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Journal

Pediatric Critical Care Medicine, 17(6)

ISSN

1529-7535

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Publication Date

2016-06-01

DOI

10.1097/pcc.0000000000000761

Peer reviewed

Impact of Telemedicine on Severity of Illness and Outcomes Among Children Transferred From Referring Emergency Departments to a Children's Hospital PICU*

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Objectives: To compare the severity of illness and outcomes among children admitted to a children's hospital PICU from referring emergency departments with and without access to a pediatric critical care telemedicine program.

Design: Retrospective cohort study.

Setting: Tertiary academic children's hospital PICU.

Patients: Pediatric patients admitted directly to the PICU from referring emergency departments between 2010 and 2014.

Interventions: None.

Measurements: Demographic factors, severity of illness, and clinical outcomes among children receiving care in emergency departments with and without access to pediatric telemedicine, as well as a subcohort of children admitted from emergency departments before and after the implementation of telemedicine.

Main Results: Five hundred eighty-two patients from 15 emergency departments with telemedicine and 524 patients from 60 emergency departments without telemedicine were transferred and admitted to the PICU. Children admitted from emergency departments using telemedicine were younger (5.6 vs 6.9 yr; $p < 0.001$) and less sick (Pediatric Risk of Mortality III score, 3.2 vs 4.0; $p < 0.05$) at admission to the PICU compared with children admitted from emergency departments without telemedicine. Among transfers from emergency departments that established telemedicine programs during the study period, children arrived significantly less sick (mean Pediatric Risk of Mortality III scores, 1.2 units lower; $p = 0.03$) after the implementation of telemedicine ($n = 43$) than before the implementation of telemedicine ($n = 95$). The observed-to-expected mortality ratios of posttelemedicine, pretelemedicine, and no-telemedicine cohorts were 0.81 (95% CI, 0.53–1.09), 1.07 (95% CI, 0.53–1.60), and 1.02 (95% CI, 0.71–1.33), respectively.

Conclusions: The implementation of a telemedicine program designed to assist in the care of seriously ill children receiving care in referring emergency departments was associated with lower illness severity at admission to the PICU. This study contributes to the body of evidence that pediatric critical care telemedicine programs assist referring emergency departments in the care of critically ill children and could result in improved clinical outcomes. (*Pediatr Crit Care Med* 2016; 17:516–521)

Key Words: mortality; pediatric critical care; pediatric intensive care unit; pediatrics; severity of illness; telemedicine

Previous research has demonstrated that children transferred and directly admitted to PICUs from referring emergency departments (EDs) have higher severity of illness at admission than children admitted directly to the PICU from EDs within the same hospital as the PICU (1–4). Higher severity of illness is associated with higher morbidity (3–6), higher mortality (1, 3, 7–9), longer length of hospital stays (1, 5), and higher resource utilization (1, 5, 9, 10).

The higher severity of illness among children transferred from referring EDs can be partly explained by the lack of pediatric subspecialty expertise (11–14), experience (11, 14), equipment (14), and infrastructure in EDs (14) located within nontertiary children's hospitals. Lower annual pediatric volumes and the regionalization of pediatric specialty care make it difficult to maintain the sufficient infrastructure and clinical staff specialized in the care of seriously ill children. Because of this, telemedicine has been increasingly used by referring EDs to address disparities in access to pediatric subspecialists (15). Data from previous research have demonstrated that the use

*See also p. 566.

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The authors have disclosed that they do not have any potential conflicts of interest.

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DOI: 10.1097/PCC.0000000000000761

of telemedicine to support the care of seriously ill children in referring EDs results in higher provider and patient satisfaction (16–19), improved clinical outcomes (20), fewer medication errors (12), and higher quality of medical care (17, 21). Pediatric telemedicine consultations can sometimes obviate unnecessary transfers (20–23), facilitate timely and appropriate stabilization prior to and during the transfer process (22, 23), and may result in lower severity of illness at admission to the PICU and improved outcomes.

