BRIEF REPORT

Anticipating Pediatric Patient Transfers From Intermediate to Intensive Care

Daryl R. Cheng, MBBS, MPH, FRACP,[a,b,c,d] Caitlyn Hui, BSc,[e] Kate Langrish, RN, MN,[a,f] Carolyn E. Beck, MD, FRCPC[a,g,h]

ABSTRACT

OBJECTIVES: To explore characteristics of patients who were admitted to the intermediate care (IC) unit at a tertiary academic institution. In particular, we sought to compare the characteristics of IC patients who were transferred with the characteristics of those who were not transferred to PICU care and evaluate predictors of patient transfer.

METHODS: Data were collected on all admitted IC patients between July 2016 and June 2018. Patients whose index IC admission was from the PICU were excluded. Data collected included demographics and physiologic characteristics: heart rate, respiratory rate, temperature, oxygen therapy, as well as Bedside Pediatric Early Warning System (BPEWS) score.

RESULTS: In this time period, 427 eligible patient visits occurred, with 66 patients (15.46%) being transferred to the PICU. Patients were commonly transferred early in their IC course (1.41 days into admission [0.66–3.87]); transferred patients had higher median admission BPEWS scores (7 [4.25–9] vs 5 [3–7]; $P < .01$). In the univariate analysis, no individual physiologic characteristic was predictive for transfer. In the multivariate analysis, BPEWS ($P < .001$) and need for any form of respiratory support ($P = .04$) were significant predictive factors for transfer ($R^2 = 0.56$).

CONCLUSIONS: The need for close monitoring of physiologic parameters remains paramount, especially in the first 48 hours of admission, in predicting the need for transfer from the IC to PICU. The need for any form of respiratory support is predictive of transfer. Situational awareness and assessment including BPEWS score is of critical importance.

[b]Pediatric Outcomes Research Team and [a]Division of Paediatric Medicine, The Hospital for Sick Children, Toronto, Ontario, Canada; [b]Department of General Medicine, The Royal Children's Hospital Melbourne, Parkville, Victoria, Australia; [c]Murdoch Children's Research Institute, Parkville, Victoria, Australia; [d]Department of Paediatrics, University of Melbourne, Carlton, Victoria, Australia; and [g]Department of Paediatrics, [e]Faculty of Medicine, and [f]Lawrence S. Bloomberg Faculty of Nursing, University of Toronto, Ontario, Canada

www.hospitalpediatrics.org
DOI:https://doi.org/10.1542/hpeds.2019-0260

Address correspondence to Daryl R. Cheng, MBBS, MPH, FRACP, Department of General Medicine, The Royal Children's Hospital Melbourne, Parkville, VIC 3052, Australia. E-mail: daryl.cheng@rch.org.au

HOSPITAL PEDIATRICS (ISSN Numbers: Print, 2154-1663; Online, 2154-1671).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Dr Cheng conceptualized and designed the study, participated in data collection and analysis, and drafted the initial manuscript; Ms Hui assisted with data collection, analysis, and manuscript drafting; Dr Beck and Ms Langrish conceptualized and designed the study and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

Pediatric intermediate care (IC) units aim to improve care delivery while optimizing resource use by grouping specific patient types together to receive acuity-specific care.[1,2] These units are equipped with increased monitoring capabilities, higher nurse/patient ratios, and enhanced staff training for specific medical interventions, such as noninvasive ventilation.[3] Cost benefits, increased patient flow and throughput, as well as improved nursing productivity are potential benefits.[4–8]

Understanding the characteristics and predictive factors of IC patients requiring transfer to the PICU is critical. Patient safety may be improved through early recognition of deterioration and clinical intervention to prevent transfer, improved system-wide resource allocation, and refinement of admission criteria toward optimal value.[9] Furthermore, such understanding allows for enhanced resource management and communication between treatment teams and assists with appropriate and timely patient flow and length of stay (LOS) within the hospital.[10]

