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ORIGINAL RESEARCH

Pediatrics

The hospital costs of high emergency department pediatric readiness

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Abstract

Objective: We estimate annual hospital expenditures to achieve high emergency department (ED) pediatric readiness (HPR), that is, weighted Pediatric Readiness Score (wPRS) ≥ 88 (0–100 scale) across EDs with different pediatric volumes of children, overall and after accounting for current levels of readiness.

Methods: We calculated the annual hospital costs of HPR based on two components: (1) ED pediatric equipment and supplies and (2) labor costs required for a Pediatric Emergency Care Coordinator (PECC) to perform pediatric readiness tasks. Data sources to generate labor cost estimates included: 2021 national salary information from U.S. Bureau of Labor Statistics, detailed patient and readiness data from 983 EDs in 11 states, the 2021 National Pediatric Readiness Project assessment; a national

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PECC survey; and a regional PECC survey. Data sources for equipment and supply costs included: purchasing costs from seven healthcare organizations and equipment usage per ED pediatric volume. We excluded costs of day-to-day ED operations (ie, direct clinical care and routine ED supplies).

Results: The total annual hospital costs for HPR ranged from $77,712 (95% CI 54,719–100,694) for low volume EDs to $279,134 (95% CI 196,487–362,179) for very high volume EDs; equipment costs accounted for 0.9–5.0% of expenses. The total annual cost-per-patient ranged from $3/child (95% CI 2–4/child) to $222/child (95% CI 156–288/child). After accounting for current readiness levels, the cost to reach HPR ranged from $23,775 among low volume EDs to $145,521 among high volume EDs, with costs per patient of $4/child to $48/child.

Conclusions: Annual hospital costs for HPR are modest, particularly when considered per child.

KEYWORDS
children, costs, emergency, equipment, mortality, personnel, readiness

1 | INTRODUCTION

1.1 | Background

The National Pediatric Readiness Project (NPRP) is focused on improving the quality of emergency care for all children in the United States.[1] A recent study, involving 983 emergency departments (EDs) demonstrated an association between high ED pediatric readiness (HPR) (i.e., a weighted Pediatric Readiness Score [wPRS] ≥ 88 using a 0–100 scale) and improved short- and long-term survival in children.[2] Previous studies on critically ill and injured children demonstrated similar results.[3–5] Yet only 20.2% (720out of 3557) of EDs have HPR.[6] Top barriers to pediatric readiness include cost of training and maintaining personnel, most critically a Pediatric Emergency Care Coordinator (PECC).[7] PECCs are physicians and nurses who oversee administrative aspects of pediatric readiness and are associated with HPR[7–10] and lower mortality rates than expected based on degree of injury and other patient demographic factors.[11]

1.2 | Importance

HPR is associated with improved pediatric survival; yet, data regarding the costs of HPR are limited.[12] Estimating the cost of HPR is critical given financial pressures in healthcare.[13]

1.3 | Goals of this investigation

In this study, we estimate the overall hospital costs required for HPR, and hospital costs after accounting for current levels of readiness. We provide practical information for hospital administrators and others involved in hospital budgets to improve pediatric emergency care.

2 | METHODS

2.1 | Study design

We estimate the total costs of HPR, stratified by ED annual pediatric volume. Total costs included PECC time (based on time spent on coordination, quality improvement [QI], patient safety, and policies, as derived from the two PECC surveys) and ED equipment and supply costs. We excluded labor costs for clinical duties that are part of baseline ED operations. We also quantified the cost of reaching HPR from current levels of ED readiness, representing the cost gap. The study protocol was reviewed and approved by Institutional Review Boards at Oregon Health & Science University and the University of Utah School of Medicine.

2.2 | Setting and measurements

In addition to national data sources, we estimated the amount of time required for PECC activities, based on responses from a national survey of PECCs[14] and a regional survey of PECCs in Los Angeles County.[15]

2.2.1 | Pediatric readiness

The hospital cost of HPR was based on results from the 2021 NPRP assessment: a 92-question survey of U.S. EDs providing emergency care 24 h per day, 7 days per week.[6–8] ED pediatric readiness, measured by the wPRS, is a weighted score from 0 to 100 based on the NPRP assessment.[16] The relationship between wPRS and mortality in children has been established.[2,4,5,7,17] Thus, we defined HPR as wPRS ≥ 88,that is, the threshold necessary for improved survival.[2]

We defined lower levels of ED pediatric readiness based on quartiles of wPRS from the 2021 NPRP assessment.[6] To provide detailed cost estimates across a broad range of ED volumes, we used previously collected data on ED pediatric readiness (from the 2013 NPRP assessment) and annual ED pediatric volume for 983 EDs in 11 states.[2]

