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Pediatrics 2009;124;485-493; originally published online Jul 27, 2009;
DOI: 10.1542/peds.2008-2858

Pediatric Patient Safety in Emergency Departments: Unit Characteristics and Staff Perceptions

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KEY WORDS
pediatric patient safety, quality improvement, pediatric emergency care, health care quality

ABBREVIATIONS
ED— emergency department
PECARN—Pediatric Emergency Care Applied Research Network

www.pediatrics.org/cgi/doi/10.1542/peds.2008-2858

doi:10.1542/peds.2008-2858

Accepted for publication Nov 25, 2008

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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

WHAT'S KNOWN ON THIS SUBJECT: EDs are especially prone to medical errors. Currently there are few data on pediatric ED characteristics related to patient safety or the perceptions of ED staff members concerning the climate of safety in EDs.

WHAT THIS STUDY ADDS: The study defines the current state and perceptions of pediatric patient safety in 21 EDs. There is large variability among EDs in safety characteristics; and the study suggests specific structures and processes that may improve the safety climate.

abstract

OBJECTIVES: The goals were (1) to describe emergency department (ED) characteristics thought to be related to patient safety within the Pediatric Emergency Care Applied Research Network, (2) to measure staff perceptions of the climate of safety in EDs, and (3) to measure associations between ED characteristics and a climate of safety.

METHODS: Twenty-one EDs were surveyed to assess physical structure, staffing patterns, overcrowding, medication administration, teamwork, and methods for promoting patient safety. A validated survey on the climate of safety was administered to all emergency department staff members. Safety climate scores were compared to evaluate associations with ED characteristics.

RESULTS: A total of 1747 staff members (49%) responded to the survey on the climate of safety. A minority of EDs had organized safety activities such as safety committees (48%) or walk-rounds (38%), used computerized physician order entry (38%), had ED pharmacists (19%), or had formal physician/registered nurse teams (38%). The majority (67%) treated patients in hallways. Most (67%) varied staffing on the basis of seasonal patient volume. Of the 1747 ED staff members (49%) responding to the survey, there was a wide range (28%–82%) in the proportion reporting a positive safety climate. Physicians' ratings of the climate of safety were higher than nurses' ratings, and perceptions varied according to work experience. Characteristics associated with an improved climate of safety were a lack of ED overcrowding, a sick call back-up plan for physicians, and the presence of an ED safety committee.

CONCLUSIONS: Large variability existed among EDs in structures and processes thought to be associated with patient safety and in staff perception of the safety climate. Several ED characteristics were associated with a positive climate of safety. *Pediatrics* 2009;124:485–493

Emergency departments (EDs) are especially prone to medical errors.[1,2] In particular, prescribing errors seem to be more frequent among both emergency and pediatric patients,[1,2] which suggests that pediatric EDs might be especially vulnerable. Many medical errors are the result of systems failures.[3,4] ED characteristics such as structure (eg, staffing and bed capacity), process measures (eg, methods of medication prescribing and administration), the culture of staff communication and teamwork, and methods for promoting patient safety all may be associated with staff members' ability to provide safe care.[5,6] Currently, there are few data on pediatric ED characteristics related to patient safety or the perceptions of ED staff members concerning the climate of safety in EDs.

The objectives of this study were (1) to describe ED characteristics thought to be related to patient safety within the 21 hospitals in the Pediatric Emergency Care Applied Research Network (PECARN), (2) to measure staff perceptions of the climate of safety for children in PECARN EDs, and (3) to examine the association between the described ED characteristics and staff perceptions of the climate of safety. We hypothesized that a climate of safety, as perceived by ED staff members, would be associated with the following ED characteristics: the presence of regular safety walk-rounds (quality-focused visits to the ED by senior leaders),[7,8] the presence of a functioning safety committee, formal mechanisms for disseminating results of safety reports to ED staff members, greater staff member/patient ratios, the presence of a sick call back-up plan, the presence of a high-volume back-up plan, the presence of a pharmacist in the ED, the presence of computerized physician order entry, and the existence of clinical guidelines.

METHODS

Setting

The study was performed within PECARN, a federally funded network of hospitals with broad geographic representation and a diversity of hospital types and patient populations. Ten of the 21 hospitals are freestanding children's hospitals, and 19 have a PICU. Detailed descriptions of the PECARN EDs were reported previously.[9–11] The institutional review boards for all participating hospitals and the data center approved the study.

