical condition-related UHR (n=17)[31 53 54 56–60 67 70 73–75 77 78] and (3) general medical condition-related UHR (n=7)[55 62 66 71 72 76]. The 30-day UHR rates varies from 1.5%[53] to 41.2%[71].

Among the 37 predictive models included, 32 (87%) used a development design[22 31 53–61 63–67 70–78]; 3 (8%) used an external validation design[62 65 69]; and 2 (5%) used an incremental value design[66 68]. All external validated models were based on existing predictive models that had been previously used in the adult population[65 69] or for different outcomes[62]. Furthermore, 5 of the 28 studies included did not state the primary aim to develop, validate externally or assess the incremental value of the respective 30-day UHR predictive model.[65 67–70]

Of the predictive models with a development or incremental value design, 18 employed an apparent validation[31 53–55 58–61 67 68 73–78] and 16 employed an internal validation[22 56 57 63–66 70–72]. The most commonly applied internal validation method was cross-validation (n=8)[22 63 64] followed by split sample (n=5)[56 65 70–72] and bootstrapping (n=3)[57 66]. In order to analyse the data, either a logistic regression[22 31 53–55 57–61 63–68 70–78] or a Cox proportional hazard regression[56] was used. Most models presented their results by ORs with a 95% CI. With a p value of <0.05, we considered the results as statistically significant.[3] A summary of characteristics of all included studies is provided in tables 1 and 2.

Applicability and significant risk factors in predictive models

Based on the 28 predictive models with a development or incremental value design, 25 significant risk factors associated with 30-day UHRs were identified (see table 3). The most common risk factors were comorbidity (n=18), (postoperative) length of stay (n=10), illness severity (n=9) and principal procedures (n=9). The significant risk factors were inconsistently defined across predictive models, allowing a direct comparison only to a limited extent. ORs for comorbidity ranged from 1.01[72] to 10.08[58] across predictive models. A length of stay of ≥15 days (OR=2.39)[61] and a postoperative length of stay of >4 days (hazard ratio=3.12)[56] were considered to be a major risk factor. For illness severity, 'intensive care unit stay' (OR=3.302)[67] and for principal procedures 'isolated primary anterior spinal fusion' (OR=7.65)[54] were one of the most pronounced risk factors, respectively. The risk factor with the highest OR value was 'any inpatient complication' (OR=180.44).[53] For all-cause UHRs, UHRs related to surgical conditions and UHRs related to general medical conditions, 14, 19 and 12 significant risk factors were found, respectively.

Most predictive models are potentially applicable at discharge (n=33), while 4 predictive models can be used at index admission,[22 63 66 76] based on the significant and examined variables (see online supplemental table A6 in the online supplemental material for an overview of variables and table 4 for an application description).

Completeness in reporting and discriminative ability at model level

Information about TRIPOD adherence and performance at model level is provided in table 4. The median TRIPOD adherence of the models was 59% (P_{25}–P_{75}, 55%–69%; average: 60%), ranging from 33%[69] to 81%[66]. Developed predictive models had a more favourable reporting quality in comparison with external validated models (ie, 59% (P_{25}–P_{75}, 55%–69%; average: 61%) compared with 44% (P_{25}–P_{75}, 39%–50%; average: 44%), respectively). Two models with poor adherence in reporting were based on an external validation design, and the validation of these models was not the primary aim of the study.[65 69]

Including all 37 items, we found that the overall median adherence per TRIPOD item across models was 65% (P_{25}–P_{75}, 32%–92%; average: 57%), ranging from 0% to 100% (see online supplemental table A7 in the online supplemental material for a detailed description by model type). The overall adherence per TRIPOD item is illustrated in figure 1.

14% of the models reported the title (item 1) completely, while 19%[62–66 68] of the models mentioned the predictive model type in this context. 3% of the models had a completed abstract (item 2). The detailed predictor definition (item 7a) was fulfilled for more models (95%), in contrast to outcome definition (item 6a) (reported in 70%). The handling of predictors in the analysis (item 10a) showed incomplete reporting in 82% of the models. In addition, the handling (item 9, reported in 35%) and reporting of missing values (part of item 13b, reported in 32%) were not addressed in many models. Just 9% of the models displayed complete reporting of the model-building procedure (item 10b), as the majority of the models (91%) did not address the testing of interaction terms[22 31 53–61 64–68 70 72–75 77 78]. The description (item 10d) and reporting of performance measures (item 16) were incomplete in 68% and 89% of the models. Just 24% of the models addressed results of calibration measures (cf. table 4). No model presented the full predictive model (item 15a) by providing an example of an intercept. An explanation for using the prediction model (item 15b, eg, by a simplified scoring rule) was presented in 21% of the models. One model provided detailed information about a simplified scoring rule (item 15b) in the online supplemental material[66].

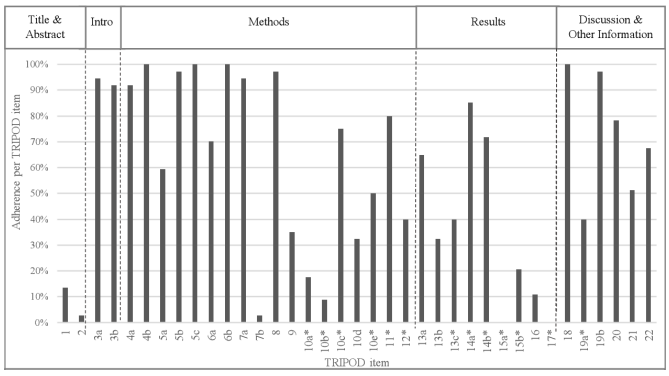

Figure 1 Overall adherence per TRIPOD item across all included predictive models (n=37). Notes: Percentages relate to the number of models for which an item was applicable (in this case, the respective item should have been reported). *Indication of derivation from the total number of models for which a TRIPOD item was applicable (N=# of models for which the TRIPOD item is applicable): 10a (N=34), 10b (N=34), 10c (N=4), 10e (N=2), 11 (N=5), 12 (N=5), 13c (N=5), 14a (N=34), 14b (N=32), 15a (N=34), 15b (N=34), 17 (N=1), 19a (N=5). TRIPOD, Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis

The discriminative ability (c-statistic) of the models ranged from 0.28[62] to 0.87[53]. 14 out of 37 predictive models had a c-statistic of <0.7. The linear correlation between c-statistic and TRIPOD score at model level was not statistically significant (r=–0.241, p=0.15). Models with good discriminative ability (c-statistic >0.7)[31 53–60 65 67–75 77 78] are primary applicable at discharge and have a TRIPOD score ranging from 41%[31] to 69%[57]. The two models with the highest reporting quality (79% and 81%) are applicable for predicting 30-day UHRs of children with complex chronic conditions. The c-statistic values of these models were 0.65[66] and 0.67[66], respectively (see online supplemental figure A2 in the online supplemental material for an illustration of the models' performance and TRIPOD adherence).

DISCUSSION

Based on 28 studies, this systematic review identifies 37 predictive models that could potentially be used for determining individual 30-day UHR risk in paediatrics.

According to the models, the 4 most common significant risk factors in predictive models were comorbidity, (postoperative) length of stay, illness severity and principal procedures. 23 validated predictive models have a c-statistic of >0.7. The median TRIPOD adherence of the predictive models included was 59% (P_{25}–P_{75}, 55%–69%), ranging from 33% to 81%, which is similar to that of other systematic reviews[12 27].

Practical clinical and policy implications

In general, reporting quality and discriminative ability can provide crucial information about the strengths and weaknesses of a predictive model for implementation in practice (see online supplemental figure A2 in the online supplemental material for a combined illustration). However, the results from this systematic review revealed considerable differences in the c-statistics (0.28[62]–0.87[53]) and in the TRIPOD scores (33%[69]–81%[66]) at the model level. When considering the available information about reporting quality and discriminative ability in relation to each other, it should be noted that the linear correlation between c-statistic and TRIPOD score at model level was not statistically significant (r=−0.241, p=0.15). Therefore, an independent evaluation of both aspects for the selection of an appropriate predictive model is recommended.

Clinicians and decision makers should use predictive models with good discriminative ability (ie, c-statistic above 0.7) and sufficient data availability. Especially predictive models that are based on census data[61 65 66 68] or manual data entry (eg, written discharge documentation[22]) may be more difficult to implement than models relying on centralised databases[31 53 54 56–60 69–78]. The TRIPOD score at the predictive model level (see table 4) can be used as a first indicator if the predictive model can be assessed and implemented with the given information.

Similar to a previous systematic review,[3] comorbidity and (postoperative) length of stay were identified as consistently cited risk factors across the included studies. In addition, illness severity was one main risk factor among all three health condition groups. For surgical condition-related UHR, the principal procedure has been shown to be crucial as a risk factor. The practical application of risk factors should be made with caution because risk factors are often inconsistently defined across studies. Therefore, knowledge about study-related predictor definitions is required before application.

Limitations

This systematic review has certain limitations:

1. The studies included needed be to published in English or German with full-text access.
2. Summarising the results of the included studies quantitatively was not possible due to the heterogeneity of the predictive models (resulting from differences in sample sizes, the examined variables or variations in the periods of data collection).
3. The sample size of the included studies was reported in different units (eg, encounters and discharges), impeding the comparisons of UHR rates.
4. Our assignment of the predictive models that are potentially applicable at discharge assumes that the required variables are available at the time point. If clinicians and other stakeholders decide to use a predictive model, it should be checked beforehand whether complete data collection is possible at the desired time.
5. In addition to the identified medical risk factors (eg, comorbidity) and several country-specific risk factors (eg, location of residence) that result in paediatric readmissions, health-policy initiatives may also affect the readmission rates in paediatric clinical practice[79]. However, due to a lack of data, these aspects could not be captured by this review.

Future research

This systematic review did not identify predictive models for individualised risk prediction of potentially preventable UHRs in paediatrics, emphasising past discussions to expand the research field further.[3]

Current external validation studies were conducted in the USA and examined the applicability of existing predictive models with other outcomes or population backgrounds to paediatric 30-day UHRs.[62 65 69] Therefore, external validation studies are needed for those models that are explicitly developed to predict 30-day UHRs in paediatrics. Because the number of predictive models related to medical condition-related UHRs was small (n=7)[55 62 66 71 72 76], with 4 out of 7 models demonstrating a c-statistic below 0.7[62 66 76], there is a need for high-quality models in this area.

Non-regression-based techniques (eg, machine learning) are an increasing field in order to predict 30-day HRs in paediatrics, most of which show good discriminative ability[21 22 47 49–52 69] (see online supplemental table A4 in the online supplemental material). Future systematic reviews should summarise and critically assess existing non-regression-based HR predictive models in paediatrics, for instance, by applying the TRIPOD-ML statement that is going to be published.[80]

Existing studies discuss the benefit of shorter time intervals in order to identify preventable readmissions more accurately[6 81]; one study concluded that a 30-day UHR metric was more precise (c-statistic=0.799) for paediatric trauma patients than a 7-day UHR metric (c-statistic=0.737).[70] To our knowledge, there is one predictive model for 365-day[7], 3 for 90-day[59 67 75] and one for 7-day[70] UHRs in paediatrics with good discriminative ability (c-statistic>0.7). Future studies should address the evaluation of paediatric UHR predictive models with different time intervals.

CONCLUSION

This systematic review revealed an increase in the development of predictive models for 30-day UHRs in paediatrics

in recent years. To support the implementation of the predictive models in the long term, it is essential to validate existing models in order to test their applicability in different settings. To increase accessibility for use, more attention should be given on completeness in reporting, particularly for items that may be relevant for the implementation of paediatric 30-day UHR predictive models in practice (ie, those relating to outcome and predictor definitions, handling of missing values, full predictive model presentation and an explanation for its use).

Contributors IMN conceptualised and designed the systematic review, participated in the literature search, study selection, quality assessment, data extraction and data analyses, and drafted the initial manuscript. NK contributed to the literature search, study selection, quality assessment and data extraction, and critically reviewed the manuscript. SS contributed to the data analysis and critically reviewed the manuscript. JD contributed to the study selection, data extraction and data analysis, and critically reviewed the manuscript. DM conceptualised and designed the systematic review, participated in the study selection, quality assessment, data extraction and data analyses, and critically reviewed the manuscript. All authors approved the final manuscript for submission and agreed to be accountable for all aspects of the work. IMN is the guarantor of the study.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study does not involve human participants.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Additional information, including the protocol, is available from the corresponding author.

