Trends in Pediatric Hospitalizations and Readmissions: 2010–2016

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abstract

BACKGROUND: Health reform and policy initiatives over the last 2 decades have led to significant changes in pediatric clinical practice. However, little is known about recent trends in pediatric hospitalizations and readmissions at a national level.

METHODS: Data from the 2010–2016 Healthcare Cost and Utilization Project Nationwide Readmissions Database and National Inpatient Sample were analyzed to characterize patient-level and hospital-level trends in annual pediatric (ages 1–17 years) admissions and 30-day readmissions. Poisson regression was used to evaluate trends in pediatric readmissions over time.

RESULTS: From 2010 to 2016, the total number of index admissions decreased by 21.3%, but the percentage of admissions for children with complex chronic conditions increased by 5.7%. Unadjusted pediatric 30-day readmission rates increased over time from 6.26% in 2010 to 7.02% in 2016 with a corresponding increase in numbers of admissions for patients with complex chronic conditions. When stratified by complex or chronic conditions, readmission rates declined or remained stable across patient subgroups. Mean risk-adjusted hospital readmission rates increased over time overall (6.46% in 2010 to 7.14% in 2016) and in most hospital subgroups but decreased over time in metropolitan teaching hospitals.

CONCLUSIONS: Pediatric admissions declined from 2010 to 2016 as 30-day readmission rates increased. The increase in readmission rates was associated with greater numbers of admissions for children with chronic conditions. Hospitals serving pediatric patients need to account for the rising complexity of pediatric admissions and develop strategies for reducing readmissions in this high-risk population.

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WHAT'S KNOWN ON THIS SUBJECT: Health reform and increasing regionalization of pediatric care over the last 2 decades have led to significant changes in pediatric clinical practice. Little is known about recent trends in pediatric hospitalizations and readmissions on a national level.

WHAT THIS STUDY ADDS: From 2010 to 2016, pediatric admissions declined as patient complexity increased. Pediatric readmissions increased over this time and were associated with greater numbers of admissions for patients with complex and/or chronic conditions.

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Health reform and major policy initiatives over the last 2 decades have led to significant changes in pediatric clinical practice. Under Medicaid and the Children's Health Insurance Program, the percentage of US children without health insurance has declined by two-thirds from 14.9% in 1997 to 4.8% in 2015,[1–3] and patient-centered medical homes and accountable care organizations have led to greater care coordination.[4,5] In addition, multi-institutional collaborations have generated new opportunities to improve patient care.[6–8] Along with these improvements in care, the complexity of pediatric patients has changed because children with chronic disease are living longer and developing long-term consequences of their diagnoses.[9,10]

Despite these changes, few researchers have examined trends in the delivery of pediatric care over time. Recent data suggest that pediatric care is becoming increasingly concentrated in large academic centers.[11,12] These findings may be due in part to the increasing complexity of pediatric patients admitted to US hospitals.[13,14] However, no researchers have examined changes in hospitalization characteristics over time at a national level across all payers and all hospitals treating pediatric patients.

More recently, readmissions have also come into the spotlight. After the 2012 implementation of the Hospital Readmissions Reduction Program by the Centers for Medicare and Medicaid Services (CMS),[15,16] many hospitals developed internal strategies to reduce their readmission rates,[17–20] and several national campaigns were launched to help hospitals decrease readmission rates globally.[21] Although these efforts were largely directed at Medicare beneficiaries and for specific target conditions, studies have revealed that such hospital-wide efforts successfully decreased readmission rates in nonpenalized conditions,[22–24] and multiple pediatric-specific initiatives have been launched simultaneously.[25–27] Nevertheless, almost nothing is known about national trends in pediatric readmission rates during this time.

Accordingly, we used nationally representative 2010–2016 inpatient claims data to characterize trends in all-condition pediatric hospitalizations. Specifically, we evaluated trends in patient- and hospital-level admissions and 30-day readmissions and compared differences in admission and readmission trends across patient and hospital characteristics. Such information is critical to our understanding of temporal trends in pediatric care and may offer insight into how recent initiatives have affected pediatric hospitalization rates.

METHODS

Data Source

Data from the 2010 to 2016 Healthcare Cost and Utilization Project (HCUP) Nationwide Readmissions Database (NRD), an all-payer database of hospital inpatient stays that are drawn from the HCUP State Inpatient Databases, were used to identify pediatric discharges after an inpatient hospitalization.[28,29] NRD includes data from between 18 and 27 geographically diverse states which are weighted to represent the annual national number of US hospitalizations. Patient identifiers are used to link individuals across hospitalizations within each state. Weights are constructed by HCUP for pediatric patients specifically.