Although many telemedicine programs have been implemented in the recent past, few studies have evaluated the impact of these programs on pediatric patients transferred for direct admission to PICUs. The objective of this study was to compare characteristics of and outcomes among seriously ill children admitted to a children's hospital PICU from EDs with and without access to pediatric critical care consultations using telemedicine. Using a subcohort of our sample, we also compared the characteristics of and outcomes among children transferred to the PICU from referring EDs before and after the implementation of a pediatric critical care telemedicine program. Our hypothesis was that the presence of a telemedicine program would result in more appropriate therapies and improved stabilization of patients such that these children would arrive less sick and have better outcomes than children transferred from EDs without a telemedicine program.

MATERIALS AND METHODS

Patient Population and Data Source

We analyzed all pediatric patients (<18 yr old) admitted to the PICU at the University of California, Davis Children's Hospital, directly from a referring ED between 2010 and 2014. Referring EDs are located throughout a 33-county region covering 65,000 square miles, include both urban and rural/underserved areas in Northern California, and serve approximately six million people. Pediatric patients are transferred from referring EDs to the PICU at the discretion of the referring ED physicians and/or the recommendation of the consulting pediatric critical care physician.

Data were abstracted from the UC Davis Children's Hospital Virtual PICU Performance System (VPS) database, which is part of a national collection of high-quality data elements used for internal and external benchmarking to better understand, evaluate, and improve care and outcomes of critically ill children (24). All patients admitted to the PICU are entered into the database, which includes patient demographic information, diagnostic data, and the physiologic and laboratory data needed to calculate illness severity (25). The UC Davis PICU uses the VPS-recalibrated coefficients for the Pediatric Risk of Mortality (PRISM III) as its preferred measure of severity of illness and mortality prediction algorithm (26).

Telemedicine Overview

The Pediatric Critical Care Telemedicine Program at the UC Davis Children's Hospital was initiated in 2000 and provides telemedicine consultations to approximately 8.6% of the critically ill pediatric patients transferred from participating referring EDs (27). To request a consultation, a remote ED physician calls a toll-free number and a UC Davis pediatric critical care physician is then paged to initiate the consultation. The telemedicine consultation consists of audiovisual interactive communication involving the patient, parent/guardian, referring ED providers (physician, nurse, and respiratory therapist), and the pediatric critical care physician. The telemedicine equipment consists of a pole-mounted turn-key videoconferencing unit (e.g., Polycom or Cisco), a high-resolution monitor, and uninterrupted power supply. The video camera is capable of 10× zoom, remote control, pan, and tilt capabilities (17). Upon concluding the consultation, an electronic health record note is either electronically transferred or faxed to the referring hospital to be included in the patient's medical records (17, 27).

Outcome Measures

We compared demographic factors, such as age, and other factors known to be associated with severity of illness at PICU admission, including ground transport distance and day and time of admission. Transport distance is directly proportional to transport time, and longer times could result in physiological deterioration and/or improvements prior to PICU admission. Prior research has demonstrated the association of day and time of admission with severity of illness and clinical outcomes (28, 29). Time of admission was categorized as daytime (8 AM to 8 PM) or nighttime (8 PM 8 AM). Day of admission was categorized as weekday (Monday to Friday) or weekend (Saturday and Sunday). We also compared clinical factors, such as illness severity as measured by the PRISM III score, PICU length of stay, mortality, and disposition.

Two separate analyses were conducted. First, we compared factors among all children transferred to the UC Davis PICU from referring EDs with and without access to pediatric telemedicine. Second, among hospitals that obtained access to pediatric telemedicine during the study period, we compared pretelemedicine factors to posttelemedicine factors. This allowed us to further improve the comparability of telemedicine and nontelemedicine groups by minimizing bias because of unknown hospital-associated factors in our study groups. To evaluate the association between the existence of a telemedicine program in referring EDs and the PICU risk-adjusted mortality after admission, we also compared standardized observed-to-expected mortality ratios (ratio of observed number of deaths to the number of deaths predicted by the PRISM III score) among nontelemedicine and telemedicine cohorts, as well as the pretelemedicine and posttelemedicine cohorts.