Survey on ED Site Characteristics

The investigators met regularly to develop consensus on ED characteristics thought to be associated with patient safety. A survey instrument was developed to assess structures and processes, including the physical structure of the ED, medical and nursing staffing patterns, ED overcrowding, medication prescribing and administration, staff communication and teamwork, and methods for promoting patient safety.

PECARN investigators (all attending physicians) completed the survey, recording ED characteristics for calendar year 2006. Survey responses were abstracted to an electronic database (SelectSurveyASP Advanced 8.2.1; Atomic Design, Overland Park, KS) by staff members at the central data management and coordinating center at the University of Utah.

Characteristics of the 21 participating EDs are presented. ED treatment spaces are described with mean, minimal, and maximal numbers of beds and treatment spaces per hospital and per 1000 patient visits for the 21 sites overall and according to patient acuity (annual admission rate of $<10\%$, 10%–15%, or $>15\%$). The range of typical shift lengths, the maximal shift length, and the maximal number of hours per week among the 21 EDs are presented according to job category. Staffing data are presented as hours per patient visit overall and according to patient acuity. We tested for associations between clinical hours per patient visit and acuity by using the Jonckheere-Terpstra test for trend.[12,13] Data analyses were performed by using SAS 9.1 (SAS Institute, Cary, NC).

Staff Survey on Climate of Safety

A nationally validated survey on the climate of safety, from the Institute for Healthcare Improvement (Cambridge, MA), was administered to all ED staff members at each institution. ED staff members were defined as individuals whose primary job responsibilities were in the ED, including clinicians (registered nurses, physicians, and technicians), clerical staff members, and other ancillary workers (environmental service workers, child life workers, and social workers) but not including trainees on ED rotations. The survey has 19 questions regarding staff perceptions of the climate of safety each using a 5-point Likert-type scale for responses, in addition to 6 demographic questions about the responder. PECARN site investigators administered surveys anonymously to all ED staff members in the spring of 2007. The survey was available on paper or with an online survey tool (SelectSurveyASP Advanced 8.2.1; Atomic Design).

In accordance with the survey instructions, responses from 7 questions relating to the climate of safety were averaged. This safety climate score was scaled to range from 0 to 100. A score of ≥ 75 was validated previously to indicate a positive safety climate. Two additional measures were calculated for each site, that is, the proportion of staff members with scores of >75 and the proportion responding "agree or strongly agree" to the statement, "I

would feel safe being treated here as a patient."

We evaluated associations between ED characteristics and site safety climate scores. We present differences in mean site safety climate scores between sites grouped according to the presence or absence of each ED characteristic. In calculations of means, site safety climate scores were weighted with the inverse variance of the score, to account for the number of respondents and the variability of the scores.[14] Differences in safety climate scores are also presented according to job type and years of experience overall. Differences in response rates are reported overall and according to job type. Individual 95% confidence intervals are presented for differences in mean safety climate scores.

TABLE 1 ED Characteristics Thought To Be Associated With Patient Safety ($N = 21$)

Characteristic	*n* (%)
Climate of safety	
Patient safety walk-rounds in ED	8 (38)
ED morbidity and mortality conferences	14 (67)
ED patient safety committee	10 (48)
Crowding	
Hallways never used for patient treatment	7 (33)
Rarely wait for inpatient beds	4 (19)
High-volume staffing plan for physicians or registered nurses	14 (67)
Separate treatment area for low-acuity cases	13 (62)
Communication/coordination of care	
Registered nurses and/or physicians working together in formal teams	8 (38)
Electronic patient-tracking system	18 (86)
Bedside rounds at change of shift	5 (24)
ED electronic medical record	14 (67)
Electronic access to previous ED and inpatient visit records	17 (81)
Clinical pathways used	18 (86)
Medication safety	
Computerized physician order entry	8 (38)
Prescriptions typed or computer-generated	11 (52)
Standard concentrations used for infusions	18 (86)
Standing orders not used	3 (14)
Pharmacists in ED	4 (19)

RESULTS

Site Characteristics

For the 2006 calendar year, ED census counts ranged from 12 319 to 91 531 pediatric visits. Admission rates varied greatly (from 5.8% to 22.5%). Table 1 reports site characteristics of the 21 EDs related to patient safety.