There are limited data identifying specific predictors of pediatric patient admission to the PICU, although identification of these factors is important from both clinical and resource perspectives.[11] Predictors may include vital signs or pediatric early warning scores that aim to provide a proxy measure of patient wellbeing.[12,13] However, they have variable penetrance and efficacy as predictors of subsequent patient deterioration.[14–17] Other, more recent methods, such as the Pediatric Rothman Index, as well as situational awareness assessments provide alternative, robust ways of identifying patients who are at risk of deterioration.[18–20]

The overarching goal in our study was to explore characteristics of patients who were admitted to the IC unit at a pediatric, tertiary-care academic institution. Specifically, we aimed to (1) compare the characteristics of patients in IC who were transferred with the characteristics of those who were not transferred to PICU care and (2) evaluate predictors of patient transfer from IC to the PICU.

METHODS

Study Setting

The study was conducted at a 360-bed, tertiary academic center located in Canada with 15 000 inpatient admissions annually. The 8-bed IC unit was designed to geographically cohort general pediatric patients who met specific IC admission criteria (Fig 1) to provide more focused medical and nursing care. Currently, the unit has a dedicated interprofessional care team and functions as a standalone unit colocated adjacent to a general pediatric ward.

During daytime hours, the IC unit is staffed by a dedicated medical team comprising a general pediatric hospitalist, a third-year pediatric resident, and an IC-specific nurse practitioner. After hours (weekends and after 5 PM on weekdays), cross-coverage is provided by a third-year and first-year pediatric resident team, who rotate every night and are not always familiar with the IC patients. There is an allocated respiratory therapist with 24-hour availability to support noninvasive ventilation per admission criteria (Fig 1). Nurse/patient ratios are 1:2 for both AM and PM shifts.

IC admission criteria (Fig 1) were designed with input from multiple stakeholders and comprise a range of physiologic and resource-based measures that reflect resource availability and clinical expertise.

Study Cohort

Nonidentifiable data were collected via retrospective chart analysis. Data were collected for all patients who were admitted to IC since its establishment, including those who were subsequently transferred to the PICU, spanning a 2-year period (July 2016–June 2018). Patients whose index IC admission was as a transfer from the PICU were excluded.

Predictor variables collected included patient demographics, admission origin and discharge destination, IC LOS, form of respiratory support (low-flow oxygen, high-flow oxygen, continuous positive airway pressure [CPAP], or bilevel positive airway pressure [BiPAP]), individual physiologic parameters at the time of admission and transfer (heart rate, respiratory rate, temperature, and oxygen therapy), and Bedside Pediatric Early Warning System (BPEWS) score. Change in BPEWS and ICU transfer scores were considered outcome variables.

The BPEWS is a validated early warning score system used as standard of care on all pediatric wards at our institution.[12,16] It has previously been validated in multicenter trials for use as a tool for early recognition of pediatric patient deterioration.[12,21]

Data Analysis

Continuous data were presented as median (interquartile range) or mean (SD) and compared by using the Mann-Whitney *U* test. Categorical data were presented as relative frequencies with corresponding percentages and compared by using the Fisher's exact test. *z* scores for heart rate and respiratory rate were calculated on the basis of existing parameters in the literature.[22] Variables in the univariate analysis, which were defined as significant if $P \leq .10$, were then entered into a multivariate analysis model. In the multivariate model, $P < .05$ was considered statistically significant. All data were analyzed by using Stata 12.0 SE (Stata Corp, College Station, TX). This study was approved as a quality-improvement project by our institution's Department of Quality and Risk Management.

RESULTS

Of patient visits to IC, 595 occurred during the study period, with 427 admissions being included for analysis after excluding those whose index IC admission was as a "step-down" transfer from the PICU (Table 1).

The most common admission criterion was for use of high-flow nasal cannula (50.1%). Of patients, 43.1% were managed by the institution's complex care program, indicating they had at least 2 chronic medical conditions and depended on life-sustaining medical technology.[23,24] There were 3 deaths in the cohort, all of which occurred in the context of palliation.