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Supplemental Material

Table A1: Search strategy for PubMed

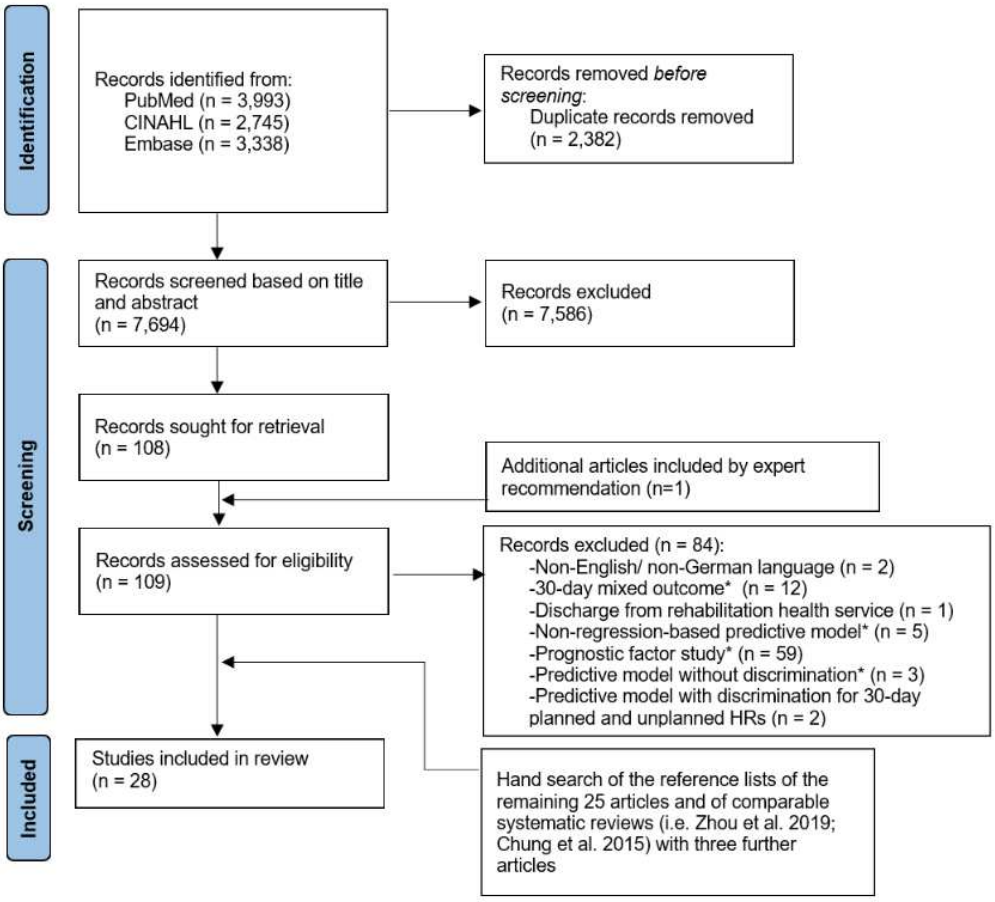
#	PubMed (Search date: 01st January 2021; Updated Search date: 07th October 2021)	Results from initial search	Results from updated search
1	"Patient Readmission"[Mesh]	18,336	20,199
2	rehospitali*[Title/Abstract]	8,017	8,645
3	readmission*[Title/Abstract]	31,790	35,343
4	(hospital[Title/Abstract]) AND readmission*[Title/Abstract]	21,144	23,398
5	(unplanned[Title/Abstract]) AND readmission*[Title/Abstract]	2,360	2,677
6	(patient[Title/Abstract]) AND readmi*[Title/Abstract]	16,395	18,106
7	readmit*[Title/Abstract]	8,289	8,926
8	re-admission*[Title/Abstract]	2,205	2,416
9	(repeat*[Title/Abstract]) AND hospital*[Title/Abstract]	29,556	31,364
10	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9	75,738	81,968
11	predictive factor*[Title/Abstract]	28,124	30,391
12	predict*[Title/Abstract]	1,646,322	1,765,658
13	"Predictive Value of Tests"[Mesh]	207,290	215,023
14	"ROC Curve"[Mesh]	60,417	65,077
15	model*[Title/Abstract]	3,025,019	3,240,665
16	c-statistic*[Title/Abstract]	6,938	7,765
17	ROC*[Title/Abstract]	55,019	62,608
18	"Sensitivity and Specificity"[Mesh]	595,955	619,284
19	Sensitivity [Title/Abstract]	827,733	873,715
20	Specificity [Title/Abstract]	478,451	502,627
21	11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20	5,225,692	5,555,402
22	"Child"[Mesh]	1,936,577	2,010,900
23	"Infant"[Mesh]	1,152,685	1,189,047
24	"Adolescent"[Mesh]	2,058,561	2,216,512
25	(((((adolescen*[Title/Abstract]) OR teen*[Title/Abstract]) OR youth[Title/Abstract]) OR juvenile*[Title/Abstract]) OR young person*[Title/Abstract]) OR young people*[Title/Abstract]	464,723	492,107
26	"Pediatrics"[Mesh]	59,136	61,129
27	((((((((((child*[Title/Abstract]) OR (infant*[Title/Abstract])) OR (toddler*[Title/Abstract])) OR (bab*[Title/Abstract])) OR (newborn*[Title/Abstract])) OR (neonat*[Title/Abstract])) OR (school age*[Title/Abstract])) OR (preschool)) OR (paediatric*[Title/Abstract])) OR (pediatric*[Title/Abstract])) OR (kid*[Title/Abstract])) OR (boy*[Title/Abstract])) OR (girl*[Title/Abstract])	2,246,452	2,343,927
28	22 OR 23 OR 24 OR 25 OR 26 OR 27	4,365,971	4,517,928
29	10 AND 21 AND 28	3,674	3,993

Table A2: Search strategy for CINAHL

	CINAHL (Initial Search date: 01st January 2021; Updated Search date: 07th October 2021)	**Results from initial search**	**Results from updated Search**
1	(MH "Readmission")	14,256	15,177
2	rehospitali*	2,624	2,779
3	readmission*	21,640	23,205
4	hospital AND readmission*	13,210	14,167
5	unplanned AND readmission*	1,227	1,363
6	patient AND readmi*	17,823	19,163
7	readmit*	2,588	2,791
8	re-admission*	954	1,029
9	repeat* AND hospital*	12,404	12,997
10	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9	36,195	38,498
11	predictive factor*	10,824	11,733
12	predict*	394,485	423,169
13	(MH "Predictive Value of Tests")	52,176	54,193
14	(MH "ROC Curve")	27,863	29,859
15	model*	626,177	669,950
16	c-statistic*	2,593	2,822
17	ROC*	45,218	74,438
18	(MH "Sensitivity and Specificity")	85,260	87,853
19	sensitiv*	236,551	247,288
20	specific*	481,504	511,797
21	(MH "Predictive Validity")	5,587	5,746
22	11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21	1,337,979	1,442,565
23	(MH "Child")	467,217	486,202
24	(MH "Infant+")	260,190	268,903
25	(MH "Adolescence+")	535,922	557,353
26	adolescen* OR teen* OR youth OR juvenile* OR young person* OR young people*	598,199	624,571
27	(MH "Pediatrics+")	21,316	21,917
28	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*	1,150,913	1,264,003
29	23 OR 24 OR 25 OR 26 OR 27 OR 28	1,413,615	1,514,718
30	10 AND 22 AND 29	2,459	2745

Table A3: Search strategy for Embase

	Embase (Initial Search date: 01st January 2021*; Updated Search dates: 7th June 2021, 07th October 2021)	**Results from updated search 7th June 2021**	**Results from updated search 07th October 2021**
1	'hospital readmission'/exp	73,736	76,850
2	rehospitali*:ab,ti	10,922	15,528
3	readmission*:ab,ti	57,908	64,311
4	(hospital NEAR/10 readmission*):ab,ti	22,791	25,140
5	(unplanned NEAR/10 readmission*):ab,ti	3,446	3,749
6	(patient NEAR/5 readmi*):ab,ti	5,568	6,357
7	readmit*:ab,ti	16,262	18,777
8	're admission*':ab,ti	5,802	5,982
9	(repeat* NEAR/5 hospital*):ab,ti	5,341	5,466
10	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9	100,580	107,753
11	'predictive factor*':ab,ti	47,721	49,181
12	predict*:ab,ti	2,301,090	2,367,382
13	'predictive value'/exp	191,705	199,896
14	'roc curve'/exp OR 'receiver operating characteristic'/exp	149,025	157,486
15	'model'/exp	3,201,228	3,267,314
16	'c statistic*':ab,ti	12,892	13,511
17	roc*:ab,ti	196,628	207,024
18	'sensitivity and specificity'/exp	391,861	405,843
19	'sensitivity':ab,ti	1,109,211	1,135,520
20	'specificity':ab,ti	636,321	650,496
21	'predictive validity'/exp	8,691	8,839
22	11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21	6,371,499	6,524,117
23	'child'/exp	3,031,530	3,082,756
24	'infant'/exp	1,180,824	1,197,926
25	'adolescent'/exp	1,741,216	1,770,557
26	adolescen*:ab,ti OR teen*:ab,ti OR youth:ab,ti OR 'juvenile*':ab,ti OR 'young person*':ab,ti OR 'young people':ab,ti	598,758	613,037
27	'pediatrics'/exp	123,610	125,641
28	'child*':ti,ab OR 'infant*':ti,ab OR 'toddler*':ti,ab OR bab*:ti,ab OR 'newborn*':ti,ab OR neonat*:ti,ab OR 'school age*':ti,ab OR 'preschool':ti,ab OR 'pediatric*':ti,ab OR kid*:ti,ab OR 'boy*':ti,ab OR 'girl*'	3,642,407	3,715,357
29	23 OR 24 OR 25 OR 26 OR 27 OR 28	5,498,512	5,594,597
30	#10 AND #22 AND #29	2,902**	3,338
* Final result from initial search: 2,845 ** Search term: #10 AND #22 AND #29 AND [1-1-1966]/sd NOT [2-1-2021]/sd			



Abbreviations: HRs, hospital readmissions; PRISMA, preferred reporting items for systematic reviews and meta-analyses.

* The study outcome definition for hospital readmissions was (i) 30-day unplanned hospital readmission or (ii) 30-day planned and unplanned hospital readmission.

Figure A1: Flowchart for the search and study selection process (PRISMA)

Table A4: Summary of study characteristics for excluded predictive models relating to machine learning studies (n=8), predictive model studies without discrimination (n=3) and predictive model studies with discrimination for 30-day planned and unplanned HRs (n=2).

Reference	Model type	Medical condition	Model Outcome	Study design/ data source	Sample size/ readmission rate	Age group	Period of data collection	Discrimination (c-statistic)
All-cause related HRs								
Desai et al. 2014, USA	PM without D	All-cause	30 day unplanned HRs	Prospective/ Survey data (PedsQL Infant Scales instrument or PedsQL 4.0 Generic Core Scales instrument)	19,139 eligible patients/ NR	1 month - 18 years	1. Oct. 2011 - 31. Dec. 2013	-
Santos et al. 2020, Brazil	PM without D	All-cause	30 day HRs	Prospective/ 1 public hospital, StrongKids data (nutritional screening)	641 patients/ 2%	1 month - 17 years	2014 - 2018	-
Jovanovic et al. 2016, USA	ML-PM	All-cause	30 day HRs	Retrospective/ State Inpatient Databases, Healthcare Cost and Utilization Project	66,994 patients/ 17%	general paediatric population	2009-2011	0.783 (Lasso), 0.779 (Tree-Lasso)
Stiglic et al. 2015, USA	ML-PM	All-cause	30 day HRs	Retrospective/ State Inpatient Databases, Healthcare Cost and Utilization Project	61,111 discharge records/ 18%	≤ 10 years	2009-2011	0.750-0.771
Stiglic et al. 2014, USA	ML-PM	All-cause	30 day HRs	Retrospective/ State Inpatient Databases, Healthcare Cost and Utilization Project	66,994 discharge records/ 17%	≤ 10 years	2009-2011	0.787 (distributed model), 0.789 (elastic net model)
Taylor et al. 2020, USA	ML-PM	All-cause	30 day unplanned HRs	Retrospective/ PHIS database	1,111,323 children/ 4.4%	< 18 years	2016-2017	0.811
Zhou et al. 2021, Australia*	ML-PM	All-cause	30 day unplanned HRs	Retrospective matched case-control / 1 tertiary paediatric facility, administrative inpatient data, medical records, written discharge documentation	940 patients/ 4.55%	different paediatric age groups	2010 - 2014	Model 1: 0.519 (random forest), 0.5 (elastic net), 0.509 (gradient bossted tree); Model 2: 0.603 (random forest), 0.616 (elastic net), 0.624 (gradient bossted tree); Model 3: 0.642 (random forest), 0.635 (elastic net), 0.654 (gradient bossted tree)
Ehwerhemuepha et al. 2020, USA*	ML-PM	All-cause	30 day (unplanned) HRs	Retrospective/ Cerner Health Facts Database, 48 hospitals	1.4 million encounters/ 12.6% (DC)	< 18 years	2000-2017	M1 (single-center): 0.8226, M2 (single-center): 0.8756, M3 (multi-center): 0.8451

Reference	Model type	Medical condition	Model Outcome	Study design/ data source	Sample size/ readmission rate	Age group	Period of data collection	Discrimination (c-statistic)
Wolff et al. 2019, Chile	ML-PM	All-cause	30 day HRs	Retrospective/ administrative data, 1 paediatric hospital	56,558 admissions/ 3.7%	general paediatric population	July 2011 - Oct. 2017	0.47 - 0.65
Surgical conditions related HRs								
Janjua et al. 2019, USA	ML-PM without D	Spinal cord tumor surgery	30 day HRs	Retrospective/ Nationwide Readmissions Database	397 patients/ 10.8%	≤ 20 years	2010-2015	-
Jiang et al. 2018, USA	PM with D	Urological surgery	30-day HRs after paediatric urological procedures	Retrospective/ Nationwide Readmissions Database/ State Inpatient Databases	Nationwide Readmissions Database: 8,006 patients/ NR; State Inpatient Databases: 6,236 patients/ NR	<18 years	Nationwide Readmissions Database: 2013; State Inpatient Databases: 2007-2010	Nationwide Readmissions Database: 0.63 (CCI), 0.54 (VWI), 0.58 (Rhee index); State Inpatient Databases: 0.63 (CCI), 0.54 (VWI), 0.56 (Rhee index)
Smith et al. 2015, USA	PM with D	Cardiac surgery	30-day HRs following congenital heart surgery	Retrospective/ PHIS database, US census data, 43 not-for-profit, tertiary care paediatric hospitals	17,871 discharges (DC: 9,104, VC: 8,767)/ 11.0% (DC), NR (VC)	< 18 years	2011 (DC), 2012 (VC)	0.68 (DC), 0.68 (VC)

Abbreviations: CCI, Charlson Comorbidity Index; D, discrimination; DC, derivation cohort; HR, hospital readmission; ML, machine learning; NR, not reported; PHIS, Paediatric Health Information Systems; PM, predictive model; VC, validation cohort; VWI, Van Walraven Index

* This study contains one or more predictive models that were included in the systematic review.