We also used data from the 2010 to 2016 HCUP Nationwide Inpatient Sample (NIS) to confirm our findings regarding discharge characteristics.[30,31] The NIS is an all-payer database that is also drawn from the HCUP State Inpatient Databases but includes substantially more states. The 2010–2016 NIS data sets contain inpatient discharges from 44 to 45 US states comprising >97% of the US population. In 2012, NIS underwent redesign to improve national estimates. Before 2012, NIS included all discharges from a sample of participating hospitals. From 2012 to 2016, NIS is a sample of discharge records from all HCUP-participating hospitals. Individuals cannot be linked across hospitalizations, preventing the calculation of readmission rates.

Study Population

In this study, we included all inpatient admissions discharged between January 1 to November 30 of each year for patients aged 1 to 17 years. December index discharges were excluded to allow for the full 30-day readmission window. Observation stays were not included. Infants <1 year old were excluded because more than half of the states in the NRD excluded these records.[28] Patients who died, left against medical advice, or were discharged to another acute care setting were excluded.

For patient-level analyses, all admissions were included. For hospital-level analyses, only hospitals admitting at least 30 pediatric patients annually were included to obtain stable 30-day risk-standardized readmission rates.[32–34] Thirty-day risk-standardized readmission rates were also repeated for hospitals with 30 to 99, 100 to 999, and ≥1000 pediatric discharges annually.

Although the HCUP NRD and NIS were not designed to examine trends in hospital characteristics over time because different states and hospitals are sampled each year, we reported hospital characteristics by year for reference when interpreting changes in admission and readmissions over time.

Outcomes

We identified all index admissions and readmissions occurring within 30 days of discharge from the index admission. Only the first readmission within 30 days was considered and subsequent admissions after 30 days from discharge were evaluated as another index hospitalization.[32,33] Readmission hospitalizations within 30 days of a previous discharge were not categorized as index hospitalizations. In addition, we excluded readmissions for planned procedures and chemotherapy.[32,33]

Admission and Hospital Characteristics

We examined trends in admissions and 30-day readmissions stratified by patient- and hospital-level characteristics. Patient admission characteristics included age, sex, insurance, and the presence of a chronic or complex condition. We used the Pediatric Medical Complexity Algorithm (PMCA) to identify children with chronic or complex conditions.[35] Hospital characteristics included number of pediatric discharges annually, ownership, teaching status (defined in NRD as metropolitan nonteaching, metropolitan teaching, and nonmetropolitan), and percentage of discharges covered by Medicaid.

Statistical Analyses

We used SAS version 9.4 (SAS Institute, Inc, Cary, NC) survey procedures to account for the complex sampling design. Index admission and hospital characteristics were summarized across years and compared by using χ^2 for categorical variables and analysis of variance for continuous variables. Weighted index admission and 30-day readmission totals were calculated across years. Annual patient-level 30-day readmission rates were calculated overall and stratified by admission characteristics (eg, sex, age, chronic and/or complex conditions).

To estimate national trends in patient-level 30-day readmission rates, we fit a generalized linear model using weighted counts with a Poisson link function. The log-transformed total admission-years was used as an offset in the model to obtain the expected number of 30-day readmissions. Multivariable analyses were performed by using a similar approach. The total number of 30-day readmissions and the total admission-years were calculated for 18 demographic categories (representing age [1–5, 6–12, 13–17], sex, and chronic and/or complex condition subgroups [nonchronic, chronic noncomplex, and complex chronic]) and used to fit a generalized linear model with a Poisson link function, adjusting for age, sex, and the presence of a chronic and/or complex condition. These analyses were repeated, stratified by age, sex, and chronic and/or complex conditions to identify patient subgroups with changing 30-day readmission rates.

Hospital-level 30-day readmission rates were calculated by using the Pediatric All-Condition Readmission Measure to adjust for differences in case-mix across hospitals.[32,33] This measure uses a hierarchical logistic regression model with a random hospital intercept that includes age, sex, presence of 17 chronic condition body system indicators, and number of body systems affected by chronic conditions. Psychiatric and obstetric admissions were excluded in accordance with the measure. Trends in mean hospital 30-day risk-adjusted readmission rates were evaluated overall and stratified by hospital characteristics by using linear regression with year and intercept included in the model.