2.2.2 | National PECC survey

The national survey[14] (September 2021 to March 2022) included 114 PECCs across the United States participating in the EMS for Children (EMSC) PECC Workforce Development Collaborative[18] and PECC Trauma Improvement Sprint.[19] Participants self-identified as PECCs represented EDs from 49 states with a median wPRS = 92. Questions included PECC characteristics, hours spent on PECC activities, shared versus nonshared PECC role, and ED annual pediatric volume.[14] To estimate the time the PECC spent on readiness, we used answers from the following question in the survey: *"How many hours per week do you spend on pediatric champion/PECC responsibilities and tasks?"*[14] We converted monthly PECC hours to percentage effort (ie, the percentage of a full-time equivalent) based on a 40-h workweek for PECCs, stratified by standardized annual ED pediatric volume categories (described below). The type of clinicians serving as PECCs were stratified by physician versus nonphysicians.

2.2.3 | Regional PECC survey

We conducted a separate survey of 82 PECCs in 37 EDs in Los Angeles County (median wPRS = 92) to obtain domain-specific data on PECC time. EDs in Los Angeles County have verified HPR, and have two PECCs (a nurse and a physician) to oversee pediatric readiness activities.[20] We used four questions to estimate personnel time required for the PECC role. Each of these questions began, "*How many hours per month do you spend on…*" and focused on QI, patient safety, policies and procedures, and general PECC activities (supplemental on-line material). To quantify the total hours per month spent on ED pediatric readiness, we summed time estimates across the four questions. We converted monthly PECC hours to percentage effort based on a 40-h workweek. As with the national PECC survey, we stratified the results by physician versus nonphysician PECCs and by standardized ED volume categories. Of the 82 respondents, 61 (74%) included the necessary information on annual ED pediatric volume to be included in the analysis.

2.2.4 | Salary information

To convert percentage effort into hospital costs for physician and nonphysician PECCs, we used average national salaries and corresponding measures of variability for the most recent year (2021) of the U.S. Bureau of Labor Statistics Occupational Employment and Wages for hospital-based registered nurses,[21] hospital-based nurse practitioners (NPs),[22] and emergency physicians.[23] To calculate the fringe rate for nurses, we used the U.S. Bureau of Labor Statistics Employer Costs for Employee Compensation for civilian workers (registered nurse occupations) and for NPs, we used data from the U.S. Bureau of Labor Statistics industry group "healthcare"[24] (data specific to NPs was not available). For physicians, we obtained fringe rates from 11 academic and academic-affiliated hospitals across the United States. Based on the national PECC survey,[14] nonphysician PECCs included 97.7% nurses and 2.3% NPs, so we applied these proportions to the national salary estimates to generate the composite salary estimate for nonphysician PECCs. We multiplied the full-time salary estimates (including fringe benefits) by their respective percentage effort estimates for physician and nonphysician PECCs, stratified by the ED volume categories, to generate total annual hospital costs for ED readiness activities performed by PECCs.

The Bottom Line

This study estimated the annual hospital expenditures to achieve high emergency department pediatric readiness (HPR) scores across departments with different pediatric volumes of children. After accounting for current readiness levels, the cost to reach HPR ranged from $23,775 among low volume EDs to $145,521 among high volume EDs, with costs per patient of $4/child to $48/child. These are the first estimated costs to achieve high HPR scores, which are associated with improved pediatric survival in emergency departments.

2.2.5 | Equipment costs

For the ED readiness domain of equipment and supplies, we estimated annual costs by averaging the purchasing cost of each item listed in the 2021 NPRP assessment across seven healthcare organizations (four U.S. children's hospitals, two regional EMS agencies, and one national medical supplier) and calculated the annual frequency of ED use. We averaged the cost of each item after excluding outlier values and assumed that costs related to tracking, purchasing, and stocking equipment were part of baseline ED operating expenses. Equipment items stocked by ≥90% of low-readiness EDs (below the median wPRS) in the 2013 *and* 2021 NPRP assessments were considered part of baseline ED operating expenses and therefore excluded from cost estimates. Of the 43 pieces of equipment included in the 2021 NPRP assessment,[6] 30 items were routinely stocked in EDs based on the above definition. We included the other 13 items (Table S1) in the cost evaluation.