Organized Safety Activities

Patient safety walk-rounds were routine in a minority of the EDs and occurred monthly in only 6 EDs (29%). At most sites, safety walk-rounds included hospital leaders and ED staff leaders. Approximately one half ($n = 10$) of the sites had multidisciplinary ED patient safety committees that met at least quarterly. Two thirds of the EDs had formal mechanisms to disseminate patient safety information, usually through staff meetings, newsletters, or e-mail.

Facility (ED/Hospital)

The numbers of ED treatment spaces and rooms, 23-hour ED observation beds, and inpatient pediatric and PICU beds varied greatly across sites (Table 2). A substantial proportion of EDs reported that inpatient bed availability was a problem (most of the year: 33%; during high-volume months: 48%). In addition to care provided in single-patient treatment rooms, the majority of EDs treated patients in hallways (1 in 4 on a daily basis). Few EDs (19%) diverted ambulances away.

ED Staffing

All PECARN EDs have pediatric emergency medicine attending physician coverage, with the majority also using pediatricians (71%) and general emergency physicians (57%). Many EDs use nurse extenders (emergency medical technicians or licensed practical nurses) and physician extenders (nurse practitioners or physician assistants). Table 3 lists the categories of staff members available for the EDs, with their typical shift lengths and maximal hours worked per week.

Most EDs (86%) reported that annual patient visit data were used to budget staffing, but less than one half used standard staffing formulas. On average, attending physicians were staffed at 30 minutes per patient, whereas nursing staffing averaged 80 minutes per patient. Increased registered nurse staffing, but not physician staffing, was associated with higher-acuity hospitals (Table 4). Many of the EDs varied either physician or registered

TABLE 2 Hospital Resources

	N	Total No. Per Hospital			No. Per 1000 Visits		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Pediatric inpatient beds	21	173	9	460	3.72	0.40	8.71
PICU beds	21	27	0	93	0.71	0.00	2.04
ED 23-h beds	8	10	3	20	0.28	0.11	0.80
ED single-patient rooms	21	19	1	60	0.42	0.04	0.84
ED treatment spaces	21	26	7	63	0.65	0.33	1.39
Admission rate of <10%	7	17	9	28	0.71	0.33	1.39
Admission rate of 10%–15%	9	32	18	51	0.60	0.37	1.14
Admission rate of >15%	5	28	7	63	0.66	0.57	0.83

TABLE 3 Shift Lengths and Time Worked per Week According to Job Category

Job Category	*N*	Typical Shift Length, Range, h	Maximal Shift Length, h	Maximal Time Per Week, h
Attending physicians	21	7–12	14	56
Pediatric emergency medicine fellows	16	6–10	12	80
Physician residents	21	8–12	13	80
Nurse practitioners and physician assistants	14	8–12	14	50
Registered nurses	21	8–12	18	96
Emergency medical technicians, paramedics, and licensed practical nurses	11	8–12	18	60
Social workers	15	7.5–12	12	80
Child life staff members	11	7.5–12	12	55
Respiratory therapists	12	7.5–12	16	72
Radiology technicians	10	8–12	16	80
Clerical/registration staff members	21	4–12	18	80
Environmental services staff members	18	7.5–12	16	60

nurse staffing according to season (67%), day of the week (76%), or patient volume (86%), whereas approximately two thirds (67%) had a sick call back-up system in place. A shortage of nurses on a shift often was handled through reassignment of patients (95%), use of float nurses (81%), salaried overtime (71%), and mandatory overtime (38%).

Medication Issues

Computerized physician order entry, which was available in several EDs (38%), is capable of providing dose calculations, dose information, weight checks (outside the 5th and 95th percentiles), and allergy alerts. Approximately one half of the EDs used computer-generated prescriptions. Most EDs (86%) had delegated protocols for medication orders and used standard concentrations for drug infusions. Most ED medications were prepared by nurses (range: 25%–100%), whereas pharmacists prepared one fourth (range: 0%–75%). Most EDs (90%) had protocols requiring that medication orders be double-checked before administration.