Statistical Analyses

We performed all statistical analyses by using Stata Statistical Software: Release 13 (StataCorp, College Station, TX). For baseline univariable comparisons, we used the Student *t* tests for continuous variables and the chi-square test for categorical variables. We performed multivariable linear regression to compare severity of illness among patients transferred from EDs with telemedicine to those transferred from EDs without telemedicine, adjusting for

confounders such as age, transport distance, and day and time of admission. To compare PICU admission severity of illness among patient cohorts before and after the implementation of telemedicine at referring EDs, we performed a linear regression analysis and adjusted for clustering at the hospital level using cluster robust SEs. p values less than 0.05 were considered statistically significant. The Institutional Review Board at the University of California, Davis, approved this study.

RESULTS

A total of 582 patients were transferred directly to the PICU from 15 EDs with pediatric telemedicine and 524 patients were transferred from 60 EDs without pediatric telemedicine. As shown in **Table 1**, children transferred from EDs with telemedicine were significantly younger (5.6 vs 6.9 yr; $p < 0.001$) and were transported over a greater distance (72.4 vs 63.1 miles; $p < 0.05$) when compared with children transferred from EDs without telemedicine. Fewer children transferred from EDs with telemedicine were admitted during nighttime hours (56.0% vs 63.9%; $p < 0.05$); however, children transferred from EDs with telemedicine had similar rates of admission during the weekend (31.8% vs 29.2%; $p = 0.35$) compared with children transferred from EDs without telemedicine. In terms of clinical factors, patients transferred from EDs with telemedicine arrived to the PICU less ill (PRISM III score, 3.2 vs 4.0; $p < 0.05$) compared with patients transferred from EDs without telemedicine (Table 1). We did not find statistically significant differences in lengths of stay (3.1 vs 3.8 d; $p = 0.11$) and observed mortality (2.4% vs 4.4%; $p = 0.07$) between children admitted from EDs with telemedicine compared with those admitted from EDs without telemedicine. After adjusting for age, transport distance, and time and day of admission, children admitted from EDs with telemedicine had lower PRISM III scores on presentation than children admitted from EDs without telemedicine ($\beta = -0.74$; 95% CI, –1.46 to –0.01; **Table 2**).

During the study period, four EDs obtained telemedicine capabilities. Among this cohort, there were 95 patients in the pretelemedicine cohort and 43 in the posttelemedicine cohort. Baseline characteristics of the pretelemedicine and posttelemedicine patient cohorts are shown in **Table 3**. In general, findings were consistent with the entire telemedicine versus nontelemedicine cohorts; however, the differences were not statistically significant, including PRISM III scores (3.8 vs 2.5; $p = 0.22$) and length of stay (4.1 vs 2.4 d; $p = 0.22$).

Regression analysis of the subcohort demonstrated that patients transferred after the implementation of telemedicine had lower PRISM III scores ($\beta = -1.2$ units; $p = 0.03$) than patients transferred before the implementation of telemedicine. The O/E ratios of posttelemedicine, pretelemedicine, and no-telemedicine cohorts were 0.81 (95% CI, 0.53–1.09), 1.07 (95% CI, 0.53–1.60), and 1.02 (95% CI, 0.71–1.33), respectively. The O/E ratios were not statistically different from one another.

DISCUSSION

In our study, we evaluated the impact of a pediatric critical care telemedicine consultation program for referring EDs on the severity of illness of children arriving to a tertiary care children's hospital PICU. We found that children transferred from EDs with telemedicine capabilities were significantly less sick on arrival to the PICU, suggesting better care and more appropriate stabilization than that of children transferred from EDs

TABLE 1. Demographic and Clinical Factors of Pediatric Patients Transferred From Emergency Departments With and Without Telemedicine