Compared with nontransferred patients, patients who were transferred to the PICU (15.5%) showed no significant difference in age, sex, source of admission, or being part

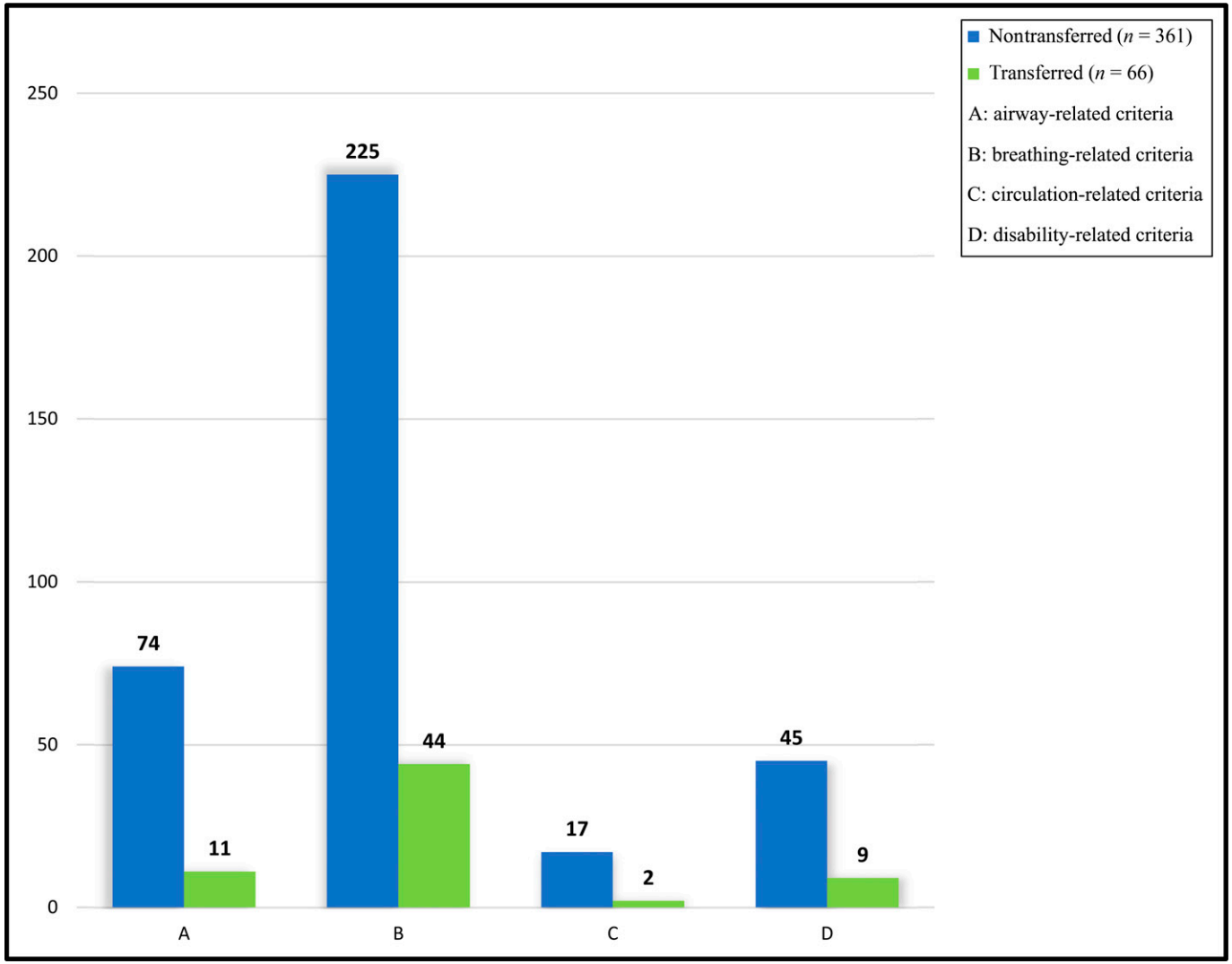

FIGURE 1 IC patient admission criteria. Airway criteria were as follows: (1) extubated for 6 to 24 hours; (2) new tracheostomy after 1 week or after first change with comorbidities; (3) chronic tracheotomy in which the patient is dependent on clinical staff for airway maintenance (suction, tracheotomy change and/or care, etc); (4) NP tube for suctioning required every 1 to 2 hours; and (5) suctioning required to maintain the airway every 30 minutes to 2 hours. Breathing criteria were as follows: (1) FiO2 50% to 75% for >2 hours; (2) high-flow nasal cannula at flow rates <1.5 LPM/kg; (3) NPPV with established parameters >24 hours; (4) stable NPPV settings; and (5) NPPV therapy applied for <12 hours in a 24-hour period. Circulation criteria were as follows: (1) inotropes weaned >6 to 12 hours; (2) hemodynamic instability requiring fluid resuscitation <60 mL/kg within 3 hours; and (3) BP monitoring hourly or more frequently for >4 hours. Disability criteria were as follows: (1) neurovitals every 2 to 4 hours; (2) laboratories monitored every 2 to 4 × 12 hours (gases, glucose, and/or electrolytes) when a central line is in situ; (3) removal of life-sustaining therapy and expected death within 24 to 48 hours; and (4) thermoregulation interventions required for temperature management >35°C or >40°C with ice to the head, isolette, warm blankets, heating cooling packs, or draft shields. BP, blood pressure; FiO2, fraction of inspired oxygen; LPM, liters per minute; NP, nasal prongs; NPPV, noninvasive positive-pressure ventilation.

TABLE 1 Comparison of Nontransferred and Transferred IC Patients