To quantify the volume of ED equipment purchased each year, we obtained detailed annual purchase data from one children's hospital ED (annual ED volume 17,400 children/year). Using the annual ED purchase volume for each item and pediatric patient volume, we created a

multiplier ratio for each piece of equipment (the volume of equipment purchased per annual ED pediatric volume). We calculated the average number of items purchased per year for each ED volume category. The total annual number of items purchased (minimum of one per year) was multiplied by the average cost per item and summed to yield the total equipment and supply costs for EDs in each volume category.

We assumed that all equipment were replaced annually at the calculated usage rate, including items that may be retained over a year (e.g., laryngoscopes). Although low volume EDs may not need to replace all equipment annually, this assumption minimized underestimates of equipment costs. We did not account for special purchasing agreements or discounts.

2.2.6 | Pediatric volume

To provide representative estimates for ED pediatric readiness by ED pediatric volume, we used previously collected data from 983 EDs in 11 states[2] and defined five ED volume categories: <1800, 1800–4999, 5000–9999, 10,000–24,999, and ≥25,000 children per year. While the 2021 NPRP national assessment included four volume categories (the highest category was ≥10,000 patients/year[6,14]), we created a fifth category because ≥10,000 children/year includes a wide range of ED volumes with major differences in personnel time and equipment costs. Among the 983 EDs, the 95th percentile for ED pediatric volume was 24,118 children/year. Based on this information, we defined "super high-volume" EDs as ≥25,000 children/year.

2.3 | Outcomes

The primary outcome was total annual hospital costs of HPR, stratified by the five pediatric ED volume categories. We adjusted all costs to 2022 U.S. dollars using national data from the Bureau of Economic Analysis.[25] We also calculated the costs required to reach HPR from current levels of readiness (based on the 2021 NPRP assessment), representing the cost gap.

2.4 | Data analysis

We used descriptive statistics to characterize hospital costs related to ED pediatric readiness, stratified by the annual ED pediatric volume categories. The hospital was the unit of analysis. We used median and interquartile range (IQR) to describe the percentage effort among physician and nonphysician PECCs (from the national and regional surveys), stratified by ED volume. We then used a consensus approach across the investigative team (including three national experts on ED pediatric readiness) to determine the final estimates for PECC percentage effort within the calculated IQRs. The investigative team reviewed survey results and independently responded to initial calculations for each percentage effort as appropriate, low, or high. The results were discussed in conjunction with PECC responses of adequacy of percentage effort. The PECC percentage effort categories were re-rated by the investigative team and adjusted within the initial IQR bounds based on final consensus. Face validity was confirmed by steady increases in consensus-based PECC percentage effort estimates across ED volume categories. We translated the final percentage effort estimates into costs using the average national salary data for physicians and nonphysician PECCs, and then combined these values to generate total personnel labor costs. We combined personnel costs and equipment costs to yield the total annual cost of ED pediatric readiness within each volume category. We also calculated the total annual cost-per-child for each volume category to represent the relationship between the hospital cost of pediatric readiness and annual ED pediatric volume.

We estimated the variability in costs for each ED volume category using a combination of statistics based on available data. Using the PECC survey data, we calculated the IQR around each percentage effort to characterize the variability in personnel time. We calculated 95% confidence intervals for annual salaries for physician and nonphysician PECCs using a standard deviation derived from state-by-state mean wage data for emergency physicians and registered nurses from the U.S. Bureau of Labor Statistics Occupational Employment and Wages.[21,23] For each volume category and type of PECC, we calculated the mean and 95% CI salary cost by multiplying salary estimates by the percentage effort. For equipment costs, we based the CIs on the 95% lower and upper observed bounds of equipment utilized within each ED volume category. Finally, we estimated conservative 95% upper and lower CI bounds for total annual costs by summing the bounds for both personnel and equipment costs.

We estimated the cost gap of reaching HPR from current levels of ED readiness (hospitals with wPRS < 88) by ED volume category. To generate the cost gap for labor, we totaled the weighted scores for the four labor-based domains in the 2021 NPRP assessment[6] (administration/coordination, QI, patient safety, and policies/procedures) for each volume and ED readiness category. We divided the resulting total weighted score for EDs in each category by the maximum possible weighted score to yield the percent current ED readiness. The difference between the percent of current ED readiness and 100% represented the labor gap to reach HPR, which we then multiplied by the previously calculated average personnel cost for HPR in each volume category. This process allowed us to estimate the gap in labor specific to ED pediatric readiness from current levels of readiness to the level associated with improved survival. We calculated the cost gap for equipment as previously detailed, adjusted for ED volume. A sample calculation is included in the on-line appendix.