Variable	No Telemedicine, $n = 524$	Telemedicine, $n = 582$	p
Mean age, yr (SD)[a]	6.9 (5.9)	5.6 (5.7)	< 0.001
Mean transport distance, miles (SD)[a]	63.1 (70.9)	72.4 (69.6)	< 0.05
Nighttime admission, *n* (%)[a]	335 (63.9)	326 (56.0)	< 0.05
Weekend admission, *n* (%)	153 (29.2)	185 (31.8)	0.35
Mean Pediatric Risk of Mortality III score (SD)[a]	4.0 (6.7)	3.2 (5.4)	< 0.05
Mean length of PICU stay, d (SD)	3.8 (9.4)	3.1 (5.5)	0.11
Mortality, *n* (%)	23 (4.4)	14 (2.4)	0.07
PICU disposition, *n* (%)			
General care floor	297 (56.7)	334 (57.4)	0.37
Home	150 (28.6)	184 (31.6)	
Step-down unit	15 (2.9)	13 (1.2)	
Another ICU	8 (1.5)	9 (1.5)	
Other	54 (10.3)	42 (8.3)	

[a]$p < 0.05$.

TABLE 2. Multivariable Analysis Predicting Pediatric Risk of Mortality III Score

Variable	β Coefficient	SE	95% CI
Emergency department with telemedicine	−0.74	0.37	−1.47 to −0.02
Transport distance, miles	−0.002	0.003	−0.007 to 0.003
Age, yr	0.07	0.03	0.01–0.13
Daytime admission	0.68	0.37	−0.06 to 1.41
Weekend admission	0.25	0.40	−0.53 to 1.02

TABLE 3. Demographic and Clinical Factors of Pediatric Patients Transferred From Emergency Departments Before and After Implementation of a Telemedicine Program

Factors	Pretelemedicine, *n* = 95	Posttelemedicine, *n* = 43	*p*
Mean age, yr (SD)	6.6 (6.0)	4.6 (4.9)	0.06
Nighttime admission, *n* (%)	53 (55.8)	23 (53.5)	0.80
Weekend admission, *n* (%)	24 (25.3)	15 (34.9)	0.51
Mean Pediatric Risk of Mortality III score (SD)	3.8 (5.9)	2.5 (3.5)	0.22
Mean PICU length of stay, d (SD)	4.1 (8.9)	2.4 (2.3)	0.22
Mortality, *n* (%)	4 (4.2)	1 (2.3)	0.58

without telemedicine capabilities. This finding was consistent even after adjusting for confounders. Among a subcohort of children from hospitals that initiated telemedicine during the study period, those transferred from EDs to the PICU during the posttelemedicine period were significantly less sick on arrival than those transferred from the same EDs during the pretelemedicine period. We also found that standardized mortality ratios (O/E ratios) were lower than 1.0 for children admitted from EDs with telemedicine and among the posttelemedicine cohort and higher than 1.0 for children admitted from EDs without telemedicine and among the pretelemedicine cohort. These findings suggest that access to telemedicine consultations with pediatric critical care specialists during the initial treatment of children in EDs might offer an opportunity to reduce mortality.

Our study adds to the existing body of knowledge about the variation in illness severity among children admitted to PICUs from different hospitals and hospital locations. The finding that children transferred from EDs lacking pediatric expertise are more ill when they arrive at a PICU in a tertiary care children's hospital is in agreement with previous literature (1–4). Improving the initial care that these children receive in referring EDs could likely improve clinical outcomes and reduce burdens associated with increased morbidity, length of stay, and mortality (30, 31). In the case of children who are not critically ill, appropriate pretransfer care might also prevent unnecessary and resource-intensive emergency transportation to a distant and possibly overcrowded PICU (20, 22, 23, 32).

Since the 2006 release of the Institute of Medicine's report (33), "The Future of Emergency Care in the United States Health System, Emergency Care for Children: Growing Pains," the medical community has realized that with the regionalization of pediatric emergency services, there are significant disparities in the ability of different EDs to care for seriously ill children (34). A recent assessment of EDs underscored the association of annual patient volumes with pediatric readiness for day-to-day and disaster care (35). Readiness was also associated with the presence of physician and nurse pediatric emergency coordinators. Although there have been improvements in pediatric readiness of all EDs over the past decade, there remain opportunities for more EDs to become compliant with national guidelines. Only 12% of California-based hospitals and 10% of all U.S. hospitals have both an ED and PICU to evaluate and manage critically ill children (35, 36). Thus, it is imperative that EDs without 24/7 access to pediatric subspecialists identify solutions to improve pretransfer care of this extremely vulnerable population.