Information Systems

Most EDs had electronic patient-tracking systems (86%) and had portions of their visits recorded electronically (67%). Nursing documentation was more frequently electronic (79%), compared with physician documentation (29%). Almost all EDs had electronic access to information on previous ED visits (90%) and inpatient hospitalizations (90%), whereas few (19%) had full access to information on office or subspecialty visits within their institutions. Results of laboratory tests and official radiology readings from the current ED visit were transmitted electronically to ED tracking systems in >75% of sites. One half of EDs could view digital images of radiographs and computed tomographic scans electronically.

TABLE 4 ED Staffing

	Time Per Patient Visit, Mean ± SD, h			
	Attending Physician	Registered Nurse	Other Clinical	Total
Overall ($n = 21$)	0.48 ± 0.2	1.31 ± 0.4	1.21 ± 0.5	3.00 ± 0.8
Admission rate of <10% ($n = 7$)	0.56 ± 0.2	1.15 ± 0.4	1.13 ± 0.6	2.84 ± 0.7
Admission rate of 10%–15% ($n = 9$)	0.37 ± 0.1	1.24 ± 0.3	1.00 ± 0.2	2.60 ± 0.4
Admission rate of >15% ($n = 5$)	0.57 ± 0.1	1.66 ± 0.3	1.69 ± 0.5	3.92 ± 0.8
P[a]	.8707	.0471	.0553	.1531

[a] Jonckheere-Terpstra test for ordered differences among classes.

Coordination of Care

Fewer than one half of EDs had organized their physicians or nurses into formal clinical care teams (38%) or conducted formal bedside rounds at shift changes (24%). Most EDs (86%) used clinical guidelines, typically having 4 or 5 available (range: 0–33 guidelines).

ED Staff Perceptions of the Patient Safety Climate

ED staff response rates for the safety climate survey varied from 24% to 97% among the 21 EDs, with an overall response rate of 49% (1747 of 3574 surveys). Response rates were higher, on average, for physicians than for nurses (55% vs 46% [95% confidence interval for difference: 5%–14%]).

Hospital safety climate scores ranged from 59.1 to 84.4, with a mean of 76.0 and little variation (quartile 1: 73.4; quartile 2: 74.8; quartile 3: 80.3). There was general agreement with the statement, "I would feel safe being treated here as a patient" (range: 64%–95%). The proportions of respondents reporting positive safety climate scores of ≥75 ranged from 28% to 82% (Fig 1).

On average, physicians' ratings of the climate of safety were higher than nurses' ratings. Perceptions of safety varied with work experience; nurses and physicians with <3 years of experience reported higher safety climate scores than did those with more experience. Three ED characteristics were associated with positive ED staff safety climate scores, namely, a lack of ED overcrowding (ie, limited use of hallways for patient care), a sick call back-up plan for physicians, and the presence of an ED safety committee (Table 5).