To confirm our findings, we repeated calculations for annual discharge totals and characteristics in the HCUP NIS 2010–2016 data sets. Given the 2012 redesign, publicly released trend weights for 2010–2011 data were merged with the original files to create national estimates for trend analysis that can be combined with the 2012–2016 data. Analyses were weighted to national totals by using SAS survey procedures. Because admissions could not be linked across patients to differentiate between index admissions and readmissions, our estimates represent both. Deaths, discharges against medical advice, and discharges to other acute care settings were excluded. Hospital characteristics were similarly calculated among hospitals with a minimum of 30 pediatric admissions. This analysis was deemed exempt under federal regulation 45 CFR §46.101(b).

RESULTS

Admission Trends

This analysis included 2 714 235 index admissions among 2 405 756 pediatric patients, weighted to represent 8.3 million pediatric admissions. From 2010 to 2016, the total number of pediatric index admissions decreased by 21.3% from 1 325 616 to 1 043 802 annually (Table 1). The complexity of admissions increased over time as evidenced by a greater percentage of admissions with ≥1 complex chronic condition on record (16.7% [SE 1.0] in 2010 vs 22.4% [SE 1.1] in 2016, $P < .001$). The mean age, distribution of payers, and percentage of inpatient transfers remained constant.

Hospital Characteristics

Hospital numbers fluctuated annually depending on the number of states included in the NRD sample (Table 2). The percentage of nonmetropolitan and nonteaching hospitals decreased, whereas the percentage of metropolitan teaching hospitals increased in the NRD sample (29.5% in 2010 vs 57.3% in 2016). Similarly,

TABLE 1 Weighted Admission Characteristics for All Pediatric Index Admissions Between 2010 and 2016

	Pediatric Index Admissions							
	2010	2011	2012	2013	2014	2015	2016	*P*[a]
No. pediatric index admissions	1 325 616	1 296 696	1 233 523	1 168 124	1 117 346	1 096 683	1 043 802	—
Age in y, mean (SE)	9.7 (0.1)	9.7 (0.1)	9.8 (0.1)	9.7 (0.1)	9.8 (0.1)	9.8 (0.1)	9.9 (0.1)	.32
Female sex, % (SE)	50.5 (0.4)	50.3 (0.4)	50.4 (0.3)	50.8 (0.3)	51.0 (0.3)	51.1 (0.4)	51.0 (0.4)	.69
Payer, % (SE)								.54
Private insurance	38.0 (1.1)	37.9 (1.2)	37.8 (1.2)	37.9 (1.1)	37.7 (1.1)	38.3 (1.1)	37.7 (1.0)	
Medicare/Medicaid	55.1 (1.1)	55.4 (1.1)	55.3 (1.2)	55.8 (1.0)	56.2 (1.0)	56.2 (1.0)	57.0 (1.0)	
Self-pay/other	6.9 (0.4)	6.8 (0.5)	6.8 (0.5)	6.3 (0.3)	6.1 (0.4)	5.5 (0.3)	5.3 (0.3)	
PMCA chronic and/or complex conditions, % (SE)								<.001
Nonchronic condition	76.6 (1.0)	75.8 (1.0)	74.5 (1.1)	73.0 (0.9)	72.4 (0.9)	72.6 (1.0)	71.0 (1.1)	
Noncomplex chronic condition	6.7 (0.3)	6.7 (0.3)	6.9 (0.3)	6.8 (0.2)	6.8 (0.3)	5.9 (0.2)	6.6 (0.2)	
Complex chronic condition	16.7 (1.0)	17.5 (1.0)	18.6 (1.1)	20.1 (1.0)	20.8 (1.0)	21.4 (1.0)	22.4 (1.1)	
Inpatient transfer, % (SE)	0.9 (0.1)	0.9 (0.1)	0.9 (0.1)	1.0 (0.1)	0.9 (0.1)	1.0 (0.1)	1.0 (0.1)	.80
Length of stay in d, mean (SE)	3.77 (0.09)	3.75 (0.08)	3.81 (0.08)	3.82 (0.08)	3.87 (0.08)	3.96 (0.07)	4.05 (0.09)	.006
Patient-level readmission rate, % (SE)[b]	6.26 (0.23)	6.30 (0.20)	6.50 (0.27)	6.50 (0.21)	6.59 (0.22)	6.79 (0.22)	7.02 (0.21)	<.001

[a] *P* values were calculated using Cochran-Armitrage test for trend for categorical variables and linear regression for continuous variables.
[b] Adjusted tests for trend for patient-level readmission rates are provided in Table 3.

the percentage of private nonprofit hospitals sampled increased (60.3% in 2010 vs 69.8% in 2016) as other forms of hospital ownership decreased.