Table A5: Risk of bias assessment at study level

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
Vo et al. 2018	- Low - surgery was conducted in inpatient or outpatient setting; Deidentification of hospital-related data (i.e. facility type), but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Moderate - No detailed description of statistical analysis for the simplified scoring rule; Unadjusted associations for "Complications" are missing	**1**
Polites et al. 2017	- Low - surgery was conducted in inpatient or outpatient setting; Deidentification of hospital-related data (i.e. facility type), but all hospitals are from the USA	- Moderate - 38.5% missing values for the ICD-9-diagnosis variable used for determining the reasons for readmission	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Low -	**1**
Brittan et al. 2018	- Moderate - Potential limitation of generalizability as just one paediatric hospital was examined; Only basic information about "age"	- Moderate - About 75% of patients were missing homecare values in the original data (the study assumption is that this patients did not received home health)	- Moderate - Assumption that 75% of patients did not receive home health; Possible omission or error of clinical documentation	- Moderate - no clear description for the determination of unplanned hospital readmissions	- Low - just PFs of the composite score are considered	- Low -	**1**

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
Sills et al. 2017	- Low -	- Moderate - No flow diagram	- Moderate - Area-level SDH data were not created for research and are a biased proxy for individual-level SDH measures; Handling of continuous predictors relating to ZIP-Codes (i.e. linear or non-linear) not clear described	- Low -	- Low -	- Low -	**1**
Ehwerhemuepha et al. 2018	- Moderate - Potential limitation of generalizability as just one hospital was examined; No detailed information about the source of ZIP-related variables; No information about characteristics of patients in the validation cohort (Random-Split-Sample)	- Low -	- Moderate - No detailed description for the handling of continuous predictors and method for categorized predictors	- Low - The outcome was determined automatically and not validated by manual chart review	- Low -	- Moderate - No detailed definition for LACE variables; Missing information for the validation cohort	**2**
Learly et al. 2019	- Moderate - Potential limitation of generalizability as just one hospital examined; No detailed information about the source of ZIP-related variables	- Low -	- Moderate - Method to choose the cut-points was not clearly presented	- Low -	- Low -	- Low -	**2**

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
Bradshaw et al. 2020	- Moderate - Potential limitation of generalizability as just one hospital was examined; Due to deidentification of patient data demographic characteristics are not captured	- Low -	- Low -	- Moderate - "The multiple categories that comprise the HARRPS-tool have different weight values associated that help prevent planned readmissions from skewing the results."(p. 53)	- Low -	- Low -	**1**
Delaplain et al. 2020	- Moderate - Focus on baseline characteristics of readmission in 7 days; No detailed characteristics for the validation cohort (random-split sample)	- Moderate - Information about the patient flow are provided at hospital level; Hospitals were excluded, if data were not collected for all variables related to the study; Missing information for validation cohort (random-split sample)	- Low - Predictors are presented by focusing on 7-day readmissions	- Moderate - Clear definition for 7-day unplanned readmissions with possible transfer to 30-day unplanned readmissions	- Low -	- Moderate - Missing information for validation cohort (random-split sample)	**1**
Zhou et al. 2020	- Moderate - Potential limitation of generalizability as just one hospital was examined; One-day procedures are also included (discharge within 24h)	- Low -	- Moderate - Census data might be a biased proxy for individual level measures; Method to choose the cut-points was not clearly described	- Low -	- Low -	- Low -	**1**
Ehwerhemuepha et al. 2020	- Moderate - Basic information just for the training data set	- Moderate - Missing information for test data set	- High - No summary information for all predictors included in the validated model; No clear definition of predictors	- Moderate – It is unclear, if the definition captures readmissions to the	- Low - Due to external validation of LACE index confounders are not relevant	- High - Applied method for LACE is not clear (i.e. possible updating); Missing information for training data set	**1**

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
				same or also to other institutions			
Hoenk et al. 2021	- Low -	- Moderate - Information about the patient flow are based on hospital level; Hospitals were excluded if data were not collected for all variables related to the study and if there were not at least 500 encounters for a neoplastic condition; Missing information for test data set	- Moderate - Method to choose the cut-points was not clearly presented	- Moderate – It is unclear, if the definition captures readmissions to the same or also to other institutions	- Low -	- Moderate - Missing information for validation cohort (random-split sample)	**1**
Zhou et al. 2021	- Moderate - Potential limitation of generalizability as just one hospital was examined	- Moderate – 470 instead of 550 patient pairs because of the burden associated with extracting data from medical records	- Low -	- Low -	- Low-	- Moderate - No detailed final model presentation (i.e. missing presentation of odds ratios in multivariable analysis)	**6**
Ryan et al. 2021	- Moderate - Potential limitation of generalizability as just one hospital was examined	- Low -	- Low -	- Moderate - It is unclear, how unplanned readmissions are determined	- Low - Due to external validation of PASS confounders are not relevant	- Moderate - Summary information of predictors are not clearly reported	**1**
O´Connell et al. 2021	- Low -	- Moderate - Information about the patient flow are based on hospital level; Hospitals were excluded if data were not collected for all variables related to the study and if there were	- Moderate - No summary information for all predictors included in the multivariable model; Method to choose the cut-points was not clearly presented	- Low -	- Low -	- Moderate - No clear reporting regarding the differentiation between training and test data set (i.e. summary information for predictors)	**1**

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
		not at least 1000 encounters for a nervous system condition; No clear information on differentiation between training and test data set					
Chotai et al. 2017	- Moderate - Potential limitation of generalizability as just one hospital examined; Focus on baseline characteristics of readmission in 90 days	- Low -	- Low -	- Moderate - Detailed description for the determination of unplanned readmission is missing	- Low -	- Moderate - Apparent validation with small sample size	**1**
Davidson et al. 2021	- Low - surgery was conducted in inpatient or outpatient setting; Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Low -	**1**
Garcia et al. 2018	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Moderate - Apparent validation with small sample size	**1**
Lee et al. 2021	- Moderate – Possible selection bias due to exclusion of patients which were admitted within the last quarter of the year	- Moderate - No detailed information about the patient flow	- Low -	- Low -	- Low -	- Low -	**1**
Minhas et al. 2016	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Moderate - No complete reporting of the model development (e.g. uni- and multivariable analysis)	**3**
Roddy & Diab 2017	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Moderate - No detailed information about the patient flow	- Low -	- Moderate - Detailed description for the determination of unplanned readmission is missing	- Low -	- Low -	**1**

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
Sherrod et al. 2016	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Low -	**1**
Tahiri et al 2015	- Low - surgery was conducted in inpatient or outpatient setting; Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Low -	**1**
Wheeler et al. 2018	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Moderate – Patients which were admitted in December were excluded.	- Low -	- Low -	- Low -	- Moderate – Incomplete reporting of statistical analysis (e.g. p-values)	**1**
Vedantam et al. 2018	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Moderate - Apparent validation with small sample size	**1**
Basques et al. 2015	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Moderate – Incomplete reporting of statistical analysis (e.g. univariable analysis, control variables)	**1**
Martin et al. 2015	- Low - Deidentification of hospital-related data, but all hospitals are from the USA	- Low -	- Low -	- Moderate - varied lengths at which patients were at risk for readmission	- Low -	- Low -	**1**
Sanchez-Luna et al. 2016	- Low -	- Moderate - No information about the "gender" characteristics of the study sample	- Low -	- Moderate - Detailed description for the determination of "non-staged" readmission is missing	- Low -	- Moderate – No detailed presentation of results	**1**

Reference	1. Domain: Study participation	2. Domain: Study attrition	3. Domain: Prognostic factor measurement	4. Domain: Outcome measurement	5. Domain: Study confounding	6. Domain: Statistical analysis and reporting	# predictive models considered*
	'Did the study population adequately represent the population of interest?'	'Did the study data available adequately represent the study sample?'	'Were the prognostic factors measured in a similar way for all participants?'	'Was outcome of interest measured in a similar way for all participants?'	'Were important potential confounding factors appropriately accounted for?'	'Was the statistical analysis appropriate?' and 'Were all primary outcomes reported?'	
Sacks et al. 2017	- Moderate - Potential limitation of generalizability as just one hospital examined	- Moderate – study just included patients, which are living close to the hospital	- Low -	- Moderate - Detailed description for the determination of unplanned readmission is missing	- Low -	- Low -	**1**

* For the risk of bias assessment at study-level, only the predictive models that were also included in the systematic review were considered.

Table A6: Examined and significant variables for all 37 included predictive models