	Overall Population	Univariate Analysis			Multivariate Analysis		Missing Data
		IC Only (Nontransferred)	IC Then PICU (Transferred)	*P*	Odds Ratio	*P*	
No. patients (%)	427	361 (84.5)	66 (15.5)	—	—	—	—
Age, y, median (IQR)	4.12 (1.34–8.89)	4.12 (1.34–8.89)	3.20 (0.74–8.61)	.27	—	—	0
Male sex, *n* (%)	238 (55.7)	201 (55.7)	37 (56.1)	.98	—	—	0
Complex care program, *n* (%)	184 (43.1)	158 (43.8)	26 (39.4)	.59	—	—	0
Admitted from ED, *n* (%)	364 (85.3)	307 (85.0)	57 (86.4)	.99	—	—	0
IC LOS, d, median (IQR)	3.73 (2.04–7.30)	4.34 (2.35–7.54)	1.41 (0.66–3.87)	—	—	—	0
Patients who died, *n* (%)	3	3	N/A	—	—	—	0
BPEWS score, median (IQR)	5 (3–8)	5 (3–7)	7 (4.25–9)	<.01	1.02 (1.02–1.06)	<.01	1
HR (beats per min), mean ± SD	123.34 ± 27.34	122.33 ± 27.44	128.83 ± 26.33	.07	1.01 (0.98–1.03)	.36	1
RR (rpm), mean ± SD	35.12 ± 14.63	34.72 ± 14.47	37.30 ± 15.41	.21	—	—	1
Body temperature, ºC, mean ± SD	37.03 ± 0.76	37.01 ± 0.74	37.14 ± 0.86	.16	—	—	1
Pulse oxygen saturation, mean ± SD	97.36 ± 2.85	97.48 ± 2.67	96.71 ± 3.64	.10	0.99 (0.88–1.03)	.16	1
Respiratory support, *n* (%)	310 (72.6)	259 (72.0)	54 (81.8)	.10	1.11 (1.0–1.23)	.04	1

ED, emergency department; HR, heart rate; IQR, interquartile range; N/A, not available; rpm, reps per minute; RR, respiratory rate; —, not applicable.

of the complex care program (Table 1, Fig 1).

Transfers from IC to the PICU occurred more commonly after hours (72.7%), which is commensurate with the after-hours time in each week. Transferred patients had a shorter IC LOS (1.4 days into admission [0.7–3.9] vs 4.3 [2.4–7.5]) and significantly higher median admission BPEWS scores (BPEWS score of 7 [4.3–9] vs 5 [3–7]; $P <$ .01) compared with the nontransferred group. No other individual physiologic characteristic showed a significant difference between the 2 groups (Table 1).