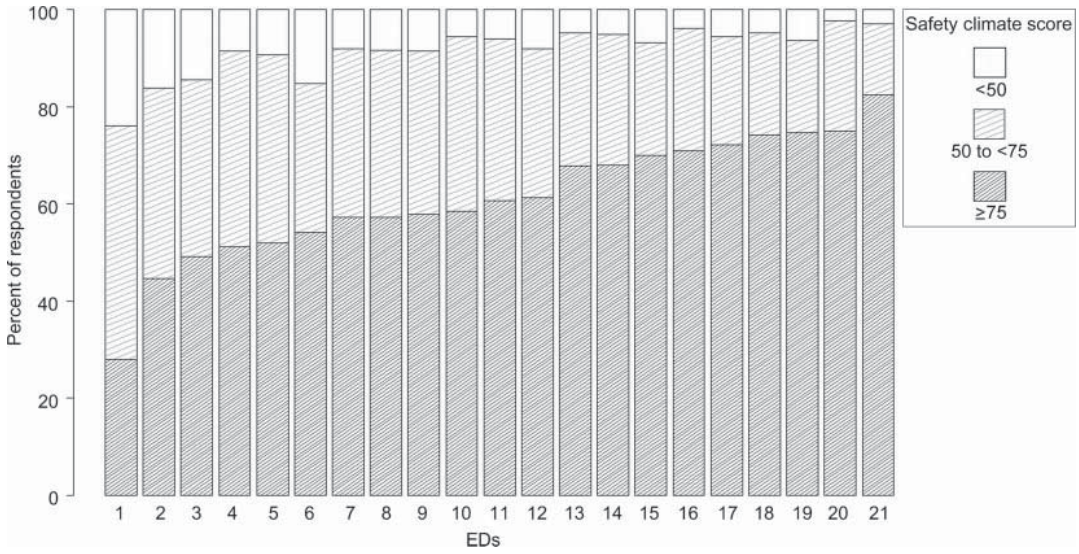

FIGURE 1
Proportions of respondents in 21 EDs reporting a positive safety climate. Safety climate scores of >75 indicate a positive safety climate.

DISCUSSION

This is the first report from a cohort of pediatric EDs regarding staff perceptions of the climate of safety and detailed descriptions of ED characteristics intended to minimize medical errors. Emergency medicine practitioners recognize that children are at special risk for medical errors, and they have recommended strategies to minimize this risk.[5,6] We report major variations among EDs in processes and structures available to minimize the risk of medical errors and in staff perceptions of the safety climate. Staff members' perceptions and attitudes toward safety in their work environment may affect job attitudes and performance.[15] We were able to identify several ED characteristics that were associated with positive staff perceptions of safety, that is, a lack of ED overcrowding (ie, limited use of hallways for patient care), a sick call back-up plan for physicians, and the presence of an ED safety committee.

Safety climate surveys measure staff members' perceptions of whether safety is valued and safe practices are endorsed and widely followed in the clinical environment. Lessons from the aviation industry indicate that a poor climate of safety can have a direct impact on crew performance and the safety of the environment.[16] A study of 2 ICUs found that safety climate score improvements were associated with improvements in medication error rates, lengths of stay, and nursing turnover rates.[17]

Safety climate surveys reflect the influence of management on safety.[18,19] This is consistent with our finding that the presence of an ED safety committee was associated with higher staff safety climate scores. An ED safety committee demonstrates leaders' commitment to providing a safe environment. Similarly, having a sick call back-up

TABLE 5 Site Safety Climate Scores According to ED and Respondent Characteristics

	Site Safety Climate Score, Mean		
	Site Characteristic		Difference (95% Confidence Interval)
	Present	Absent	
ED characteristics ($N = 21$)			
Safety walk-rounds more than quarterly	77.3	76.2	1.1 (−3.1 to 5.2)
Presence of safety committee	79.0	74.8	4.2 (0.6–7.9)
Sick-call system for physician staffing	78.6	74.8	3.8 (0.1–7.5)
Sick-call system for registered nurse staffing	77.4	76.1	1.3 (−2.8 to 5.4)
High-volume system for physician staffing	77.5	75.9	1.6 (−2.4 to 5.7)
High-volume system for registered nurse staffing	77.6	75.5	2.2 (−1.9 to 6.2)
<20% of medications prepared by pharmacists	76.4	77.5	−1.2 (−5.8 to 3.4)
Presence of computerized physician order entry system	77.2	76.1	1.1 (−3.0 to 5.3)
Presence of >5 clinical pathways	78.0	75.1	2.9 (−1.1 to 6.8)
No time spent on diversion	77.2	74.1	3.1 (−2.5 to 8.7)
Limited use of hallways	78.4	74.5	3.9 (0.2–7.6)
<50 000 annual visits	75.4	78.5	−3.1 (−7.0 to 0.8)
Freestanding children's hospital ED vs separate pediatric ED in general hospital	78.4	75.1	3.2 (−0.6 to 7.1)
Respondent characteristics ($N = 1638$)			
Physician (vs nurse) ($n = 1011$)	78.0	74.8	3.2 (1.0–5.4)
<3 y of clinical work experience ($n = 1005$)	78.8	75.2	3.6 (1.3–6.0)
Nurse ($n = 522$)	77.5	73.6	4.0 (0.5–7.4)
Physician ($n = 483$)	80.1	76.9	3.2 (0.0–6.5)

Mean site safety climate scores were weighted according to the inverse variance of the site safety climate scores.