To visualize the relationship between ED pediatric volume and the costs of HPR, we categorized the 983 EDs into volume groups defined by intervals of 500 patients (ie, 0–500, 501–1000, 1001–1500, etc. children per year). Equipment costs for each volume group were based on the average annual ED pediatric volume within each group. We based the cost of PECC time for each group as a linear increase in labor costs between estimates previously calculated for the five ED volume categories.

TABLE 1 Component and total annual hospital costs of emergency departments with high pediatric readiness by ED pediatric volume.*

	ED volume range	<1800 children/year		1800–4999 children/year		5000–9999 children/year		10,000–24,999 children/year		≥25,000 children/year	
	Mean ED peds volume (95% CI)	1107 (1042–1172)		3240 (3134–3346)		7033 (6852–7214)		15,155 (14,638–15,672)		40,977 (35,384–46,120)	
	Volume based on # EDs[a]	$n = 176$		$n = 304$		$n = 240$		$n = 217$		$n = 46$	
Personnel	PECC[b] type	Nonphysician	Physician	Nonphysician	Physician	Nonphysician	Physician	Nonphysician	Physician	Nonphysician	Physician
	PECC % FTE (IQR)[c]	25% (5–32%)	10% (4–10%)	30% (6–30%)	15% (9–16%)	50% (10–75%)	20% (8–25%)	60% (30–100%)	25% (10–25%)	100% (75–100%)	30% (25–40%)
	Hours/week[d]	10	4	12	6	20	8	24	10	40	12
	Salary cost[e] for % FTE	$34,253	$42,725	$41,103	$64,088	$68,505	$85,451	$82,207	$106,814	$137,011	$128,176
	Combined salary cost (95% CI)	$76,978 ($54,010–99,955)		$105,191 ($74,364–136,029)		$153,956 ($108,020–199,909)		$189,020 ($132,808–245,252)		$265,187 ($184,201–346,206)	
	Equipment and supply costs[f] (95% CI)	$734 ($708–739)		$1414 ($1384–1452)		$2637 ($2594–2691)		$5261 ($5096–5420)		$13,947 ($12,286–15,972)	
	Total annual costs (95% CI)	$77,712 ($54,719–100,694)		$106,605 ($75,747–137,481)		$156,593 ($110,614–202,600)		$194,281 ($137,904–250,672)		$279,134 ($196,487–362,179)	

*These costs do not account for current levels of ED pediatric readiness, so represent total hospital expenditures required.

[a]The number of EDs in each volume category comes from a sample of 983 EDs in 11 states with detailed annual ED pediatric volume data over 6 years (2012–2017).

[b]PECC, Pediatric Emergency Care Coordinator.

[c]% FTE, percentage effort or percent of full-time equivalent; IQR, interquartile range; 95% CI, 95% confidence interval.

[d]PECC %FTE estimates were based on median values from a national survey and regional survey of pediatric emergency care coordinators, with final estimates determined by national experts on ED pediatric readiness. The IQR was determined by combining responses from the two surveys, providing IQRs that encompassed regional and national variation. Hours per week calculated based on a 40-h workweek.

[e]Salary estimates for nonphysician (nurses and nurse practitioners) and physician (emergency physicians) PECCs were generated by multiplying the % FTE for each category by the average national salaries from the U.S. Bureau of Labor Statistics Occupational Employment and Wages for hospital-based registered nurses,[21] hospital-based nurse practitioners,[22] and emergency physicians,[23] in 2022 U.S. dollars.

[f]Supply costs were generated from the cost of individual supplies and equipment required for ED pediatric readiness, averaged across seven healthcare organizations and multiplied by an annual per-unit volume per ED volume ratio.