By multivariate analysis, BPEWS at the time of admission to IC ($P <$ .01) and need for any form of respiratory support ($P =$ .04) were significant predictive factors for transfer to the PICU ($R^2 = 0.56$).

Within the group of patients who were transferred to the PICU, the BPEWS score at the time of admission versus at the time of transfer was not significantly different (7 [4.3–9] vs 8 [6–9.8]; $P =$ .19). The majority of transferred patients required escalation in respiratory support while in the PICU: either continuous BiPAP, CPAP, or invasive positive pressure ventilation (40.9%, 22.7%, and 21.2%, respectively). Just over one-quarter of patients (27.3%) who were transferred to the PICU did not require any escalation in therapy or medical management (Table 2).

DISCUSSION

This study demonstrates that BPEWS score and need for any form of respiratory support were significant predictors of transfer from the IC to PICU. To our knowledge, this is the first Canadian study to assess key predictive factors in a pediatric IC setting.

The short LOS in transferred patients likely reflects the acuity and severity of their illness at the time of presentation and an actual need for escalation of care. Evidence for this includes the higher BPEWS score at admission and the escalation in respiratory and other supports needed in the majority of patients after transfer to the PICU. It is also an indication that PICU transfers from IC happened early in the hospital course. This metric highlights the importance of physiologic monitoring and vigilant assessment by medical and nursing staff, particularly in the first 48 hours after admission, when the patient may be at the greatest risk of deterioration.

Monitoring both physiologic and behavioral signs of patient deterioration is essential, (rather than simply focusing on one or the other).[17] Many current pediatric early warning or prediction systems contain a combination of vital signs and clinician observation and assessment,[25] recognizing the need for a synergistic approach to identify deterioration and potential need for transfer. This combination approach was evident in our results. Although there was no significant difference between the 2 patient groups in terms of vital signs at admission, there was a corresponding difference in BPEWS, suggesting a potentially greater risk of clinical deterioration.

TABLE 2 IC-to-PICU–Transferred Patient Outcomes

Interventions	Transferred Patients ($N = 66$), *n* (%)
Intubation plus invasive ventilation	14 (21.2)
Noninvasive ventilation	BiPAP: 27 (40.9); CPAP: 15 (22.7)
Fluid bolus	18 (27.3)
Vasoactive medications (eg, vasopressors)	12 (18.2)
CPR and/or defibrillation	2 (3.0)
No "critical" intervention (ie, observation or supportive therapy)	18 (27.3)

CPR, cardiopulmonary resuscitation.

BPEWS has been incorporated as the standard of care across our institution to highlight patient deterioration; hence, it was assessed in our study. Interestingly, although BPEWS at admission was predictive of PICU transfer, there was no change in BPEWS score at the time of transfer.[13] These results again suggest that the score in isolation may not be an absolute predictor of transfer in this subgroup of patients. Rather, BPEWS needs to be considered with other measures and algorithms that incorporate situational awareness and assessment to add more insight into prediction of deterioration.[26,27]

The significance of respiratory support at the time of admission offers an important predictor to explore. Given that a significant proportion of transferred patients subsequently required escalation of respiratory support in the PICU, this is likely a reflection of true illness-related deterioration. This subgroup may require specific attention, such as provision of nursing resources and provider education around specific types of respiratory diseases, monitoring, and various supportive therapies when admitted to IC.

The paucity of studies looking at IC-to-PICU transfers makes it difficult to benchmark our results. Our transfer rates were higher than previously reported pediatric ward–to–PICU transfer rates from other institutions; these variable rates of transfer are not surprising given the heterogeneous patient populations between studies.[28,29]

Likewise, Hamze-Sinno et al[13] demonstrated a 9.6% transfer rate from IC to the PICU in their institution, although the details of their IC are not described. In contrast to their study, our population was older and potentially more unwell on presentation to the hospital, as determined by early warning scores.

Our high transfer rate, coupled with the majority of transfers to the PICU requiring escalation of medical treatment, reflects both our resource capability and patients' clinical deterioration. Given that between institutions there is a lack of standardized admission criteria in IC and PICU settings, we hypothesize that patients admitted to our IC may have a degree of medical complexity and illness severity that would warrant direct admission to the PICU in some other centers.