Patient-Level 30-Day Readmission Trends

Unadjusted pediatric 30-day readmission rates increased over time from 6.26% (SE 0.23) in 2010 to 7.02% (SE 0.21) in 2016 (*P* value for trend <.001) (Tables 1 and 3). This translates to a 12.1% increase in pediatric 30-day readmission rates overall and a 1.8% (95% confidence interval [CI] 1.7% to 2.0%) increase annually. After adjustment for patient characteristics, the rate ratio decreased to 0.981 (0.980 to 0.982) corresponding to a 1.9% (95% CI 1.8% to 2.0%) decrease in pediatric 30-day readmission rates annually (Table 3).

To identify patient subgroups with increasing or decreasing readmission rates, we repeated these analyses stratified by patient characteristics (Fig 1). When stratified by the presence of chronic and/or complex conditions, 30-day readmission rates declined or remained stable in all

TABLE 2 Hospital Characteristics for Hospitals Admitting a Minimum of 30 Pediatric Patients Between 2010 and 2016

	Hospitals						
	2010	2011	2012	2013	2014	2015	2016
No. states	18	18	18	21	22	27	27
No. hospitals admitting a minimum of 30 patients, *N* (%)	851	792	697	699	652	717	665
No. admissions, median (IQR)	115 (60–304)	116 (59.5–295.5)	116 (59–306)	114 (58–324)	119.5 (59–355.5)	112 (57–300)	113 (57–350)
Ownership, *N* (%)							
Government	185 (21.7)	178 (22.5)	138 (19.8)	121 (17.3)	104 (16.0)	119 (16.6)	106 (15.9)
Nonprofit private	513 (60.3)	479 (60.5)	439 (63.0)	464 (66.4)	449 (68.9)	493 (68.8)	464 (69.8)
For-profit private	153 (18.0)	135 (17.1)	120 (17.2)	114 (16.3)	99 (15.2)	105 (14.6)	95 (14.3)
Teaching status and location, *N* (%)							
Metropolitan, nonteaching	347 (40.8)	327 (41.3)	274 (39.3)	276 (39.5)	195 (29.9)	195 (27.2)	159 (23.9)
Metropolitan, teaching	251 (29.5)	241 (30.4)	244 (35.0)	261 (37.3)	339 (52.0)	381 (53.1)	381 (57.3)
Nonmetropolitan	253 (29.7)	224 (28.3)	179 (25.7)	162 (23.2)	118 (18.1)	141 (19.7)	125 (18.8)
No. pediatric discharges, *N* (%)							
Small, 30–99	379 (44.5)	349 (44.1)	319 (45.8)	318 (45.5)	287 (44.0)	332 (46.3)	302 (45.4)
Medium, 100–999	394 (46.3)	367 (46.3)	307 (44.1)	304 (43.5)	288 (44.2)	304 (42.4)	286 (43.0)
Large, ≥1000	78 (9.2)	76 (9.6)	71 (10.2)	77 (11.0)	77 (11.8)	81 (11.3)	77 (14.3)
% of pediatric discharges covered by Medicaid, median (IQR)	57.0 (41.2–70.6)	59.0 (42.7–71.6)	58.3 (41.1–70.2)	59.0 (41.0–71.2)	58.9 (43.9–72.5)	59.3 (44.6–72.3)	58.9 (45.3–72.7)
Risk-standardized hospital-level readmission rate, mean (SD)[a]	6.46 (2.06)	6.58 (2.42)	6.61 (2.20)	6.80 (2.30)	7.03 (2.41)	6.89 (2.15)	7.14 (1.20)

IQR, interquartile range.
[a] Tests for trend for patient-level readmission rates and hospital-level readmission rates stratified by hospital characteristics are provided in Table 3.