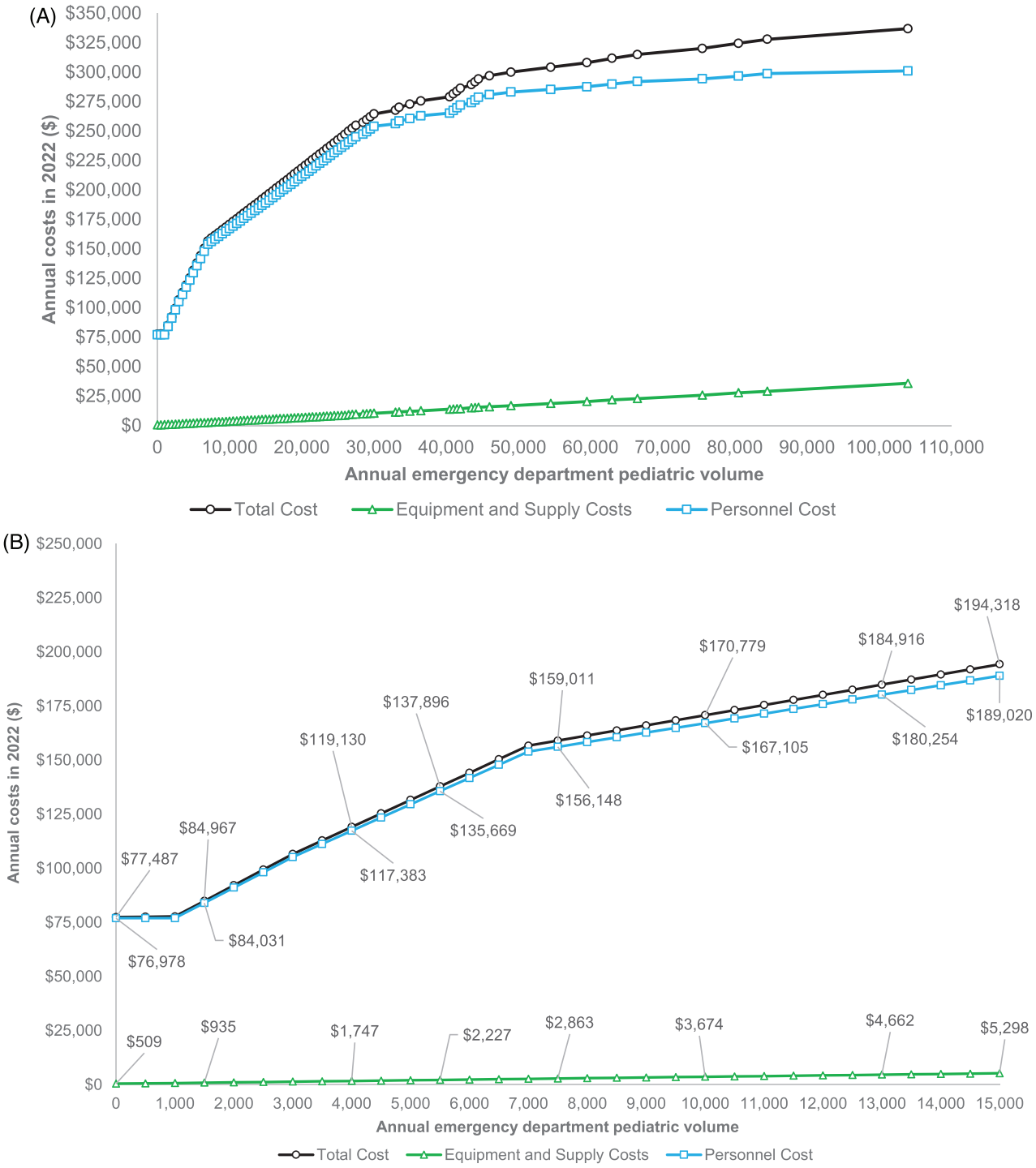

FIGURE 1 Components and total annual hospital costs of emergency departments (EDs) with high pediatric readiness by ED pediatric volume. (A) Hospital costs across all ED pediatric volumes. (B) Hospital costs for ED pediatric volumes up to 15,000 children per year (truncated *x*-axis). *846 of 983 (86.1%) of emergency departments (EDs) in this sample saw ≤15,000 children per year.

3 | RESULTS

Table 1 shows the total costs required for HPR in each of the five ED volume categories, including average PECC percentage effort, PECC hours/week, and costs for equipment and supplies. The percentage effort for nonphysician PECCs ranged from 25% in the lowest ED volume category to 100% in the highest volume category. For physician PECCs, the range of percentage effort was 10–30%. The annual total cost for HPR ranged from $77,712 (95% CI 54,719–100,694) among EDs with 1800 children/year to $279,134 (95% CI 196,487–362,179) among EDs with ≥25,000 children/year. Higher pediatric volumes necessitated higher percent effort by PECCs and thus higher