The majority of children receive emergency medical care in rural, community, and otherwise nonchildren's hospitals (14, 35, 37). Although most EDs provide high quality of care to children, particularly among the most seriously ill, literature suggests that care provided in nonchildren's hospitals may have lower ratings for quality of care and higher rates of adverse events, such as medication errors (13, 37–39). The use of telemedicine to access pediatric expertise has been shown to be well received as a potential solution to increase access to specialty care (19). It has also been suggested that telemedicine consultations could serve as opportunities for building collaborative relationships with more experienced practitioners at tertiary care children's hospitals, which has implications for

workforce recruitment and retention (19). Hence, in addition to having a potential impact on improving outcomes among children receiving care in the ED, the use of telemedicine may also indirectly improve quality of care by mitigating staffing-related issues common to rural health systems.

Our study has several limitations. First, there may be inherent differences between hospitals and EDs that participate in the telemedicine program and those hospitals that do not participate in the program. The hospitals represented a convenience sample based on their need, interest in participation, and relationship with UC Davis. Second, the sample size for our subcohort analysis comparing illness severity in pretelemedicine and posttelemedicine cohorts is small, which might limit the detection of a true effect of telemedicine in this context. However, given our relatively short study period and the low volume of critically ill children needing transfer at referring EDs (27), this analysis still provides useful insight into the clinical impact of telemedicine consultations with PICU-based pediatric subspecialists. Third, our study does not address the possibility that the lower illness severity of children transferred from EDs with telemedicine capabilities may simply be a consequence of transferring children who are less sick. Without detailed information on the therapies and interventions performed in the EDs as a result of the telemedicine consultations, we are unable to directly attribute the lower PRISM III scores on arrival to the PICU to the telemedicine program. However, our claim finds support in prior research showing that pediatric critical care telemedicine programs in EDs were effective in lowering transfer rates of children to facilities providing higher levels of care (21). Fourth, we considered the intervention in this study to be the telemedicine program and not the specific consultation modality—so not all patients transferred from EDs with telemedicine received a telemedicine consultation. We conducted our analysis this way because of the selection bias that would be introduced if we considered the nonrandom mode of consultation to be the intervention. Last, the EDs transferring patients to the PICU during the study period may not be representative of other referring EDs, potentially limiting the generalizability of our findings.

Our study conclusions are based on the assumption that all EDs that have access to telemedicine are using them appropriately for patient consultations. However, many EDs might be underusing their telemedicine capabilities, particularly just after installation because of limited proficiency and comfort of the staff with the equipment, the change in relationships with consultation providers in the PICU (19), and the tendency to continue using established methods of obtaining telephone consultations. Thus, our estimates of severity of illness for the posttelemedicine group could be overestimated. However, even if this were not the case, our inference that telemedicine consultations assist in the initial ED care and help lower the severity of illness of children on arrival to the PICU would not change. Hospitals were not randomized to telemedicine installation, so our results could be subject to confounding bias. We tried to minimize this bias by adjusting for all possible confounding variables reported in the previous literature and accounted for clustering by hospital in the secondary analyses.

We measured each patient's severity of illness using the PRISM III score, which is calculated using physiological measures recorded within the first 24 hours of admission into the PICU (26). Although PRISM III estimates the risk of mortality on admission to the PICU, the score does not account for the illness severity when the child first sought emergency care at the referring ED. Prior treatment and stabilization at the referring ED could temporarily mask severe morbidity and lead to underestimation of the illness severity score on arrival at the PICU (1, 3, 4, 21, 40). This could possibly introduce a lead-time bias and result in higher O/E ratios; however, the O/E estimates for children admitted from EDs with telemedicine were lower than 1.0 (5).