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
All-cause related readmissions					
Brittan et al. 2018	Composite Score	All-cause	30-day unplanned HRs	Age; Lenght of stay; Non-English speaking caregiver; Discharge medications; Enteral feeding (eg, gastrostomy tube feeding); Respiratory (eg, home ventilator); IV infusion (eg, infusion of IV medication); Speech therapy; Physical therapy; Occupational therapy; Skilled nursing home visits; Private duty nursing home visits; CNA nursing assistant home visits; Durable medical equipment (eg, wheel chair); Home Care ≥ 1 order; Composite score = 0; Composite score = 1; Composite score = 2; Composite score = 3	Score based on the variables: Non-English speaking caregiver, Discharge medications, Home Care ≥ 1 order: Composite score (0 vs 1) (OR=1.7; 95% CI 1.5-2); Composite score (0 vs ≥ 2) (OR=4.2; 95% CI 3.6-4.9)
Sills et al. 2017	PACR + SDH	All-cause	30-day unplanned HRs	CCI count; Infectious and parasitic disease; Neoplasms; Endocrine, nutritional, and metabolic diseases and immunity disorders; Diseases of blood and blood-forming organs; Mental disorders; Diseases of the nervous system and sense organs; Diseases of the circulatory system; Diseases of the respiratory system; Diseases of the digestive system; Diseases of the genitourinary system; Diseases of the skin and subcutaneous tissue; Diseases of the musculoskeletal system; Congenital anomalies; Certain conditions originating in the perinatal period; Symptoms, signs, and ill-defined conditions; Injury and poisoning; Factors influencing health status and contact with health services; Age group; Sex; Race; Hispanic ethnicity; Payer; Median household income; Proportion of housing units vacant; Proportion of households with children that are single-parent; Proportion of families below poverty level; Unemployment rate; Proportion of adults with less than a high school diploma or equivalent	CCI count: [2 body systems (OR=1.51; 95% CI 1.44-1.58), 3 body systems (OR=1.57; 95% CI 1.48-1.67), >3 body systems (OR=1.31; 95% CI 1.19-1.44)]; CCIs: Neoplasms (OR=0.46; 95% CI 0.44-0.48), Endocrine, nutritional, and metabolic diseases and immunity disorders (OR=0.8; 95% CI 0.77-0.83), Diseases of blood and blood-forming organs (OR=0.59; 95% CI 0.56-0.61), Mental disorders (OR=0.95; 95% CI 0.92-0.99), Diseases of the nervous system and sense organs (OR=0.78; 95% CI 0.75-0.8), Diseases of the circulatory system (OR=0.73; 95% CI 0.7-0.76), Diseases of the respiratory system (OR=1.08; 95% CI 1.05-1.12), Diseases of the digestive system (OR=0.65; 95% CI 0.63-0.68), Diseases of the genitourinary system (OR=0.7; 95% CI 0.66-0.74), Congenital anomalies (OR=0.88; 95% CI 0.85-0.91), Injury and poisoning (OR=0.63; 95% CI 0.54-0.74), Factors influencing health status and contact with health services (OR=0.51; 95% CI 0.49-0.53); Age group: [1-<5y (OR=0.84; 95% CI 0.81-0.87), 5-<8y (OR=0.73; 95% CI 0.69-0.76), 8-<12 y (OR=0.72; 95% CI 0.68-0.75), 12-<18 y (OR=0.79; 95% CI 0.76-0.83)]; male (OR=0.96; 95% CI 0.93-0.98); Race: [Asian (OR=0.91; 95% CI 0.84-0.99), Other (OR=0.92; 95% CI 0.88-0.96)], Hispanic (OR=1.06; 95% CI 1.02-1.1); Payer: [Private (OR=0.85; 95% CI 0.83-0.88)]; Median household income (per $10 000 increase) (OR=1.02; 95% CI 1.02-1.02); Vacancy rate (per 10% increase) (OR=0.96; 95% CI 0.94-0.99); Percent single-parent (per 10% increase) (OR=1.03; 95% CI 1.01-1.04)
Ehwerhemuepha et al. 2018	Unnamed	All-cause	30-day unplanned HRs	Sex; Race and/or ethnicity; Length of stay, d; Age, y; Median income by zip code, per $10 000; Percent vacant houses by zip code; Percent single parents by zip code; Low income primary medical insurance; Planned admission; ED visits within last 6 mo; Admitted through ED; Previous inpatient visits within last 6 mo; History of 30 d readmission within last 6mo; Ambulatory resource use within last 6 mo; Charlson's comorbidities; Complex chronic conditions; Was in ICU; pRI: Admitting; pRI: Discharge; pRI: Minimum; pRI: Maximum; pRI: Average; pRI: Decreasing slope across entire stay; pRI: Decreasing slope during last 24 h of hospitalization; pRI: Minimum occurred first 24 h; pRI: Maximum occurred last 24 h; Infectious and/or parasitic; Neoplasms (excluding encounters for chemotherapy); Blood and/or immune; Endocrine, nutritional, and/or metabolic; Mental and/or neurodevelopment; Nervous, eye, ear, and/or mastoid; Circulatory; Respiratory; Digestive; Skin and/or subcutaneous tissue; Musculoskeletal; Genitourinary; Perinatal period; Congenital malformations; Symptoms, signs, and/or laboratory findings not classified elsewhere; Injury and/or poison; External morbidity causes; Health status and/or services factors	Length of stay, d: [<4 (2, 3) (OR=1.23; NR% CI 1.07–1.42), < 7 (4, 5, 6) (OR=1.42; NR% CI 1.20–1.67), 7 or more (OR=1.80; NR% CI 1.51–2.14)]; Planned admission: [Yes (OR=0.65; NR% CI 0.52–0.82)]; ED and/ or department visits within last 6 mo: [1 (OR=1.27; NR% CI 1.11–1.45), 2 or more (OR=1.30; NR% CI 1.12–1.50)]; Admitted through ED: [Yes (OR=1.15; NR% CI 1.02–1.29)]; Previous inpatient visits within last 6 mo: [1 (OR=1.86; NR% CI 1.59–2.17), 2 or more (OR=2.39; NR% CI 1.94–2.94)]; History of 30 d readmission within last 6mo: [1 (OR=1.27; NR% CI 1.06–1.52), 2 or more (OR=2.75; NR% CI 2.19–3.44)]; Complex chronic conditions: [1 (OR=1.63; NR% CI 1.42–1.87), 2 or more (OR=1.66; NR% CI 1.43–1.92)]; Discharge pRI (10 pt increment) (OR=0.86; NR% CI 0.81–0.90); Maximum pRI occurred last 24 h of hospitalization (OR=0.85; NR% CI 0.75–0.95); Neoplasms (excluding encounters for chemotherapy): [Yes (OR=2.17; NR% CI 1.85–2.55)]; Blood and/or immune: [Yes (OR=1.30; NR% CI 1.14–1.48)]; Nervous, eye, ear, and/or mastoid: [Yes (OR=1.21; NR% CI 1.08–1.37)]; Circulatory: [Yes (OR=1.33; NR% CI 1.14–1.56)]; Respiratory: [Yes (OR=0.75; NR% CI 0.66–0.85)]; External morbidity causes: [Yes (OR=0.64; NR% CI 0.45–0.89)]; Health status and/or services factors: [Yes (OR=1.20; NR% CI 1.06–1.35)]
	LACE (validation)			Length of stay, d; Admitted through ED; Charlson's comorbidities; ED visits within last 6 mo	External validation study

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
Bradshaw et al. 2020	HARRPS-tool	All-cause	30-day unplanned HRs	Other Diagnosis; Anemia/Neutropenia; Appendectomy; Asthma; Bronchiolitis; Gastroenteritis; Pneumonia; Seizure; Sickle Cell Crisis; Upper Respiratory Tract Infection; Ventricular Shunt; At-risk admission diagnosis present; Chronic condition indicator; Readmitted within 30 days (history); Inpatient Admit in last 6 months; Acuity of admission: No admission acuity identified; Acuity of admission: ICN/PICU Admission; Acuity of admission: Significant psychosocial concern; Acuity of admission: Medical transport from outside facility; Acuity of admission: Other; Insurance type: Self-Pay; Insurance type: Medicaid; Insurance type: Commercial/Private; Insurance type: Medicaid & Self-Pay; Caregiver language: English; Caregiver language: Spanish; Caregiver language: Other; Medical equipment/Supplies count at home; Home nursing: Private Duty Nursing; Home nursing: Skilled Nursing; Home nursing: Private Duty Nursing and/or Skilled Nursing; Home therapy: Home Occupational Therapy; Home therapy: Home Physical Therapy; Home therapy: Home Speech Therapy; Home therapy: Home Occupational Therapy, Home Physical Therapy and/or Home Speech Therapy	The final scoring system also includes risk factors, which were not significant in the multivariable analysis (i.e. At-risk admission diagnosis present; Home nursing: Private Duty Nursing and/or Skilled Nursing; Home therapy: Home Occupational Therapy, Home Physical Therapy and/or Home Speech Therapy): Chronic condition indicator: [1 (OR=1.43; 95% CI 1.13-1.81), 2 (OR=1.75; 95% CI 1.27-2.40), 3 (OR=1.41; 95% CI 1.12-1.78)]; Previous 30-day readmission (OR=1.70; 95% CI 1.38-2.09); Inpatient admission in last 6 months (OR=2.21; 95% CI 1.76 2.54); ICN or PICU admit (OR=1.43; 95% CI 1.17-1.75); Self-Pay or Medicaid (OR=1.21; 95% CI 1.05 1.39); Medical equipment/Supplies count at home: [2 (OR=1.43; 95% CI 1.09-1.88), 3 (OR=2.68; 95% CI 1.80 4.01), 4 (OR=2.21; 95% CI 1.53 3.19)]
Zhou et al. 2020	Unnamed	All-cause	30-day unplanned HRs	Age; Gender; Admission status; Funding source as inpatients; Source of referral transport; State/Territory of residence; Care type provided; Type of health insurance; Index of Relative Social-Economic Advantage and Disadvantage (IRSAD); Interpreter service; ICU stay at index admission; Had GA at index admission; LOS at index admission; Day of index admission date (weekdays or weekend); Day of index admission date; Day of discharge from index admission; Day of discharge from index admission (weekdays or weekend); Number of Co-diagnoses	Age: [13-15y (OR=1.30; 95% CI 1.14–1.48) >=16y (OR=1.46; 95% CI 1.07–1.98)]; Private health insurance (OR=1.16; 95% CI 1.00–1.34); Aeromedical service (OR=0.47; 95% CI 0.31–0.71); IRSAD (%): 91-100 (OR=1.20; 95% CI 1.02–1.41) - based on residential postcode; GA at index admission (yes) (OR=0.67; 95% CI 0.64–0.76); LOS: [LOS 2-7 days (OR=1.42; 95% CI 1.30–1.55), LOS 8-14 days (OR=2.35; 95% CI 1.97–2.82), LOS >= 15 days (OR=2.39; 95% CI 1.88–2.98)]; Admission on Friday (OR=1.21; 95% CI 1.05–1.39); Day of discharge from index admission: [Friday (OR=1.26; 95% CI 1.10–1.44), Saturday (OR=1.34; 95% CI 1.15–1.57), Sunday (OR=1.24; 95% CI 1.05–1.47)]; Number of Co-diagnoses:[1 (OR=1.28; 95% CI 1.16–1.41), 2 (OR=1.73; 95% CI 1.53–1.95), 3 (OR=2.10; 95% CI 1.80–2.46), >=4 (OR=2.41; 95% CI 2.08–2.80)]
Ehwerhemuepha et al. 2020	LACE (validation)	All-cause	30-day unplanned HRs	Length of stay, d; Admitted through ED; Charlson's comorbidities; ED visits within last 6 mo	External validation study
Zhou et al. 2021	Model 1: GLM	All-cause	30-day unplanned HRs	Age; Sex; Admission status; Length of hospital say (LOS); Funding source as an inpatient; Health insurance status; Source of referral transport ; State/Territory of residence; Care type; Socioeconomic indexes for areas (SEIFA); Distance to hospital; Had general anaesthetic; Had intensive care unit (ICU) stay; Day of admission date; Day of discharge date; Number of co-diagnosis	Variables included in the final model: Day of admission date; Day of admission (weekday/weekend and public holiday)
	Model 1: G-S			Age; Sex; Admission status; Length of hospital say (LOS); Funding source as an inpatient; Health insurance status; Source of referral transport ; State/Territory of residence; Care type; Socioeconomic indexes for areas (SEIFA); Distance to hospital; Had general anaesthetic; Had intensive care unit (ICU) stay; Day of admission date; Day of discharge date; Number of co-diagnosis	Variables included in the final model: Distance from residential address to hospital; Day of discharge date; Day of admission date, Day of admission (weekday/weekend and public holiday)
	Model 2: GLM			Age; Sex; Admission status; Length of hospital say (LOS); Funding source as an inpatient; Health insurance status; Source of referral transport ; State/Territory of residence; Care type; Socioeconomic indexes for areas (SEIFA); Distance to hospital; Had general anaesthetic; Had intensive care unit (ICU) stay; Day of admission date; Day of discharge date; Number of co-diagnosis; Significant social history (legal custody or patient was under the care of Department for Child Protection); Language other than English; Significant laboratory result; Significant imaging result; Significant vital signs; Added new medication at discharge upon existing regular medication regime; Number of past medical history recorded in the patient progress notes; Known allergies; Usage of hospital services 12 months prior to the index admission: number of emergency department (ED) presentations; Usage of hospital services 12 months prior to the index admission: number of hospitalisations; Usage of hospital services 12 months prior to the	Variables included in the final model: Day of discharge date; Day of admission date; Day of admission (weekday/weekend and public holiday); No. admissions in the previous 12 months; No. emergency department presentations in the previous 12 months; No. past medical histories recorded in the progress notes