LIMITATIONS

Our study's main challenge was its retrospective design and our heterogeneous patient population. Therefore, we relied on standardized markers such as vital signs and BPEWS to achieve objectivity in assessing predictors of patient transfer. We acknowledge that BPEWS is not the only tool to predict patient deterioration, and its evaluation as the optimum marker of deterioration is beyond the scope of this study. However, it has been validated and is currently used at our institution across both ward and PICU settings. As a result, BPEWS was recorded consistently and accurately in our included patients and thus allowed for ease of comparison.

CONCLUSIONS

The need for close monitoring of physiologic parameters remains paramount, especially in the first 48 hours of admission, in predicting the need for transfer from the IC to PICU. Particular attention should be paid to patients requiring any form of respiratory support in addition to overall situational awareness and patient assessment, including potentially incorporating the use of a standardized score such as BPEWS.

Acknowledgments

We thank Drs Cohen, Friedman, and Mahant for providing peer review and suggestions for the study and article.

REFERENCES

1. Geneslaw AS, Jia H, Lucas AR, Agus MSD, Edwards JD. Pediatric intermediate care and pediatric intensive care units: PICU metrics and an analysis of patients that use both. *J Crit Care*. 2017;41:268–274
2. Crabtree I. 'A bridge to the future': impact on high dependency and intensive care. *J* Child Health Care. 2001; 5(4):150–154
3. Plate JDJ, Leenen LPH, Houwert M, Hietbrink F. Utilisation of intermediate care units: a systematic review. *Crit Care Res Pract*. 2017;2017:8038460
4. Jaimovich DG; American Academy of Pediatrics Committee on Hospital Care and Section on Critical Care. Admission and discharge guidelines for the pediatric patient requiring intermediate care. *Pediatrics*. 2004;113(5):1430–1433
5. Solberg BC, Dirksen CD, Nieman FH, et al. Introducing an integrated intermediate care unit improves ICU utilization: a prospective intervention study. *BMC Anesthesiol*. 2014;14:76
6. Morris KP, Oppong R, Holdback N, Coast J; West Midlands Paediatric High Dependency Group. Defining criteria and resource use for high dependency care in children: an observational economic study. *Arch Dis Child*. 2014;99(7):652–658
7. Vincent JL, Rubenfeld GD. Does intermediate care improve patient outcomes or reduce costs? *Crit Care*. 2015;19:89
8. Doman M, Prowse M, Webb C. Exploring nurses' experiences of providing high dependency care in children's wards. *J Child Health Care*. 2004;8(3):180–197
9. Rushforth K, Darowski M, McKinney PA. Quantifying high dependency care: a prospective cohort study in Yorkshire (UK). *Eur J Pediatr*. 2012;171(1):77–85
10. Behjati S, Jamieson K, Montgomery M, Patel N, Jaswon M. Do paediatric high dependency units in district general hospitals improve patient care? A local review of children presenting with seizures. *Arch Dis Child*. 2012;97(6):582
11. Chapman SM, Grocott MP, Franck LS. Systematic review of paediatric alert criteria for identifying hospitalised children at risk of critical deterioration. *Intensive Care Med*. 2010;36(4):600–611
12. Parshuram CS, Duncan HP, Joffe AR, et al. Multicentre validation of the Bedside Paediatric Early Warning System score: a severity of illness score to detect evolving critical illness in hospitalised children. *Crit Care*. 2011;15(4):R184
13. Hamze-Sinno R, Abdoul H, Neve M, Tsapis M, Jones P, Dauger S. Can we easily anticipate on admission pediatric patient transfers from intermediate to