plan to maintain adequate physician staffing levels represents a commitment to patient care and was associated with higher safety climate scores. Implementation of a back-up plan for the ED staff that can be used during high-volume periods and times of sickness has been associated with increased staff satisfaction.[20] Patient safety walk-rounds, which were reported to be an effective means of communicating with front-line staff members regarding the importance of patient safety,[7,8] were uncommon in this sample and were not found to be associated with safety climate scores. Active vigilance of front-line staff members regarding potential mishaps is essential for developing an organization with high reliability.[21]

ED crowding occurs when the demand for emergency services exceeds available resources,[22] and it is a critical national problem.[23] Crowding is associated with treatment delays, increases in the numbers of patients who leave without treatment and ambulance diversions, and poor patient and staff member satisfaction.[22] More importantly, overcrowding is associated with medical errors, predominantly errors of omission.[24,25] According to the Joint Commission, 50% of all sentinel events that lead to patient injury or death occur in EDs; nearly one third of these are related to overcrowding.[26] Our results suggest that PECARN EDs are not without overcrowding. Most EDs treated patients in hallways and reported delays in obtaining inpatient admission beds, and there was great variability in resources and staffing. Staff members in EDs in which hallways were not used for routine care (less crowded) reported a greater climate of safety.

Fatigue is associated with reduced performance, clumsiness, changes in mood, errors, and patient harm.[27] In our survey, shift lengths of 12 hours were typical, but certain staff members, such as nurses and physicians in training, worked up to 96 hours and 80 hours per week, respectively. Health care worker fatigue is a latent condition associated with patient safety and medical errors.[28,29] Resident physician schedules allowing for shorter shifts and more rest can reduce significantly the rates of serious diagnostic and medication errors in an acute care setting.[29] We did not find an association between maximal allowable work hours and safety climate scores.

Children are at substantial risk for medication errors because of the need for weight-based dosing.[30] Sicker children are more likely to be subjects of medication errors.[31] Trainees make more medication errors then nontrainees in pediatric emergency medicine.[31,32] PECARN EDs have many trainees and high-acuity cases, which places them at risk for medication errors. Computerized physician order entry systems with decision support reduce some medication-ordering errors,[33,34] but they do not eliminate errors.[35,36] At present, few PECARN EDs have computerized physician order entry systems in place. On-site pharmacists can reduce medication errors by using independent verification.[37] In our sample, pharmacists prepared only one fourth of medications, although most described processes for double-checking medications before administration. Our study did not evaluate how double-checking was performed or its reliability. Handwriting legibility is still a potential source of error,[38] because only one half of the EDs used typed or computer-generated prescriptions.

Although this study is an important first step in describing the environment and culture of safety in pediatric EDs, PECARN includes only 21 sites, and the power to detect smaller associations between ED environmental factors and staff perceptions of safety was limited. The sample size also precluded multifactorial analyses to look for associations or confounding between the studied ED characteristics. Because of the relatively small variation across sites in mean safety climate scores, statistical differences in perceptions of safety and ED characteristics should be interpreted as associations to be examined further in the clinical setting. Despite the diversity of PECARN, the network is not representative of most hospital EDs where children seek care; therefore, our findings might be different from those for nonpediatric ED settings. Also, our case mixture was sicker than nationally representative samples such as that in the National Hospital Ambulatory Medical Care Survey.[39] Therefore, these EDs are particularly at risk for errors, because medication errors are more common with sicker children.[31]

Survey data were limited by reliance on self-reports, which puts our results at risk for bias from nonresponders. To account for the number of respondents and the variability of the scores, the site safety climate scores were weighted in the analysis. In addition, although there was full compliance with completion of the ED site survey, these self-reported data have not been verified.

The safety climate is a malleable construct, is receptive to targeted interventions, and can be tracked over time.[40] This may explain why nurses and physicians with less clinical experience had higher safety climate scores. It is likely that new clinicians have not witnessed major medical errors, whereas more-experienced practitioners might have witnessed patient harm resulting from such errors. Alternatively, older clinicians may perceive patient safety practices and technology as being less helpful than their younger colleagues. In

developing high-reliability organizations that focus on patient safety,[21] time and energy should be devoted to teaching inexperienced clinicians about system failures and patient harm, as well as preventative safety practices. With study of the safety climate and the associated structures and processes, future targeted interventions can be assessed for their impact on the safety climate. Improvements in the health care safety climate are associated with improvements in measurable medication error rates, patient lengths of stay, and nursing turnover.[17]

We and others[41] have primarily focused on structure, that is, static characteristics of the individuals who provide care and the settings in which care is delivered. It is assumed that well-qualified people working in well-appointed and well-organized settings provide high-quality care. However, good structure is necessary but not sufficient to ensure high quality.[41,42] As we develop outcome measures for quality of care in pediatric emergency medicine, we will need to explore whether these structural measures correlate with processes and, most importantly, with patient outcomes.