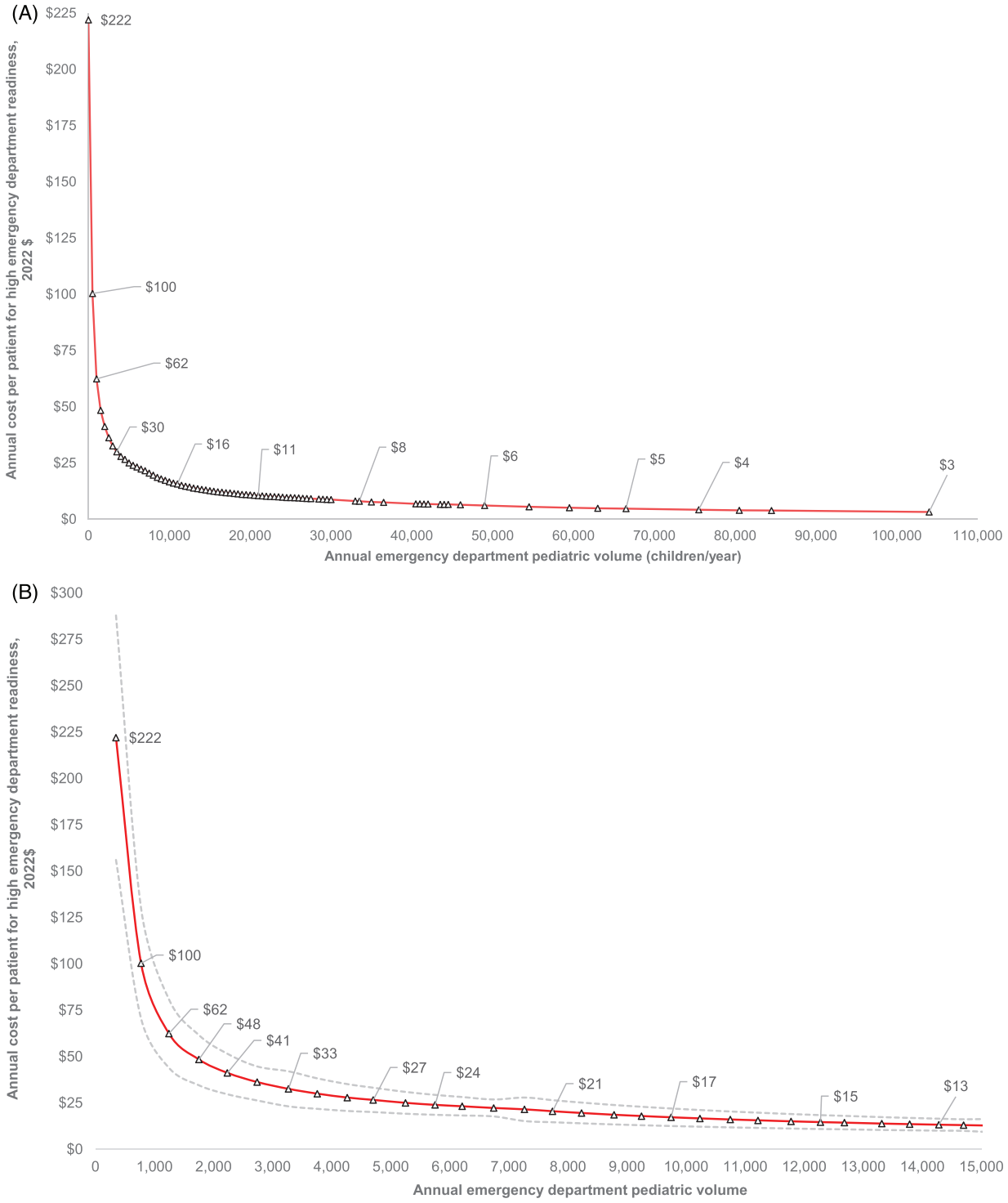

FIGURE 2 Annual total hospital cost of emergency departments (EDs) with high pediatric readiness per patient, by ED volume. (A) Annual total hospital cost per patient across all ED pediatric volumes. (B) Annual hospital cost per patient for ED pediatric volumes up to 15,000 children per year (truncated *x*-axis). *846 of 983 (86.1%) of emergency departments (EDs) in this sample saw ≤15,000 children per year. The dotted lines in panel B represent the 95% confidence interval.

labor costs. The total annual cost of HPR across a range of ED volumes is shown in Figures 1A and B. Equipment and supply costs represented 0.9–5% of total ED readiness costs across all volume categories.

The cost-per-patient for HPR decreased exponentially with increasing pediatric volume (Figures 2A and B). The cost-per-patient ranged from $222 per child (95% CI 156–288) for an ED volume of 349 children per year to $3 per child (95% CI 2–4) for an ED volume of 104,437 children per year. Figure 2B shows the cost-per-patient among EDs with volumes under 15,000 children per year, representing 86% of all EDs sampled.