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
				index admission: number of outpatient clinic attendances	
	Model 2: G-S			Age; Sex; Admission status; Length of hospital say (LOS); Funding source as an inpatient; Health insurance status; Source of referral transport ; State/Territory of residence; Care type; Socioeconomic indexes for areas (SEIFA); Distance to hospital; Had general anaesthetic; Had intensive care unit (ICU) stay; Day of admission date; Day of discharge date; Number of co-diagnosis; Significant social history (legal custody or patient was under the care of Department for Child Protection); Language other than English; Significant laboratory result; Significant imaging result; Significant vital signs; Added new medication at discharge upon existing regular medication regime; Number of past medical history recorded in the patient progress notes; Known allergies; Usage of hospital services 12 months prior to the index admission: number of emergency department (ED) presentations; Usage of hospital services 12 months prior to the index admission: number of hospitalisations; Usage of hospital services 12 months prior to the index admission: number of outpatient clinic attendances	Variables included in the final model: Day of discharge date; Day of admission date, Day of admission (weekday/weekend and public holiday); No. admissions in the previous 12 months; No. emergency department presentations in the previous 12 months; No. past medical histories recorded in the progress notes; Language spoken other than English (interpreter service required); Known allergies
	Model 3: GLM			Age; Sex; Admission status; Length of hospital say (LOS); Funding source as an inpatient; Health insurance status; Source of referral transport ; State/Territory of residence; Care type; Socioeconomic indexes for areas (SEIFA); Distance to hospital; Had general anaesthetic; Had intensive care unit (ICU) stay; Day of admission date; Day of discharge date; Number of co-diagnosis; Significant social history (legal custody or patient was under the care of Department for Child Protection); Language other than English; Significant laboratory result; Significant imaging result; Significant vital signs; Added new medication at discharge upon existing regular medication regime; Number of past medical history recorded in the patient progress notes; Known allergies; Usage of hospital services 12 months prior to the index admission: number of emergency department (ED) presentations; Usage of hospital services 12 months prior to the index admission: number of hospitalisations; Usage of hospital services 12 months prior to the index admission: number of outpatient clinic attendances; Completion of Nursing Admission and Discharge Planning Form (Admission section); Completion of Nursing Admission and Discharge Planning Form (Discharge Planning section); Operation sheet or the last entry progress note made by doctors; Clinical pathway or the last entry progress note made by nurses; Last entry progress note made by allied healthcare providers; Written evidence of discharge information given by doctors; Written evidence of discharge information given by nurses; Written evidence of discharge medications information by doctors; Written evidence of discharge medications information by nurses; Written evidence of follow-up information given by doctors; Written evidence of follow-up information given by nurses; Consistency of written discharge documentation among healthcare providers; Delay in issuing discharge summary (date of discharge summary being issued – date of discharge)	Variables included in the final model: Day of discharge date; Day of admission date; Day of admission (weekday/weekend and public holiday); No. admissions in the previous 12 months; No. emergency department presentations in the previous 12 months; No. past medical histories recorded in the progress notes; Completeness of Nursing Admission and Discharge Planning Form, Discharge Planning section (incompleteness)
	Model 3: G-S			Age; Sex; Admission status; Length of hospital say (LOS); Funding source as an inpatient; Health insurance status; Source of referral transport ; State/Territory of residence; Care type; Socioeconomic indexes for areas (SEIFA); Distance to hospital; Had general anaesthetic; Had intensive care unit (ICU) stay; Day of admission date; Day of discharge date; Number of co-diagnosis; Significant social history (legal custody or patient was under the care of Department for Child Protection); Language other than English; Significant laboratory result; Significant imaging result; Significant vital signs; Added new medication at discharge upon existing regular medication regime; Number of past medical history recorded in the patient progress notes; Known allergies; Usage of hospital services 12 months prior to the index admission: number of emergency department (ED) presentations; Usage of hospital services 12 months prior to the index admission: number of hospitalisations; Usage	Variables included in the final model: Had general anaesthetic at index admission; Source of referral transport (ambulance); Day of discharge date; Day of admission date; Day of admission (weekday/weekend and public holiday); No. admissions in the previous 12 months; No. emergency department presentations in the previous 12 months; No. past medical histories recorded in the progress notes; Significant social history; Language spoken other than English (interpreter service required); Known allergies; Completeness of Nursing Admission and Discharge Planning Form, Discharge Planning section (incompleteness); Completeness of Nursing Admission and Discharge Planning Form, Admission section (incompleteness); Progress note or Clinical Pathway documentation at discharge by nurses (not recorded); Follow-up information documented by doctors (not recorded)

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
				of hospital services 12 months prior to the index admission: number of outpatient clinic attendances; Completion of Nursing Admission and Discharge Planning Form (Admission section); Completion of Nursing Admission and Discharge Planning Form (Discharge Planning section); Operation sheet or the last entry progress note made by doctors; Clinical pathway or the last entry progress note made by nurses; Last entry progress note made by allied healthcare providers; Written evidence of discharge information given by doctors; Written evidence of discharge information given by nurses; Written evidence of discharge medications information by doctors; Written evidence of discharge medications information by nurses; Written evidence of follow-up information given by doctors; Written evidence of follow-up information given by nurses; Consistency ofwritten discharge documentation among healthcare providers; Delay in issuing discharge summary (date of discharge summary being issued – date of discharge)	
Surgical conditions related readmissions					
Vo et al. 2018	Unnamed	All surgical specialities without cardiac surgery	30-day unplanned post-surgical HRs relating to noncardiac surgery	Age; BMI; ASA class; Gender; Race; Surgical specialty; Admission status; Urgency of procedure; Prematurity; Congenital Heart Disease; Bleeding complication; Wound complication; Pulmonary complication; Renal complication; Neurologic complication, Cardiac complication	ASA>=3 (OR=1.9; 95% CI 1.8-2.0); Inpatient vs outpatient (OR=3.5; 95% CI 3.3-3.7); >1 Postoperative complication (OR=3.14; 95% CI 2.92-3.34); Presence of CHD (OR=1.66; 95% CI 1.31-2.11)
Polites et al. 2017	Unnamed	General and thoracic surgery	30-day unplanned HRs related to the index surgical procedure	Age; Sex; Race; Procedure group; Procedure type; Weight percentage; Premature birth; Congenital malformation; Any comorbidity; Diabetes mellitus (Individual comorbidity); Respiratory (Individual comorbidity); GI/Hepatobiliary (Individual comorbidity); Major cardiac (Individual comorbidity); Acute renal failure (Individual comorbidity); Neurologic (Individual comorbidity); Immunosuppression (Individual comorbidity); Nutrition (Individual comorbidity); Hematologic (Individual comorbidity); Active malignancy (Individual comorbidity); Preoperative SIRS, sepsis, septic shock; Preoperative transfusion or hematocrit <32; Case status; ASA class; Operative time, minutes; Wound class; Preoperative length of stay, days; Postoperative complication; Superficial Incisional SSI; Deep SSI; Pulmonary complications; Sepsis/CL associated bloodstream infection; Postoperative length of stay, days	Procedure group: [Head and Neck (HR=2.40; 95% CI 1.48-3.89), Hepatobiliary (HR=1.69; 95% CI 1.17-2.44), Small and Large intestine (HR=1.59; 95% CI 1.33-1.90), Thoracic (HR=0.69; 95% CI 0.52-0.91)]; Comorbidity: [Preoperative acute renal failure (HR=2.47; 95% CI 1.31-4.66), Neurologic comorbidity (HR=1.3; 95% CI 1.05-1.62)]; SIRS/Sepsis/Septic Shock within 48 h prior to index admission (HR=1.2; 95% CI 1.02-1.41); Operative time, minutes: [60–140 min (HR=1.21; 95% CI 1.06-1.39), >140min (HR=1.51; 95% CI 1.26-1.81)]; Wound class: [Contaminated (HR=1.29; 95% CI 1.05-1.60), Dirty/Infected (HR=1.92; 95% CI 1.53-2.40)]; Any complication (HR=1.34; 95% CI 1.09-1.65); Postoperative length of stay, days: [2-4 days (HR=2.17; 95% CI 1.84-2.57), >4 days (HR=3.12; 95% CI 2.60-3.74)]
Delaplain et al. 2020	30-day readmission model	Trauma-related conditions	30-day unplanned trauma HRs	Planned readmission; Sex; Length of stay (d); Admission source; Payer; Age; Race/ethnicity; Previous ED visits; Current/index visit is a readmission from a prior visit?; Previous visits; Readmission history; Free-standing pediatric hospital; Number of medications; Number of systems diagnoses; Traumatic injury (ICD-10): Abdomen, back, lumbar spine, genitalia, or pelvis (S30-S39); Traumatic injury (ICD-10): Ankle and foot (S90-99); Traumatic injury (ICD-10): Burns (T20-32); Traumatic injury (ICD-10): Early complications of trauma (T79); Traumatic injury (ICD-10): Elbow and forearm (S50-59); Traumatic injury (ICD-10): Foreign body entering through the natural orifice (T15-19); Traumatic injury (ICD-10): Head (S00-09); Traumatic injury (ICD-10): Hip and thigh (S70-79), Traumatic injury (ICD-10): Unspecified body region (T14); Traumatic injury (ICD-10): Knee and lower leg (S80-89); Traumatic injury (ICD-10): Multiple body regions (T07); Traumatic injury (ICD-10): Neck (S10-19); Traumatic injury (ICD-10): Unspecified effects of external causes (T66-T78); Traumatic injury (ICD-10): Poisoning (T36-50); Traumatic injury (ICD-10): Shoulder and upper arm (S40-49); Traumatic injury (ICD-10): Complications of surgical/medical care (T80-88); Traumatic injury (ICD-10): Thorax (S20-29); Traumatic injury (ICD-10): Toxic effects of nonmedical substances (T51-65); Traumatic injury (ICD-10): Wrist, hand, and fingers (S60-61); Surgical procedures by system: Auditory; Surgical procedures by	LOS: [LOS 2-4 days (OR=1.298; NR% CI 1.189-1.416), LOS 4-7 days (OR=1.638; NR% CI 1.493-1.797), LOS >7 (OR=1.994; NR% CI 1.816-2.189)]; Admission source: Transfer (OR=0.768; NR% CI 0.689-0.856); Previous ED visits: [1 (OR=1.137; NR% CI 1.058-1.222), 2 (OR=1.158; NR% CI 1.037-1.294), >=3 (OR=1.305; NR% CI 1.157-1.471)]; Current/index visit is a readmission from a prior visit?: [Yes: unplanned (OR=1.404; NR% CI 1.291-1.527), Yes: planned (OR=1.646; NR% CI 1.457-1.858)]; Previous visits: [1 (OR=1.746; NR% CI 1.604-1.9), 2 (OR=2.282; NR% CI 2.02-2.578), >=3 (OR=2.614; NR% CI 2.245-3.045)]; Readmission history: [1 (OR=1.473; NR% CI 1.303-1.665), 2 (OR=1.788; NR% CI 1.504-2.125), >=3 (OR=2.578; NR% CI 2.172- 3.06)]; Number of medications (OR=1.011; NR% CI 1.009-1.014); Traumatic injury (ICD-10): Abdomen, back, lumbar spine, genitalia, or pelvis (S30-S39) (OR=0.763; NR% CI 0.655-0.89); Traumatic injury (ICD-10): Burns (T20-32) (OR=0.596; NR% CI 0.494-0.719), Traumatic injury (ICD-10): Head (S00-09) (OR=0.661; NR% CI 0.594-0.735); Traumatic injury (ICD-10): Hip and thigh (S70-79) (OR=0.709; NR% CI 0.616-0.816); Traumatic injury (ICD-10): Unspecified body region (T14) (OR=0.752; NR% CI 0.62-0.912); Traumatic injury (ICD-10): Knee and lower leg (S80-89) (OR=0.727; NR% CI 0.614-0.86); Traumatic injury (ICD-10): Neck (S10-19) (OR=1.194; NR% CI 1.008-1.45); Traumatic injury (ICD-10): Poisoning (T36-50) (OR=1.16; NR% CI 1.06-1.269); Traumatic injury (ICD-10): Shoulder and upper arm (S40-49) (OR=0.547; NR% CI 0.461-0.649); Traumatic injury (ICD-10): Complications of surgical/medical care (T80-88) (OR=1.545; NR% CI 1.439-1.66); Traumatic injury (ICD-10): Toxic effects of