CONCLUSIONS

There is large variability among EDs in structures and processes thought to be associated with decreased risk for medical errors. There is also a wide range (28%–82%) in the proportions of staff members reporting a positive ED safety climate. The ED characteristics associated with a positive safety climate score include a lack of ED overcrowding (ie, limited use of hallways for patient care), a sick call back-up plan for physicians, and the presence of an ED safety committee.

ACKNOWLEDGMENTS

The PECARN is supported by cooperative agreements U03MC00001, U03MC00003, U03MC00006, U03MC00007, and U03MC00008 from the Emergency Medical Services for Children program of the Maternal and Child Health Bureau, Health Resources and Services Administration.

Participating centers and site investigators are as follows (in alphabetical order): Bellevue Hospital Center (M. Tunik), Children's Hospital Boston (L. Nigrovic), Children's Hospital of Buffalo (K. Lillis), Children's Hospital of Michigan (P. Mahajan), Children's Hospital of New York-Presbyterian (A. Kharbanda), Children's Hospital of Philadelphia (K. Shaw), Children's Memorial Hospital (E. Powell), Children's National Medical Center (J. Chamberlain), Cincinnati Children's Hospital Medical Center (R. Ruddy), DeVos Children's Hospital (J. Hoyle), Holy Cross Hospital (A. Foerster), Howard County Medical Center (D. Monroe), Hurley Medical Center (D. Borgialli), Jacobi Medical Center (Y. Atherly-John), Medical College of Wisconsin/Children's Hospital of Wisconsin (M. Gorelick), University of California, Davis, Medical Center (E. Andrada), University of Michigan (R. Stanley), University of Rochester (G. Conners), University of Utah/Primary Children's Medical Center (C. Pruitt), Washington University/St Louis Children's Hospital (D. Jaffe), and University of Maryland (R. Lichenstein); PECARN Steering Committee: N. Kuppermann (chair), E. Alpern, J. Anders, D. Borgialli, J. Chamberlain, L. Cimpello, E. Crain, P. Dayan, J. M. Dean, M. Gorelick, J. Hoyle, D. Jaffe, R. Lichenstein, K. Lillis, P. Mahajan, D. Monroe, L. Nigrovic, E. Powell, R. Ruddy, R. Stanley, and M. Tunik; Maternal and Child Health Bureau/Emergency Medical Services for Children liaisons: D. Kavanaugh and H. Park; Central Data Management and Coordinating Center: A. Davis, J. M. Dean, A. Edwards, H. Gramse, R. Holubkov, A. Donaldson, C. Olson, and S. Zuspan; Feasibility and Budget Subcommittee: K. Brown and S. Goldfarb (co-chairs), E. Kim, S. Krug, D. Monroe, D. Nelson, H. Rincon, and S. Zuspan; Grants and Publications Subcommittee: M. Gorelick (chair), D. Borgialli, L. Cimpello, A. Donaldson, G. Foltin, F. Moler, and K. Shreve; Protocol Review and Development Subcommittee: D. Jaffe (chair), L. Alpern, J. Chamberlain, P. Dayan, J. M. Dean, R. Holubkov, L. Nigrovic, E. Powell, R. Stanley, and M. Tunik; Quality Assurance Subcommittee: K. Lillis (chair), E. Alessandrini, E. Crain, R. Enriquez, M. Fjelstad, R. Lichenstein, P. Mahajan, R. McDuffie, R. Ruddy, J. Wade, and A. Walker; Safety and Regulatory Affairs Subcommittee: W. Schalick and J. Hoyle (co-chairs), S. Atabaki, K. Call, A. Foerster, H. Gramse, A. Jones, M. Kwok, R. Maio, and M. Pusic.

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Pediatrics 2009;124;485-493; originally published online Jul 27, 2009;
DOI: 10.1542/peds.2008-2858