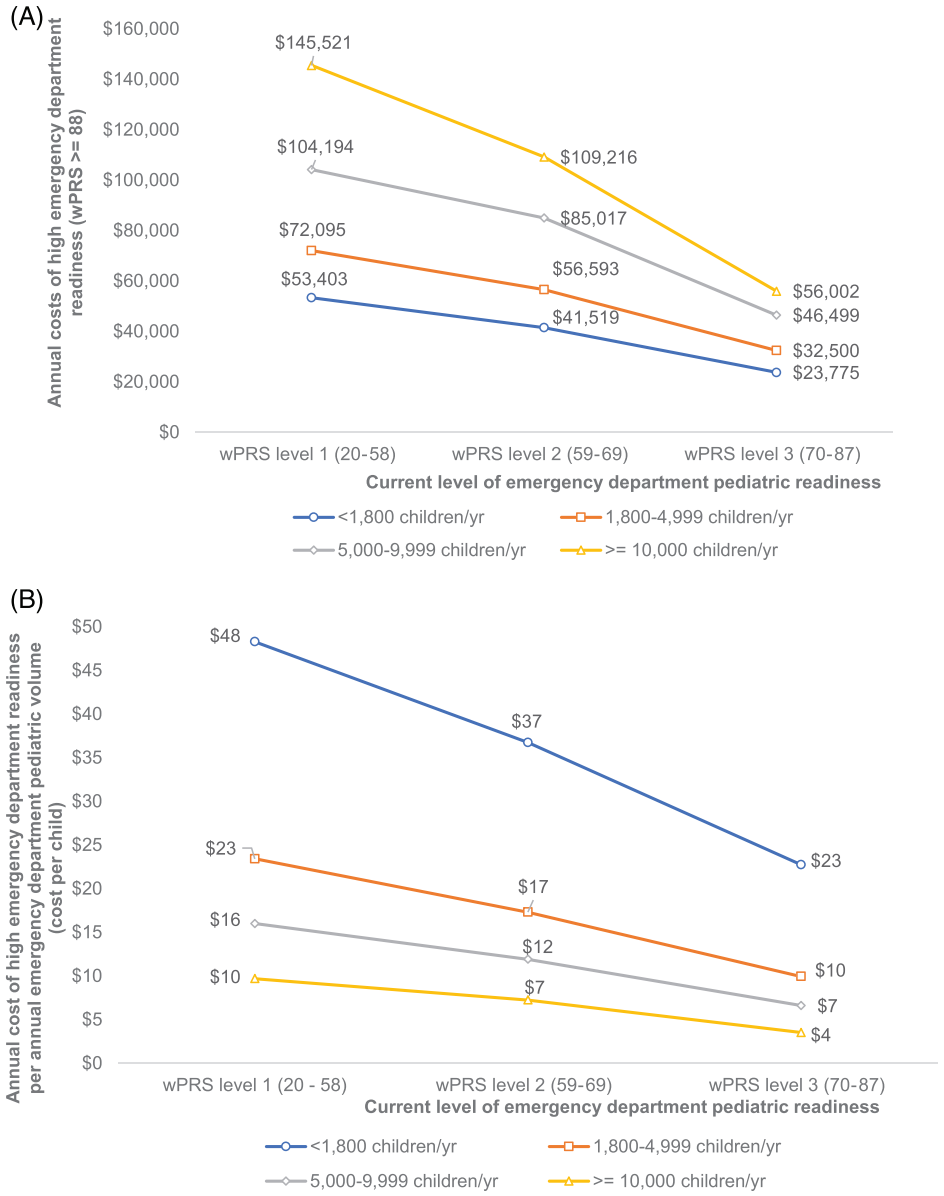

FIGURE 3 The annual costs to reach high emergency department (ED) readiness from current levels of ED pediatric readiness, by ED volume. (A) The cost difference to reach high ED readiness from current levels. (B) Cost per patient to reach high ED readiness from current levels. *The 3 "levels" of wPRS are based on quartiles 1–3 from the 2021 national ED pediatric readiness assessment, but the third level extends from wPRS 70–87 (rather than the 70–83, as reported in the assessment) to be consistent with the high readiness level (wPRS 88–100) required to improve pediatric survival. These figures preserve the ≥10,000 children/year volume category to be consistent with the 2021 National Pediatric Readiness Project categories.

In Figures 3A and B, we show the cost gap for EDs with low levels of ED pediatric readiness (wPRS < 88) to reach HPR. After accounting for current levels of ED pediatric readiness, the cost to reach HPR was greatest for high volume EDs ($56,002–145,521, depending on the starting level of readiness), while the cost-per-patient was lowest ($4 per child to $10 per child) (Figures 3A and B). Low volume EDs had the lowest cost to reach HPR from current levels ($23,775–53,403), but the highest cost-per-patient ($23/child to $48/child). Overall, the cost to reach HPR from current levels ranged from $23,775–145,521 and the cost-per-patient ranged from $4/child to $48/child Equipment costs ranged from 0.03 to 4.9% of the cost gap, with the majority of the cost differential based on labor expenses to support PECCs.