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
				system: Cardiovascular; Surgical procedures by system: Digestive; Surgical procedures by system: Integumentary; Surgical procedures by system: Musculoskeletal; Surgical procedures by system: Nervous; Surgical procedures by system: Respiratory; Traumatic injury: trauma due to frost bite; Traumatic injury: eye/ocular; Traumatic injury: endocrine; Surgical procedure: mediastinum/diaphragm; Surgical procedures by system: hematologic; Surgical procedures by system: lymphatic; Surgical procedures by system: urinary/reproductive	nonmedical substances (T51-65) (OR=0.538; NR% CI 0.404-0.716)
Chotai et al. 2017	Unnamed	Neurosurgery	30 day unplanned HRs following index surgery for neurosurgical diagnoses	Age; Sex; Race; Preterm birth at <37 wks; Brain tumor/cyst resection or biopsy; Craniectomy or craniotomy for epilepsy, vascular, trauma, CM-I, & other brain lesions; Shunt surgery or ETV-CPC; Spine surgery; Preop or intraop EVD; Median LOS in days (range); No. w/ ICU stay; No. w/ postop complications	Race: other vs white (OR=5.916; 95% CI 1.304-26.84); ICU stay (OR=3.302; 95% CI 1.325-8.231)
Davidson et al. 2021	Unnamed	Ureteroscopy	30-day unplanned HRs after ureteroscopy	Age; Sex; Weight; Stone location; Ureteral stent placement during procedure; Anaesthesia time; Operative time; Unplanned reoperation; Organ space SSI; Pneumonia; Unplanned reintubation; Progressive renal insufficiency; Urinary tract infection; Sepsis; Septic shock; Occurrence of transfusion ; Preterm birth; Previous cardiac surgery; Case type; Patient status at time of surgery; ASA class	Female (RR=2.03; 95% CI 1.34-3.07); Renal stone location (RR=1.77; 95% CI 1.10-2.83), Both ureteric and renal stone location (RR=1.29; 95% CI 0.74-2.25); Inpatient at time of surgery (RR=1.61; 95% CI 1.03-2.51)
Garcia et al. 2018	Unnamed	Kasai procedure	30-day unplanned HRs related to kasai procedure	Age; Female (vs male) ; White race; Hispanic; Prematurity; Preoperative comorbidities: Major cardiac risk factors; Respiratory comorbidity; Non-hepatobiliary GI disease; Renal disease; Neurologic comorbidity; Preoperative steroid use; Preoperative nutritional support; Systemic inflammatory response syndrome; Preoperative blood transfusion; Anemia; Hypoalbuminemia ; Total bilirubin > 8; Operative time, minutes; ASA class ≥ III; Perioperative blood transfusion; 30-day post-operative complication; Reoperation	Prematurity (OR=3.88; 95% CI 1.08-13.95); 30-day post-operative complication (OR=4.09; 95% CI 1.41-11.87)
Lee at al-2021	Unnamed	Adolescent idiopathic scoliosis surgery	30-day unplanned HRs after adolescent idiopathic scoliosis surgery	Age; Sex; Income; Primary payer; Anemia; Coagulopathy; Chronic pulmonary disease; Depression; Diabetes; Hypothyroidism; Hypertension; Liver disease; Fluid & electrolyte disorders; Pulmonary vascular disorders; Renal failure; Valvular disease; Smoker; Obesity; Weight loss; Chronic steroid use; Chronic use of antiplatelets, antithrombotics, anticoagulants; Blood transfusion; Autograft; BMP use; Osteotomy; Fusion levels; Hospital teaching status; Hospital ownership; Disposition; Index complication: Cardiac; Index complication: Pulmonary; Index complication: Neurological; Index complication: Urinary tract infection; Index complication: Paralytic ileus; Index complication: SIADH; Index complication: SMA syndrome; Index complication: Thromboembolic complications; Index complication: Wound-related complications; Index complication: Intraop hemorrhage or hematoma; Index complication: Mechanical implant-related complications; Index complication: Dural tear; LOS >5 days	Anemia (OR=2.0; 95% CI 1.6-2.5); Hypothyroidism (OR=3.0; 95% CI 2.0-4.5); Fluid & electrolyte disorders (OR=1.8; 95% CI 1.5-2.3); Obesity (OR=2.9; 95% CI 2.2-4.0); Chronic use of anticoagulants (OR=7; 95% CI 3.0-16.4); Index complication: SIADH (OR=4.7; 95% CI 2.6-8.4); Index complication: Dural tear (OR=2.7; 95% CI 1.6-4.7); LOS >5 days (OR=1.8; 95% CI 1.6-2.2)
Minhas et al. 2016	Idiopathic scoliosis Progressive infantile scoliosis Scoliosis due to other conditions	Spinal Surgeries (Scoliosis)	30-day unplanned HRs	Age; Sex; Underweight; Obesity; Diabetes; Preterm birth; Ventilator requirement; Asthma; Cystic fibrosis; CLD; Oxygen requirement; Tracheostomy; Structural pulmonary abnormality; Esophageal/GI disease; Hepatobiliary/pancreatic disease; Cardiac risk factors; History of cerebrovascular event; Childhood malignancy; CNS tumor; Impaired cognition; History of seizure; Cerebral palsy; Structural CNS abnormality; Neuromuscular Disorder; History of intraventricular hemorrhage; Immunity disorder; Chronic steroid use; Bone marrow disorder; History of organ transplant; Open wound; Weight loss; Nutritional support requirement; Bleeding disorder; Hematological disorder; Chemotherapy; Preoperative sepsis; Preoperative inotrope requirement; Prior operation within last 30 d; Preoperative transfusion requirement; ASA>=3; Posterior fusion up to 6 levels; Posterior fusion 7-12 levels; Posterior fusion 13 or more levels; Pelvic fixation; Progressive infantile scoliosis; Idiopathic scoliosis; Scoliosis due to other condition; LOS>5 d	Idiopathic scoliosis: Obesity (OR=3.09; 95% CI 1.83-5.21); Posterior fusion 13 or more levels (OR=1.86; 95% CI 1.07-3.23) Progressive infantile scoliosis: Impaired cognition (OR=10.08; 95% CI 2.78-14.23) Scoliosis due to other conditions: ASA>=3 (OR=5.92; 95% CI 1.02-10.74); Pelvic fixation (OR=2.80; 95% CI 1.14-6.89)

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
Roddy & Diab 2017	Unnamed	Spine fusion	30-day unplanned HRs	Male versus female; Race; Age; Diagnosis (vs. idiopathic); Insurance type; Approach (vs. posterior); LOS; Hospital volume per year; Discharge disposition; Number of comorbidities; Teaching hospital; Children's hospital; Infection on index admission; Mechanical complication on index admission; Discharge on the weekend; 8+ levels fused (vs. 3–7); Wound dehiscence ; Pulmonary complication; VTE; Hematoma; Ileus; Non-mechanical complication of internal prosthesis	Male versus female (OR=1.28; 95% CI 1.07–1.54); Age 12–13y (OR=0.74; 95% CI 0.57–0.97); Neuromuscular (OR=2.99; 95% CI 2.39–3.75), Congenital (OR=1.66; 95% CI 1.16-2.38), Scheuermann kyphosis (OR=2.00; 95% CI 1.27-3.17), Other diagnosis (OR=1.68; 95% CI 1.32-2.15); Medicais (OR=1.50; 95% CI 1.24-1.82); Anterior approach (OR=1.55; 95% CI 1.01-2.36); LOS <= 3 days (OR=1.89; 95% CI 1.37-2.59), LOS 6-124 days (OR=1.66; 95% CI 1.35-2.02); hospital volume 41-60 fusions (OR=0.72; 95% CI 0.54-0.97), hospital volume >80 fusions (OR=0.66; 95% CI 0.50-0.88); Short-term care hospital (OR=12.41; 95% CI 8.51-18.10), Home health care (OR=1.44; 95% CI 1.09-1.91), other discharge dispositions (OR=3.79; 95% CI 1.14-12.61); Number of comorbidities >=1 (OR=1.21; 95% CI 1.01-1.50); Teaching hospital (OR=1.59; 95% CI 1.10-2.18); Infection on index admission (OR=2.12; 95% CI 1.22-3.69); Mechanical complication on index admission (OR=3.79; 95% CI 1.71-8.39)
Sherrod et al. 2016	Unnamed	Neurosurgery	30-day unplanned HRs after neurosurgery	Shunt/ventricular catheter revision, removal, irrigation; MMC repair; Shunt/ventricular catheter placement; Craniotomy for neoplasm; Other procedures (e.g. primarily baclofen pump placement) ; Craniotomy for Chiari malformation; Spine; Craniotomy for craniosynostosis; Skin lesion; Age; Neonate; LOS; Sex; Race; Patient status; Prior operation w/in 30 days ; Concurrent procedure; Transfer status ; Discharge destination; Any comorbidity; Any non-CNS comorbidity; Obesity; Pulmonary comorbidity; Ventilator dependent; Pneumonia; Asthma; Cystic fibrosis; Bronchopulmonary dysplasia; Oxygen support; Structural pulmonary abnormality; GI comorbidity; Esophageal, gastric, intestinal disease; Biliary, liver, pancreatic disease; Renal comorbidity; Renal failure; Dialysis; CNS comorbidity; Coma >24 hrs; History of CVA or TBI; CNS tumor; Developmental delay; Cerebral palsy; Neuromuscular disorder; Seizure disorder; Structural CNS abnormality; Cardiac comorbidity; Steroid use; Chemotherapy w/in 30 days before surgery; Radiotherapy w/in 90 days before surgery; Open wound (w/ or w/o infection); Tracheostomy at time of surgery; Immune disease or immunosuppressant use; Nutritional support (IV or NG tube); Bleeding disorder; Hematological disorder; Current or previous malignancy; History of prematurity; Intraventricular hemorrhage; Congenital malformation, any system; SIRS/sepsis w/in 48 hrs before surgery; Hypoalbuminemia; Hyponatremia; Hypernatremia; Elevated WBC count; Thrombocytopenia; Elevated AST; Elevated BUN; Abnormal PT; Abnormal PTT; Anemia ; Length of operation; Triage; ASA Class; Periop blood transfusion ; Wound classification; Any complication; Any infection; Superficial SSI; Deep SSI; Organ/space SSI; (postop) Sepsis; (postop) UTI; (postop) Pneumonia; CLABI; Wound disruption; Unplanned intubation; Renal insufficiency; Acute renal failure; Coma >24 hrs; CVA/intracranial hemorrhage; (postop) Seizure; Peripheral nerve injury; Cardiac arrest; Graft or prosthesis failure; DVT; PE	Shunt/ventricular catheter revision, removal, or irrigation procedure (OR=2.283; 95% CI 1.679–3.103); MMC procedure (OR=1.979; 95% CI 1.066–3.675); Shunt/ventricular catheter placement procedure (OR=2.128; 95% CI 1.542–2.937); Craniotomy for craniosynostosis (OR=0.291; 95% CI 0.151–0.560); Spine procedure (OR=0.703; 95% CI 0.503–0.984); Native American race (OR=2.363; 95% CI 1.149–4.861); Prior operation w/in 30 days of index procedure (OR=1.378; 95% CI 1.001–1.897); Transfer from ER (OR=1.273; 95% CI 1.046–1.549); Home discharge (OR=1.885; 95% CI 1.208–2.942); Presence of any comorbidity (OR=1.943; 95% CI 1.086–3.478); Oxygen supplementation (OR=1.645; 95% CI 1.128–2.399); Preexisting seizure disorder (OR=1.250; 95% CI 1.034–1.510); Steroid use >10 days (OR=1.411; 95% CI 1.087–1.831); Nutritional support (IV or NG tube) (OR=1.403; 95% CI 1.088–1.809); Operation time (per hr increase) (OR=1.059; 95% CI 1.006–1.114); Superficial incisional SSI (OR=12.151; 95% CI 7.783–18.973); Deep incisional SSI (OR=25.547; 95% CI 10.229–63.373); Organ/space SSI (OR=19.156; 95% CI 11.618–31.585); Postop sepsis (OR=2.616; 95% CI 1.321–5.181); Postop UTI (OR=4.262; 95% CI 2.598–6.992); Postop pneumonia (OR=4.294; 95% CI 2.045–9.017); Wound disruption (OR=17.582; 95% CI 10.750–28.756); Postop seizure (OR=2.532; 95% CI 1.398–4.587); Graft/prosthesis failure (OR=11.074; 95% CI 2.882–42.548)
Tahiri et al. 2015	Unnamed	Plastic Surgery	30-day unplanned HRs following pediatric plastic surgery procedures	Sex; Race; Inpatient vs outpatient; Type of procedure; Discharge destination; Respiratory history; GI history; Cardiac history; CNS history; Nutritional history; Hematologic history; One comorbidity; Multiple comorbidities (>2); Congenital malformation; Operation within 30 days; Anesthesia type; Triage; RVUs; Wound class; ASA class; Operative time; LOS; Any complications; Surgical complications; Medical complications	Inpatient procedure (OR=1.569; 95% CI 1.028–2.395); RVUs: 19.66–87.09 (OR=0.149; 95% CI 0.057–0.387); Wound contamination (OR=2.328; 95% CI 1.347–4.024); ASA class IV (OR=7.700; 95% CI 1.479–40.079); Operative time: 93–174 min (OR=2.511; 95% CI 1.494–4.219), Operative time: >175 min (OR=3.887; 95% CI 2.220–6.808); Surgical complications (OR=6.936 ; 95% CI 3.702–12.994); Medical complications (OR=11.922; 95% CI 4.706–30.208)
Wheeler et al. 2018	Unnamed	Burn diagnosis	30-day unplanned HRs	Age; Gender; Median household income by zip code; Primary expected payer; Patient location/urban-rural; No. of chronic conditions; TBSA burned ; Burn degree; Burn to eye and adnexa; Burn of face head and neck; Burn of trunk; Burn of upper limb except wrist and hand; Burn of wrist(s) and hand(s); Burn of lower limb(s); Burn of internal organs; Burn unspecified site(s); Minor loss of function; Moderate loss of function; Major/extreme loss of function; Burn mechanism; Annual no. of admitted burn patients ; Teaching status of hospital; Major operating room procedure (index); LOS; Disposition of patient	No detailed reporting of p-values that were accepted to be significant. Predictors that were assigned as significant are included in the analysis: Patient residence: Medium metropolitan county (OR=1.03; 95% CI 1.14–3.29), Patient residence: Small metropolitan county (OR=2.04; 95% CI 1.06–3.92); TBSA burned (%) ≥ 10 (OR=1.81; 95% CI 1.18–2.79); Third burn degree (OR=2.68; 95% CI 1.69–4.24); Major operating room procedure (OR=1.76; 95% CI 1.14–2.70); LOS 2-3 days (OR=1.72; 95% CI 1.03–2.88)