CONCLUSIONS

Children transferred from EDs participating in a pediatric critical care telemedicine program arrive to the PICU less sick than those transferred from EDs without access to telemedicine. Studies evaluating the impact of telemedicine at the patient level are needed to provide further evidence that telemedicine consultations improve pretransfer care.

REFERENCES

1. Odetola FO, Rosenberg AL, Davis MM, et al: Do outcomes vary according to the source of admission to the pediatric intensive care unit? *Pediatr Crit Care Med* 2008; 9:20–25
2. Odetola FO, Davis MM, Cohn LM, et al: Interhospital transfer of critically ill and injured children: An evaluation of transfer patterns, resource utilization, and clinical outcomes. *J Hosp Med* 2009; 4:164–170
3. Gregory CJ, Nasrollahzadeh F, Dharmar M, et al: Comparison of critically ill and injured children transferred from referring hospitals versus in-house admissions. *Pediatrics* 2008; 121:e906–e911
4. Odetola FO, Clark SJ, Gurney JG, et al: Effect of interhospital transfer on resource utilization and outcomes at a tertiary pediatric intensive care unit. *J Crit Care* 2009; 24:379–386
5. Golestanian E, Scruggs JE, Gangnon RE, et al: Effect of interhospital transfer on resource utilization and outcomes at a tertiary care referral center. *Crit Care Med* 2007; 35:1470–1476
6. Odetola FO, Mann NC, Hansen KW, et al: Source of admission and outcomes for critically injured children in the mountain states. *Arch Pediatr Adolesc Med* 2010; 164:277–282
7. Combes A, Luyt CE, Trouillet JL, et al: Adverse effect on a referral intensive care unit's performance of accepting patients transferred from another intensive care unit. *Crit Care Med* 2005; 33:705–710
8. Durairaj L, Will JG, Torner JC, et al: Prognostic factors for mortality following interhospital transfers to the medical intensive care unit of a tertiary referral center. *Crit Care Med* 2003; 31:1981–1986
9. Hill AD, Vingilis E, Martin CM, et al: Interhospital transfer of critically ill patients: Demographic and outcomes comparison with nontransferred intensive care unit patients. *J Crit Care* 2007; 22:290–295
10. Pollack MM, Patel KM, Ruttimann E: Pediatric critical care training programs have a positive effect on pediatric intensive care mortality. *Crit Care Med* 1997; 25:1637–1642
11. Tilford JM, Simpson PM, Green JW, et al: Volume-outcome relationships in pediatric intensive care units. *Pediatrics* 2000; 106:289–294
12. Dharmar M, Kuppermann N, Romano PS, et al: Telemedicine consultations and medication errors in rural emergency departments. *Pediatrics* 2013; 132:1090–1097
13. Dharmar M, Marcin JP, Romano PS, et al: Quality of care of children in the emergency department: Association with hospital setting and physician training. *J Pediatr* 2008; 153:783–789
14. Athey J, Dean JM, Ball J, et al: Ability of hospitals to care for pediatric emergency patients. *Pediatr Emerg Care* 2001; 17:170–174