The PECC position was frequently missing among EDs with low levels of pediatric readiness. For EDs with the lowest level of readiness (wPRS 20–58), 0–7.5% had a PECC and less than 1% had two PECCs. Among EDs in the third level of readiness (wPRS 70–87) and across the different volume categories, 29.4–46.6% had a PECC and 19.6–26.7% had two PECCs.

4 | LIMITATIONS

We estimated personnel time associated with ED pediatric readiness based on national and regional PECC surveys. There was variability in the time estimates within and between the two surveys, as well as small sample sizes for certain questions, which could have biased the estimates. In addition, we used a group of national experts on ED pediatric readiness to interpret the estimates for face validity and alignment with real-world conditions. While we used five ED volume categories to represent a wide variety of EDs, there are other factors beyond volume that can affect the time required for HPR. We used national salary estimates, yet salary variation exists across states and specialties, which affect actual costs. We used this variability to calculate 95% confidence intervals around the estimates and we believe that we have reasonably captured the variability in hospital labor costs.

We estimated the per-item equipment purchasing ratios based on a single children's hospital usage. Therefore, we may have overestimated the equipment costs for EDs seeing lower-acuity children. We did not account for special purchasing agreements that may result in lower equipment costs. However, equipment costs constituted a small portion of expenses and variances were unlikely to impact the overall cost estimates.

5 | DISCUSSION

In this study, we quantified the annual hospital cost of EDs to reach and maintain HPR.[2] To our knowledge, this is the first study to quantify the hospital costs of ED pediatric readiness, including the cost of reaching HPR from current U.S. levels. These findings show that the cost to reach HPR is primarily based on labor costs for PECCs to complete the necessary pediatric readiness activities. These cost estimates provide a clear starting point for EDs seeking to raise their level of pediatric readiness.

The importance of understanding the costs to achieve HPR cannot be overstated since HPR is associated with improved survival in children.[2–5] The impact of raising ED readiness also has been quantified through the number of additional pediatric lives that would be saved,[2,5] demonstrating the health outcome benefit for children based on the investment required to reach HPR. Because pediatric readiness leverages current ED resources, HPR does not require structural changes, construction, or other relatively expensive aspects typical of hospital capital improvement projects. We show that the primary cost of HPR is salary support for the administrative time of PECCs; equipment costs are comparatively minimal. PECCs are part-time positions for all but the highest volume EDs and are often filled by existing clinical staff. Although hospitals have many competing costs, the cost of raising ED readiness from current levels is a fraction of that related to contracted labor during the pandemic.[13]

Quantifying the cost-per-patient to reach HPR places these costs in context. Low volume EDs have the lowest absolute costs to reach HPR, but higher per-patient costs compared with higher volume EDs. The cost-per-patient decreases rapidly with increasing annual ED volume. At a patient-level, the $4 per child to $48 per child of reaching HPR is lower than the cost per dose of most pediatric vaccines, which range from $11 to $225 per dose (mean $65 per dose) through the CDC Vaccines for Children Program and $12 to $269 per dose (mean $95 per dose) in the private sector.[26] A formal cost-effectiveness analysis is necessary to assess the balance of incremental health gains relative to incremental costs (including longer-term impacts) for HPR. Yet, our findings suggest that the hospital costs required to raise ED pediatric readiness are relatively low and the potential gains in pediatric outcomes for children substantial.

These estimates may guide budgetary planning related to ED pediatric readiness among health systems with a goal of improving pediatric survival in emergency settings.

AUTHOR CONTRIBUTIONS

K. R., M. G. H., and C. N. conceived the study. C. N. and K. R. obtained research funding. A. L. conducted the data analysis. N. K., J. G.F., and C. W. provided advice on statistical analysis. C. N. chaired the study group. K. R., M. G. H., and C. N. drafted the manuscript, and all authors contributed substantially to its revision. K. R., M. G. H., and C. N. take responsibility for the paper as a whole.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

We used data from 12 different sources to compile the necessary inputs for the study and therefore do not have a single data source for sharing. Some of these sources are publicly available (e.g., U.S. Bureau of Labor Statistics Occupational Employment and Wages) and others may be available by contacting the owners of the data (e.g., the 2021 National ED Pediatric Readiness Assessment at the EMSC Data Center, University of Utah). Patient-level data for the 983 EDs in 11 states is restricted from sharing based on binding data use agreements with these states.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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