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
Vedantam et al. 2018	Unnamed	Epilepsy surgery	30-day unplanned HRs after epilepsy surgery	Age; Gender; Race; ASA classification; Operative time; LOS; Weight ; Neurologic and neuromuscular; Other complex chronic conditions; Discharge destination; Procedure	Hemispherectomy (OR=4.11; 95% CI 1.48–11.42)
Basques et al. 2015	Unnamed	Posterior spinal fusion	30-day unplanned HRs after posterior spinal fusion	Age; Sex; BMI for age; History of asthma; Number of levels fused; Osteotomy performed; Operative time; Any inpatient complication; Serious adverse event; Return to the operating room; Wound dehiscence; Deep surgical site infection; Nervous injury; Minor adverse event; Superficial surgical site infection; Urinary tract infection; Pneumonia; Length of stay more than 6 days	Any inpatient complication (OR=180.44; 95% CI 35.47–917.97)
Martin et al. 2015	Unnamed	Spinal deformity surgery	30-day unplanned HRs after spinal deformity surgery	Age; Sex; Race; BMI ; Diabetes; Ventilator dependence; Asthma; Cystic fi brosis; Chronic lung disease; Oxygen support; Tracheostomy; Airway abnormalities; GI disease; Hepatobiliary disease; Cardiac risk factors; Previous cardiac surgery; Acute renal failure; Dialysis; History of stroke; Tumor involving CNS; Developmental delay; Seizure disorder; Cerebral palsy; CNS abnormality; Neuromuscular disorder; Immune disorder; Steroid use w/in 30 d; Bone marrow transplant; Solid organ transplant; Recent weight loss; Nutritional support; Bleeding disorder; Hematologic disorder; Chemo w/in 30 d; Rad therapy w/in 90 d; Prior operation w/in 30 d; Congenital malformation; Hx childhood malignancy; Requires inotropic support; Sodium; BUN; WBC; Hematocrit; INR; Creatinine; Albumin; ASA class; Received blood transfusion; Blood transfused; Operative time; Total case RVUs; LOS; Surgeon specialty; Isolated primary posterior arthrodesis; Revision posterior arthrodesis; Isolated primary anterior arthrodesis; Revision anterior arthrodesis; Combined anterior and posterior arthrodesis; Instrumentation extending to pelvis; Insertion of intervertebral device; Osteotomy; Bone grafting; Diagnosis	Structural pulmonary abnormalities (OR=2.53; 95% CI 1.22–5.23); ASA class (3 or 4 vs . 1 or 2) (OR=2.18; 95% CI 1.07–4.47); Isolated primary anterior spinal fusion (OR=7.65; 95% CI 1.32–44.3)
General medical conditions related readmissions					
Learly et al. 2019	Prediction at admission	Complex chronic conditions	30-day unplanned HRs	Age; Race and/or ethnicity; Boys; Non-English primary language; Insurance type (Private); Insurance type (Public); Insurance type (uninsured); Neighborhood per capita income, $; Any admissions in previous 6mo, Any ED visits in previous 6 mo; No. home medications at admission; CCC category (Neurologic); CCC category (Cardiovascular); CCC category (Gastrointestinal); CCC category (Other); No. CCC categories; Technology assistance; Admission type	Significant variables (p-value<0.05) in univariate analysis are used for the analysis of the final model: Any admissions in previous 6 mo (OR=1.70; 95% CI 1.15–2.45); Any ED visits in previous 6 mo (OR=2.04; 95% CI 1.32–3.10); No. CCC categories: [No. CCC categories = 2 (OR=1.73; 95% CI 1.19–2.49), No. CCC categories >=3 (OR=2.30; 95% CI 1.50–3.47)]; Medical admission (OR=1.82; 95% CI 1.30–2.63)
	Prediction at discharge			Age; Race and/or ethnicity; Boys; Non-English primary language, Insurance type (Private); Insurance type (Public); Insurance type (uninsured); Neighborhood per capita income, $; Any admissions in previous 6mo; Any ED visits in previous 6 mo; No. home medications at admission; CCC category (Neurologic); CCC category (Cardiovascular); CCC category (Gastrointestinal); CCC category (Other); No. CCC categories; Technology assistance; Admission type; ICU use; Discharge disposition from the hospital; LOS in d; Weekday discharge	Significant variables (p-value<0.05) in univariate analysis are used for analysis of the final model: Any admissions in previous 6 mo (OR=1.70; 95% CI 1.16–2.46); Any ED visits in previous 6 mo (OR=2.04; 95% CI 1.31–3.11); No. CCC categories: [No. CCC categories = 2 (OR=1.56; 95% CI 1.06–2.26), No. CCC categories >=3 (OR=1.72; 95% CI 1.08–2.69)]; Medical admission (OR=1.75; 95% CI 1.23–2.49); Discharge disposition from the hospital: [With services (OR=1.69; 95% CI 1.17–2.44), Other facility (OR=1.15; 95% CI 0.58–2.13)]; LOS: [LOS 2-5 days (OR=1.15; 95% CI 0.78–1.72), LOS >=6 days (OR=1.45; 95% CI 0.90–2.33)] Weekday discharge was not significant (p-value≤ 0.05) in the univariate analysis, but included in the final scoring system.
Ryan et al. 2021	PASS (validation)	Asthma	30-day unplanned HRs	Respiratory rate, Oxygen requirement, Auscultation, Retractions, Dyspnea	External validation study
O´Connell et al. 2021	Unnamed	Nervous system condition	30-day unplanned HRs	Age; Sex; race/ ethnicity; payer; Length of stay days) ; Index visit planned; Admitted through ED; Index visit is a readmission; Previouse ED visits (prior 6mo); Previous hospitalizations (prior 6mo); Previous readmissions (prior 6 mo); Number of comorbid diagnoses (by ICD 10 CM chapters); Viral Meningitis (A87); Malignant neoplasm of brain (C71); Disorders of BCAA and FA Metabolism (E71); Other AA Metabolism Disorders (E72); Other carbohydrate metabolism disorders (E74); Lipoprotein Metabolism Disorders / Lipidemias (E78); Mental Disorders Due to Physiological Condition (F06); Unspecified Intellectual Disabilities (F79); Speech &	Age (OR=0.993; 95% CI 0.99-0.997); Hispanic/Latino (OR=1.126; 95% CI 1.016-1.247); Self-Pay (OR=0.805; 95% CI 0.688-0.943); LOS 2-4 days (OR=1.228; 95% CI 1.167-1.293), LOS 4-6 days (OR=1.441; 95% CI 1.361-1.525), LOS 7 or more days (OR=1.585; 95% CI 1.492-1.683); Index visit planned: Yes (OR=0.898; 95% CI 0.847-0.952); Emergent Admission (OR=1.129; 95% CI 1.079-1.18); Index visit is a planned readmission (OR=1.338; 95% CI 1.269-1.411), Index visit is a unplanned readmission (OR=1.666; 95% CI 1.516-1.832); 1 previous ED visit (prior 6mo) (OR=1.106; 95% CI 1.056-1.159), 2 previous ED visits (prior 6mo) (OR=1.200; 95% CI 1.123-1.283), 3 or more previous ED visits (prior 6mo) (OR=1.297; 95% CI 1.209-1.391); 1 previous hospitalization (prior 6mo)

Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
				Language Development Disorders (F80); Scholastic Skill Development Disorders (F81); Motor Function Development Disorders (F82); Pervasive Developmental Disorders (F84); Psychological Development Disorders (F88); Bacterial Meningitis (G00); Meningitis, Other Causes (G03); Encephalitis, Myelitis, Encephalomyelitis (G04); Extrapyramidal & movement Disorders (G25); Nervous System Degenerative Diseases (G31); Epilepsy & Recurrent Seizures (G40); Migraine (G43); Headache Syndromes (G44); Sleep Disorders (G47); Polyneuropathies (G62); Primary Muscle Disorders (G71); Cerebral Palsy (G80); Hemiplegia & Hemiparesis (G81); Paraplegia & Quadriplegia (G82); Pain (G89); ANS Disorders (G90); Hydrocephalus (G91); Brain Disorders (G93); Spinal Cord Diseases (G95); CNS Disorders (G96); Postprocedural NS Disorders (G97); Visual Pathway Disorders (H47); Paralytic Strabismus (H49); Binocular Movement Disorders (H51); Nystagmus & Irregular Eye Movements (H55); Conductive & Sensorineural Hearing Loss (H90); Nontraumatic Intracerebral Hemorrhage (I61); Nontraumatic Intracranial Hemorrhage (I62); Cerebral Infarction (I63); Cerebrovascular Diseases (I67); Sequelae of Cerebrovascular Disease (I69); Neuromuscular Dysfunction of Bladder (N31); Nontraumatic Intracranial Hemorrhage Newborn (P52); Newborn Convulsions (P90); Newborn Cerebral Disturbances (P91); Newborn Muscle Tone Disorders (P94); Microcephaly (Q02); Congenital Hydrocephalus (Q03); Congenital Brain Malformations (Q04); Spina Bifida (Q05); Congenital Spinal Cord Malformations (Q06); Congenital Nervous System Malformations (Q07); Down Syndrome (Q90); Other Autosomal Trisomies (Q92); Nervous & Musculoskeletal System Symptoms (R29); Somnolence, Stupor, Coma (R40); Cognitive Function Symptoms (R41); Dizziness & Giddiness (R42); Headache (R51); Convulsions (R56); Intracranial Injury (S06); Number of medications; Free-standing pediatric hospital; Surgical procedures	(OR=1,695; 95% CI 1.613-1.781), 2 previous hospitalizations (prior 6mo) (OR=2.348; 95% CI 2.18-2.528), 3 or more previous hospitalizations (prior 6mo) (OR=3.014; 95% CI 2.738-3.317); 1 previous readmission (prior 6 mo) (OR=1.179; 95% CI 1.09-1.274), 2 previous readmissions (prior 6 mo) (OR=1.496; 95% CI 1.338-1.673), 3 or more previous readmissions (prior 6 mo) (OR=2.051; 95% CI 1.831-2.298); Number of comorbid diagnoses (by ICD 10 CM chapters) (OR=1.01; 95% CI 1.006-1.014); Viral Meningitis (A87) (OR=0.446; 95% CI 0.353-0.563); Malignant neoplasm of brain (C71) (OR=1.953; 95% CI 1.788-2.133); Other AA Metabolism Disorders (E72) (OR=1.313; 95% CI 1.095-1.575); Mental Disorders Due to Physiological Condition (F06) (OR=0.768; 95% CI 0.648-0.91); Speech & Language Development Disorders (F80) (OR=0.811; 95% CI 0.725-0.907); Bacterial Meningitis (G00) (OR=0.622; 95% CI 0.487-0.796); Meningitis, Other Causes (G03) (OR=0.829; 95% CI 0.698-0.985); Sleep Disorders (G47) (OR=0.84; 95% CI 0.791-0.892); Polyneuropathies (G62) (OR=1.5; 95% CI 1.248-1.803); Hydrocephalus (G91) (OR=1.218; 95% CI 1.124-1.476); Brain Disorders (G93) (OR=1.078; 95% CI 1.019-1.14); Paralytic Strabismus (H49) (OR=1.288; 95% CI 1.124-1.476); Nystagmus & Irregular Eye Movements (H55) (OR=0.825; 95% CI 0.686-0.992); Neuromuscular Dysfunction of Bladder (N31) (OR=1.155; 95% CI 1.034-1.129); Newborn Cerebral Disturbances (P91) (OR=0.822; 95% CI 0.705-0.958); Newborn Muscle Tone Disorders (P94) (OR=0.621; 95% CI 0.567-0.68); Microcephaly (Q02) (OR=1.131; 95% CI 1.005-1.272); Congenital Hydrocephalus (Q03) (OR=1.318; 95% CI 1.175-1.478); Down Syndrome (Q90) (OR=1.129; 95% CI 1.036-1.23); Other Autosomal Trisomies (Q92) (OR=1.214; 95% CI 1.019-1.448); Nervous & Musculoskeletal System Symptoms (R29) (OR=0.882; 95% CI 0.781-0.995); Somnolence, Stupor, Coma (R40) (OR=0.786; 95% CI 0.694-0.889); Cognitive Function Symptoms (R41) (OR=0.853; 95% CI 0.776-0.938); Convulsions (R56) (OR=0.922; 95% CI 0.874-0.972); Intracranial Injury (S06) (OR=0.476; 95% CI 0.418-0.543); Number of medications (OR=1.014; 95% CI 1.012-1.016); Free-standing pediatric hospital (Yes) (OR=1.586; 95% CI 1.103-2.28); Surgical procedures (Cardiovascular) (OR=1.204; 95% CI 1.109-1.216), Surgical procedures (Musculoskeletal) (OR=0.685; 95% CI 0.6-0.781), Surgical procedures (Nervous System) (OR=1.119; 95% CI 1.029-1.216)
Hoenk et al. 2021	Unnamed	Oncology	30-day unplanned HRs	Age; sex; race/ ethnicity; Payer; Acute lymphoid leukemia (ALL); Acute myeloid leukemia (AML); Brain cancer; Neuroblastoma; Wilms tumor; Hodgkin's lymphoma; Non-Hodgkin's lymphoma; Rhabdomyosarcoma; Bone/cartilage cancer; Other cancers; Chemotherapy; Bone marrow transplant; Number of cancer medications; Number of previous visits for chemotherapy (prior 30 d); Length of stay; Emergent admission; Is index/current visit itself a readmission; Previous ED visits (prior 6 mo); Number of previous visits without chemotherapy (prior 6 mo); Previous readmissions (prior 6 mo); Viral or bacterial infections (A00 - B99); Hematological conditions (D50-D69, D71-D79); Neutropenia (D70); Immunological conditions (D80-D89); Endocrine, nutritional, and metabolic diseases (E00-E89); Mental, behavioral, and neurodevelopmental disorders (F01-F99); Nervous system (G00-G99); Eye, adnexa, ear, mastoid (H00-H95); Circulatory (I00-I99); Respiratory (J00-J99); Digestive (K00-K95); Skin/subcutaneous tissue (L00-L99); Musculoskeletal and connective tissue (M00-M99); Genitourinary (N00-N99); Congenital/Chromosomal (Q00-Q99); Injuries and poisoning (S00-T88)	Age (OR=0.987; 95% CI 0.982-0.993); Acute lymphoid leukemia (ALL): Yes, not in remission (OR=0.788; 95% CI 0.721-0.861), Acute lymphoid leukemia (ALL): Yes, in remission (OR=0.656; 95% CI 0.590-0.729), Acute lymphoid leukemia (ALL): Yes, in relapse (OR=1.436; 95% CI 1.201-1.718); Brain cancer (OR=0.782; 95% CI 0.711-0.861); Neuroblastoma (OR=1.442; 95% CI 1.285-1.619); Rhabdomyosarcoma (OR=1.182; 95% CI 1.048-1.332); Bone/cartilage cancer (OR=1.618; 95% CI 1.455-1.799); Number of cancer medications (OR=1.46; 95% CI 1.117-1.175); LOS 2, 3 days (OR=1.292; 95% CI 1.184-1.410), LOS 4,5,6 days (OR=1.466; 95% CI 1.340-1.604), LOS 7 or more days (OR=1.344; 95% CI 1.219-1.481); Is index/current visit itself a readmission (Yes, unplanned) (OR=1.869; 95% CI 1.722-2.028), Is index/current visit itself a readmission (Yes, planned) (OR=1.397; 95% CI 1.250-1.560); Number of previous visits without chemotherapy (prior 6 mo) (OR=1.077; 95% CI 1.067-1.221); 1 previous readmission (prior 6 mo) (OR=1.277; 95% CI 1.126-1.336), 2 previous readmissions (prior 6 mo) (OR=1.281; 95% CI 1.145-1.433), 3 or more previous readmissions (prior 6 mo) (OR=1.263; 95% CI 1.087-1.468); Endocrine, nutritional, and metabolic diseases (E00-E89) (OR=1.141; 95% CI 1.067-1.221); Congenital/Chromosomal (Q00-Q99) (OR=0.745; 95% CI 0.657-0.844); Injuries and poisoning (S00-T88) (OR=0.838; 95% CI 0.760-0.925)
Sanchez-Luna et al. 2016	Unnamed	Acute bronchiolitis due to respiratory syncytial virus	30-day unplanned HRs	Prematurity; Gestational age; Congenital heart disease; Chronic lung disease; Down's syndrome; Velo-cardio-facial syndrome; Neuromuscular disorders; Inmunodeficiency; Number of risk factors; Heart transplant	Significant odds ratios before multilevel modelling: Prematurity (OR=3.66; 95% CI 3.15-4.27); Gestational age: <=28w (OR=12.47; 95% CI 1.76-88.51), Gestational age: 29-32w (OR=4.99; 95% CI 0.97-25.71), Gestational age: 33-36w (OR=8.48; 95% CI 4.57-15.71); Congenital heart disease (OR=3.05; 95% CI 2.51-3.71); Chronic lung disease (OR=6.76; 95% CI 3.87-11.83); Down's syndrome (OR=2.65; 95% CI 1.83-3.84); Velo-cardio-facial syndrome (OR=12.42; 95% CI 1.75-88.21); Neuromuscular disorders (OR=5.42; 95% CI 3.72-7.89); Inmunodeficiency (OR=4.35; 95% CI 1.84-10.3); Number of risk factors = 1 (OR=3.64; 95% CI 3.12-4.25), Number of risk factors >=2 (OR=3.86; 95% CI 2.28-6.54)