15. Uscher-Pines L, Kahn JM: Barriers and facilitators to pediatric emergency telemedicine in the United States. *Telemed J E Health* 2014; 20:990–996
16. Yang NH, Dharmar M, Hojman NM, et al: Videoconferencing to reduce stress among hospitalized children. *Pediatrics* 2014; 134:e169–e175
17. Dharmar M, Romano PS, Kuppermann N, et al: Impact of critical care telemedicine consultations on children in rural emergency departments. *Crit Care Med* 2013; 41:2388–2395
18. Marcin JP, Nesbitt TS, Kallas HJ, et al: Use of telemedicine to provide pediatric critical care inpatient consultations to underserved rural Northern California. *J Pediatr* 2004; 144:375–380
19. Ray KN, Demirci JR, Bogen DL, et al: Optimizing telehealth strategies for subspecialty care: Recommendations from rural pediatricians. *Telemed J E Health* 2015; 21:622–629
20. Webb CL, Waugh CL, Grigsby J, et al; American Society of Echocardiography Telemedicine Collaborators' Group: Impact of telemedicine on hospital transport, length of stay, and medical outcomes in infants with suspected heart disease: A multicenter study. *J Am Soc Echocardiogr* 2013; 26:1090–1098
21. Yang NH, Dharmar M, Kuppermann N, et al: Appropriateness of disposition following telemedicine consultations in rural emergency departments. *Pediatr Crit Care Med* 2015; 16:e59–e64
22. Labarbera JM, Ellenby MS, Bouressa P, et al: The impact of telemedicine intensivist support and a pediatric hospitalist program on a community hospital. *Telemed J E Health* 2013; 19: 760–766
23. Heath B, Salerno R, Hopkins A, et al: Pediatric critical care telemedicine in rural underserved emergency departments. *Pediatr Crit Care Med* 2009; 10:588–591
24. Bennett TD, Spaeder MC, Matos RI, et al; Pediatric Acute Lung Injury and Sepsis Investigators (PALISI): Existing data analysis in pediatric critical care research. *Front Pediatr* 2014; 2:79
25. Marcin JP, Bratton, SL: Analysis outcomes and quality. *In:* Pediatric Critical Care Medicine: Basic Science and Clinical Evidence. Wheeler DS, Wong HR, Shanley TP (Eds). London, Springer, 2007, p 58
26. Pollack MM, Patel KM, Ruttimann UE: PRISM III: An updated Pediatric Risk of Mortality score. *Crit Care Med* 1996; 24:743–752
27. Hernandez M, Hojman N, Sadorra C, et al: Pediatric critical care telemedicine program: A single institution review. *Telemed J E Health* 2016; 22:51–55
28. Arias Y, Taylor DS, Marcin JP: Association between evening admissions and higher mortality rates in the pediatric intensive care unit. *Pediatrics* 2004; 113:e530–e534
29. Barnett MJ, Kaboli PJ, Sirio CA, et al: Day of the week of intensive care admission and patient outcomes: A multisite regional evaluation. *Med Care* 2002; 40:530–539
30. Yang NH, Dharmar M, Yoo BK, et al: Economic evaluation of pediatric telemedicine consultations to rural emergency departments. *Med Decis Making* 2015; 35:773–783
31. Marcin JP, Nesbitt TS, Struve S, et al: Financial benefits of a pediatric intensive care unit-based telemedicine program to a rural adult intensive care unit: Impact of keeping acutely ill and injured children in their local community. *Telemed J E Health* 2004; 10(Suppl 2):S1–S5
32. Huang DT: Clinical review: Impact of emergency department care on intensive care unit costs. *Crit Care* 2004; 8:498–502
33. Institute of Medicine: IOM report: The future of emergency care in the United States health system. *Acad Emerg Med* 2006; 13:1081–1085
34. Marcin JP: Telemedicine in the pediatric intensive care unit. *Pediatr Clin North Am* 2013; 60:581–592
35. Gausche-Hill M, Ely M, Schmuhl P, et al: A national assessment of pediatric readiness of emergency departments. *JAMA Pediatr* 2015; 169:527–534
36. Remick K, Kaji AH, Olson L, et al: Pediatric readiness and facility verification. *Ann Emerg Med* 2016; 67:320–328.e1
37. Kanter RK: Regional variation in child mortality at hospitals lacking a pediatric intensive care unit. *Crit Care Med* 2002; 30:94–99
38. Marcin JP, Dharmar M, Cho M, et al: Medication errors among acutely ill and injured children treated in rural emergency departments. *Ann Emerg Med* 2007; 50:361–367, 367.e1–e2
39. Odetola FO, Miller WC, Davis MM, et al: The relationship between the location of pediatric intensive care unit facilities and child death from trauma: A county-level ecologic study. *J Pediatr* 2005; 147:74–77
40. Dragsted L, Jörgensen J, Jensen NH, et al: Interhospital comparisons of patient outcome from intensive care: Importance of lead-time bias. *Crit Care Med* 1989; 17:418–422