intensive care? *Minerva Anestesiol*. 2011; 77(10):1022–1023

14. Chapman SM, Maconochie IK. Early warning scores in paediatrics: an overview. *Arch Dis Child*. 2019;104(4): 395–399
15. Downey CL, Tahir W, Randell R, Brown JM, Jayne DG. Strengths and limitations of early warning scores: a systematic review and narrative synthesis. *Int J Nurs Stud*. 2017;76:106–119
16. Parshuram CS, Dryden-Palmer K, Farrell C, et al; Canadian Critical Care Trials Group and the EPOCH Investigators. Effect of a pediatric early warning system on all-cause mortality in hospitalized pediatric patients: the EPOCH randomized clinical trial. *JAMA*. 2018;319(10):1002–1012
17. Lambert V, Matthews A, MacDonell R, Fitzsimons J. Paediatric early warning systems for detecting and responding to clinical deterioration in children: a systematic review. *BMJ Open*. 2017;7(3): e014497
18. da Silva YS, Hamilton MF, Horvat C, et al. Evaluation of electronic medical record vital sign data versus a commercially available acuity score in predicting need for critical intervention at a tertiary children's hospital. *Pediatr Crit Care Med*. 2015;16(7):644–651
19. Rothman MJ, Tepas JJ III, Nowalk AJ, et al. Development and validation of a continuously age-adjusted measure of patient condition for hospitalized children using the electronic medical record. *J Biomed Inform*. 2017;66: 180–193
20. Winter MC, Kubis S, Bonafide CP. Beyond reporting early warning score sensitivity: the temporal relationship and clinical relevance of "true positive" alerts that precede critical deterioration [published online ahead of print August 29, 2018]. *J Hosp Med*. doi:10.12788/jhm.3066
21. Raymond TT, Bonafide CP, Praestgaard A, et al; American Heart Association Get With the Guidelines-Resuscitation Investigators. Pediatric medical emergency team events and outcomes: a report of 3647 events from the American Heart Association's get with the guidelines-resuscitation registry. *Hosp Pediatr*. 2016;6(2):57–64
22. Bonafide CP, Brady PW, Keren R, Conway PH, Marsolo K, Daymont C. Development of heart and respiratory rate percentile curves for hospitalized children. *Pediatrics*. 2013;131(4). Available at: www.pediatrics.org/cgi/content/full/131/4/e1150
23. Cohen E, Berry JG, Sanders L, Schor EL, Wise PH. Status complexicus? The emergence of pediatric complex care. *Pediatrics*. 2018;141(suppl 3):S202–S211
24. Dewan T, Cohen E. Children with medical complexity in Canada. *Paediatr Child Health*. 2013;18(10):518–522
25. Trubey R, Huang C, Lugg-Widger FV, et al. Validity and effectiveness of paediatric early warning systems and track and trigger tools for identifying and reducing clinical deterioration in hospitalised children: a systematic review. *BMJ Open*. 2019;9(5):e022105
26. Tarango SM, Pham PK, Chung D, Festekjian A. Prediction of clinical deterioration after admission from the pediatric emergency department. *Int Emerg Nurs*. 2019;43:1–8
27. Marcin JP, Pretzlaff RK, Pollack MM, Patel KM, Ruttimann UE. Certainty and mortality prediction in critically ill children. *J Med Ethics*. 2004;30(3): 304–307
28. Reese J, Deakyne SJ, Blanchard A, Bajaj L. Rate of preventable early unplanned intensive care unit transfer for direct admissions and emergency department admissions. *Hosp Pediatr*. 2015;5(1): 27–34
29. Miles AH, Spaeder MC, Stockwell DC. Unplanned ICU transfers from inpatient units: examining the prevalence and preventability of adverse events associated with ICU transfer in pediatrics. *J Pediatr Intensive Care*. 2016;5(1):21–27

Anticipating Pediatric Patient Transfers From Intermediate to Intensive Care

Daryl R. Cheng, Caitlyn Hui, Kate Langrish and Carolyn E. Beck

Hospital Pediatrics 2020;10;347
DOI: 10.1542/hpeds.2019-0260 originally published online March 27, 2020;

Hospital Pediatrics®

AN OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Anticipating Pediatric Patient Transfers From Intermediate to Intensive Care

Daryl R. Cheng, Caitlyn Hui, Kate Langrish and Carolyn E. Beck

Hospital Pediatrics 2020;10;347
DOI: 10.1542/hpeds.2019-0260 originally published online March 27, 2020;