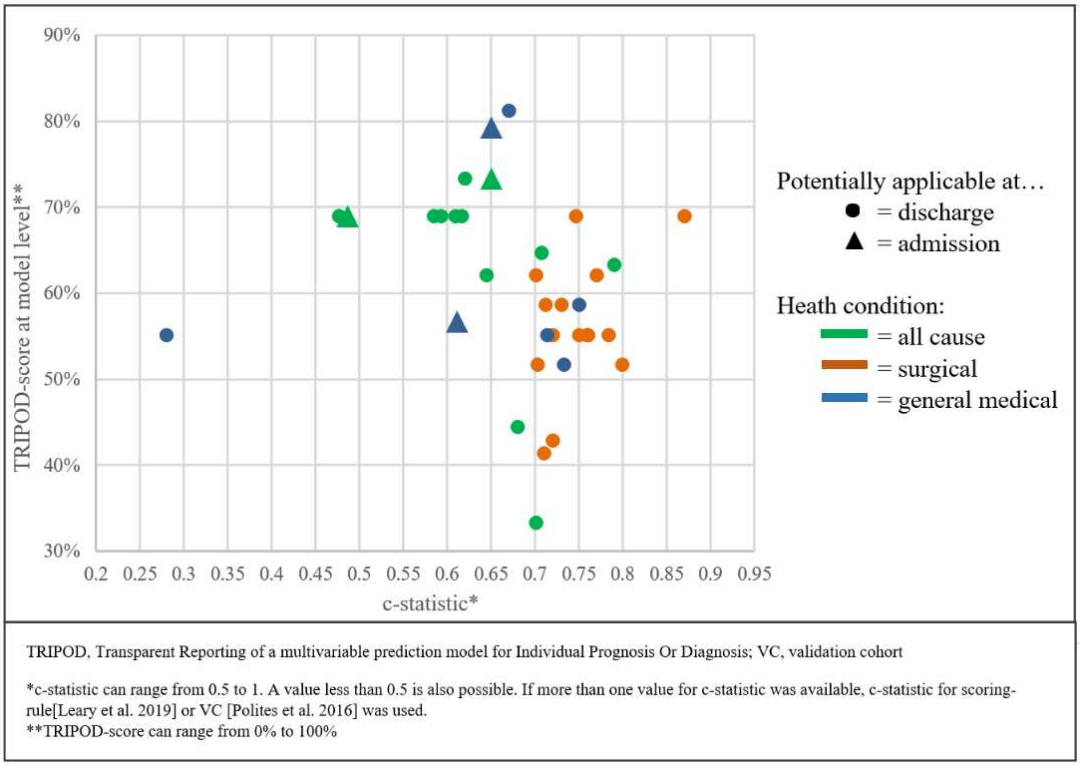
Reference	Model name	Medical condition	Model outcome	Examined variables	Significant variables*
Sacks et al. 2017	Unnamed	Cardiac conditions	30-day unplanned HRs	Age; LOS; Diagnosis count; Procedure count; First weight; Last weight; Medication count; Catheterization; Electrophysiology study; Surgery (noncardiac); ACE/ARB antihypertensive; Antacid; Antiarrhythmic; Antibiotic; Anticoagulant; Beta-blocker; Calcium channel blocker; Diuretic; Lipid management; Milrinone; Neuroactive; Pulmonary antihypertensive; Steroid; Gender; Race; Ethnicity ; Language; Insurance status; Distance from center (miles); Season of discharge; Day of discharge	Age: 1mo-1year (OR=4.11; 95% CI 2.83–5.98); Diagnosis count (OR=1.10; 95% CI 1.07–1.13); Antibiotic (OR=0.60; 95% CI 0.40–0.90)

Abbreviations: NR, not reported
* Only significant risk factors (odds ratio/ hazard ratio>1, p-value<0.05) are considered in the analysis (cf. table 2). Significant predisposed factors (1>odds ratio/ hazard ratio>0, p-value<0.05) are listed as an additional information.

Table A7: Adherence per TRIPOD-item at predictive model level

TRIPOD-item	Developed predictive models (n=32)			External validated predictive models (n=3)			Incremental value predictive models (n=2)			All predictive models (n=37)		
	# of PMs with applicable item	# of PMs adhered to item	Adherence per item	# of PMs with applicable items	# of PMs adhered to item	Adherence per item	# of PMs with applicable items	# of PMs adhered to item	Adherence per item	# of PMs with applicable items	# of PMs adhered to item	Adherence per item
1	32.00	4.00	12.50%	3.00	0.00	0.00%	2.00	1.00	50.00%	37.00	5.00	13.51%
2	32.00	1.00	3.13%	3.00	0.00	0.00%	2.00	0.00	0.00%	37.00	1.00	2.70%
3a	32.00	32.00	100.00%	3.00	1.00	33.33%	2.00	2.00	100.00%	37.00	35.00	94.59%
3b	32.00	31.00	96.88%	3.00	1.00	33.33%	2.00	2.00	100.00%	37.00	34.00	91.89%
4a	32.00	30.00	93.75%	3.00	3.00	100.00%	2.00	1.00	50.00%	37.00	34.00	91.89%
4b	32.00	32.00	100.00%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	37.00	100.00%
5a	32.00	17.00	53.13%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	22.00	59.46%
5b	32.00	31.00	96.88%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	36.00	97.30%
5c	32.00	32.00	100.00%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	37.00	100.00%
6a	32.00	23.00	71.88%	3.00	1.00	33.33%	2.00	2.00	100.00%	37.00	26.00	70.27%
6b	32.00	32.00	100.00%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	37.00	100.00%
7a	32.00	32.00	100.00%	3.00	1.00	33.33%	2.00	2.00	100.00%	37.00	35.00	94.59%
7b	32.00	1.00	3.13%	3.00	0.00	0.00%	2.00	0.00	0.00%	37.00	1.00	2.70%
8	32.00	31.00	96.88%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	36.00	97.30%
9	32.00	11.00	34.38%	3.00	1.00	33.33%	2.00	1.00	50.00%	37.00	13.00	35.14%
10a	32.00	6.00	18.75%	0.00	0.00	0.00%	2.00	0.00	0.00%	34.00	6.00	17.65%
10b	32.00	3.00	9.38%	0.00	0.00	0.00%	2.00	0.00	0.00%	34.00	3.00	8.82%
10c	0.00	0.00	0.00%	3.00	2.00	66.67%	1.00	1.00	100.00%	4.00	3.00	75.00%
10d	32.00	11.00	34.38%	3.00	0.00	0.00%	2.00	1.00	50.00%	37.00	12.00	32.43%
10e	0.00	0.00	0.00%	1.00	0.00	0.00%	1.00	1.00	100.00%	2.00	1.00	50.00%
11	5.00	4.00	80.00%	0.00	0.00	0.00%	0.00	0.00	0.00%	5.00	4.00	80.00%
12	0.00	0.00	0.00%	3.00	0.00	0.00%	2.00	2.00	100.00%	5.00	2.00	40.00%
13a	32.00	22.00	68.75%	3.00	1.00	33.33%	2.00	1.00	50.00%	37.00	24.00	64.86%
13b	32.00	10.00	31.25%	3.00	0.00	0.00%	2.00	2.00	100.00%	37.00	12.00	32.43%
13c	0.00	0.00	0.00%	3.00	0.00	0.00%	2.00	2.00	100.00%	5.00	2.00	40.00%
14a	32.00	27.00	84.38%	0.00	0.00	0.00%	2.00	2.00	100.00%	34.00	29.00	85.29%
14b	30.00	21.00	70.00%	0.00	0.00	0.00%	2.00	2.00	100.00%	32.00	23.00	71.88%
15a	32.00	0.00	0.00%	0.00	0.00	0.00%	2.00	0.00	0.00%	34.00	0.00	0.00%
15b	32.00	6.00	18.75%	0.00	0.00	0.00%	2.00	1.00	50.00%	34.00	7.00	20.59%
16	32.00	3.00	9.38%	3.00	0.00	0.00%	2.00	1.00	50.00%	37.00	4.00	10.81%
17	0.00	0.00	0.00%	1.00	0.00	0.00%	0.00	0.00	0.00%	1.00	0.00	0.00%
18	32.00	32.00	100.00%	3.00	3.00	100.00%	2.00	2.00	100.00%	37.00	37.00	100.00%
19a	0.00	0.00	0.00%	3.00	0.00	0.00%	2.00	2.00	100.00%	5.00	2.00	40.00%
19b	32.00	32.00	100.00%	3.00	2.00	66.67%	2.00	2.00	100.00%	37.00	36.00	97.30%
20	32.00	26.00	81.25%	3.00	1.00	33.33%	2.00	2.00	100.00%	37.00	29.00	78.38%
21	32.00	16.00	50.00%	3.00	1.00	33.33%	2.00	2.00	100.00%	37.00	19.00	51.35%
22	32.00	22.00	68.75%	3.00	2.00	66.67%	2.00	1.00	50.00%	37.00	25.00	67.57%

PM, predictive model; TRIPOD, Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis



TRIPOD, Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis; VC, validation cohort

*c-statistic can range from 0.5 to 1. A value less than 0.5 is also possible. If more than one value for c-statistic was available, c-statistic for scoring-rule[Leary et al. 2019] or VC [Polites et al. 2016] was used.
**TRIPOD-score can range from 0% to 100%

Figure A2: Discriminative ability, application and TRIPOD-adherence of 30-day UHR predictive models in paediatrics (n=37)