TABLE 3 Results for Tests for Readmission Trends From 2010 to 2016 Stratified by Patient and Hospital Characteristics

	Unadjusted		Adjusted	
	Rate Ratio (95% CI)[a]	Poisson *P*	Rate Ratio (95% CI)[a]	Poisson *P*
Admission-level analyses				
Overall	1.018 (1.017 to 1.020)	<.001	0.981 (0.980 to 0.982)	<.001
Sex				
Female	1.012 (1.010 to 1.014)	<.001	0.990 (0.988 to 0.991)	<.001
Male	1.019 (1.017 to 1.021)	<.001	1.001 (1.000 to 1.003)	.15
Ages, y				
1–5	1.020 (1.017 to 1.022)	<.001	0.998 (0.995 to 1.000)	.08
6–12	1.014 (1.012 to 1.017)	<.001	1.000 (0.998 to 1.002)	.97
13–17	1.011 (1.009 to 1.013)	<.001	0.987 (0.985 to 0.989)	<.001
PMCA chronic and/or complex conditions				
Nonchronic condition	0.988 (0.984 to 0.991)	<.001	0.986 (0.983 to 0.989)	<.001
Noncomplex chronic condition	1.001 (0.998 to 1.004)	.66	0.998 (0.996 to 1.001)	.27
Complex chronic condition	0.994 (0.992 to 0.996)	<.001	0.995 (0.993 to 0.997)	<.001
Hospital-level analyses			Slope (95% CI)[b]	Linear *P*
Overall	—	—	0.11 (0.08 to 0.14)	<.001
Annual No. pediatric admissions				
30–99 pediatric admissions	—	—	0.13 (0.11 to 0.16)	<.001
100–999 pediatric admissions	—	—	0.11 (0.06 to 0.15)	<.001
≥1000 pediatric admissions	—	—	−0.11 (−0.22 to 0.00)	.12
Ownership				
Public	—	—	0.17 (0.10 to 0.24)	<.001
Private, not-for-profit	—	—	0.08 (0.05 to 0.12)	<.001
Private, for-profit	—	—	0.13 (0.08 to 0.18)	<.001
Teaching status				
Metropolitan, nonteaching	—	—	0.11 (0.08 to 0.15)	<.001
Metropolitan, teaching	—	—	−0.08 (−0.14 to −0.02)	.006
Nonmetropolitan	—	—	0.13 (0.10 to 0.17)	<.001

—, not applicable.

[a] Poisson regression was used to model readmission rate as an incidence rate over time. Multivariable analyses adjusted for patient age, sex, and PMCA complex chronic conditions.

[b] Linear regression was used to model hospital risk-adjusted readmission rates as a function of y. Hospital-level risk-adjusted readmission rates adjust for differences in patient case-mix across hospitals.

subgroups (Fig 1, Table 3). Readmission rates declined by 1.2% annually in children without chronic conditions and 0.6% annually in children with complex chronic conditions. In contrast, no significant change in readmission rates over time among children with noncomplex chronic conditions was found (Table 3). Stratification by age and sex revealed an overall increase in 30-day readmission rates over time across all ages. After adjustment for patient characteristics, 30-day readmission rates declined or remained stable across all patient subgroups.

Hospital-Level 30-Day Readmission Trends

Mean risk-adjusted hospital 30-day readmission rates also increased over time from 6.46% (SE 2.06) in 2010 to 7.14% (SE 1.20) in 2016 ($P < .001$). Stratification of hospital-level readmission rates by hospital characteristics demonstrated a consistent increase in 30-day risk-adjusted readmission rates over time across most hospital subgroups, with the exception of large hospitals and metropolitan teaching hospitals (Fig 2, Table 3). Readmission rates remained stable in large hospitals and decreased in metropolitan teaching hospitals.

Sensitivity Analyses

Sensitivity analyses in which the 2010–2016 HCUP NIS data were used revealed similar trends in pediatric admission characteristics (Supplemental Table 4). The percentage of admissions with a complex chronic condition on record increased over time (16.6% [SE 1.3] in 2010 vs 20.2% [SE 0.7] in 2016, $P = .001$). There was a substantial increase in the number of hospitals included in the NIS before and after 2012 because of changes in sampling procedures (Supplemental Table 5). Nevertheless, similar trends to the NRD were observed over time, including an increase in the number of metropolitan teaching hospitals with a corresponding decrease in nonmetropolitan and nonteaching hospitals.

DISCUSSION

In this nationally representative sample of US hospitalizations, we demonstrated 2 major trends in the delivery of pediatric care in the United States. First, total pediatric admissions declined over time as the complexity of these admissions increased, evidenced by a greater

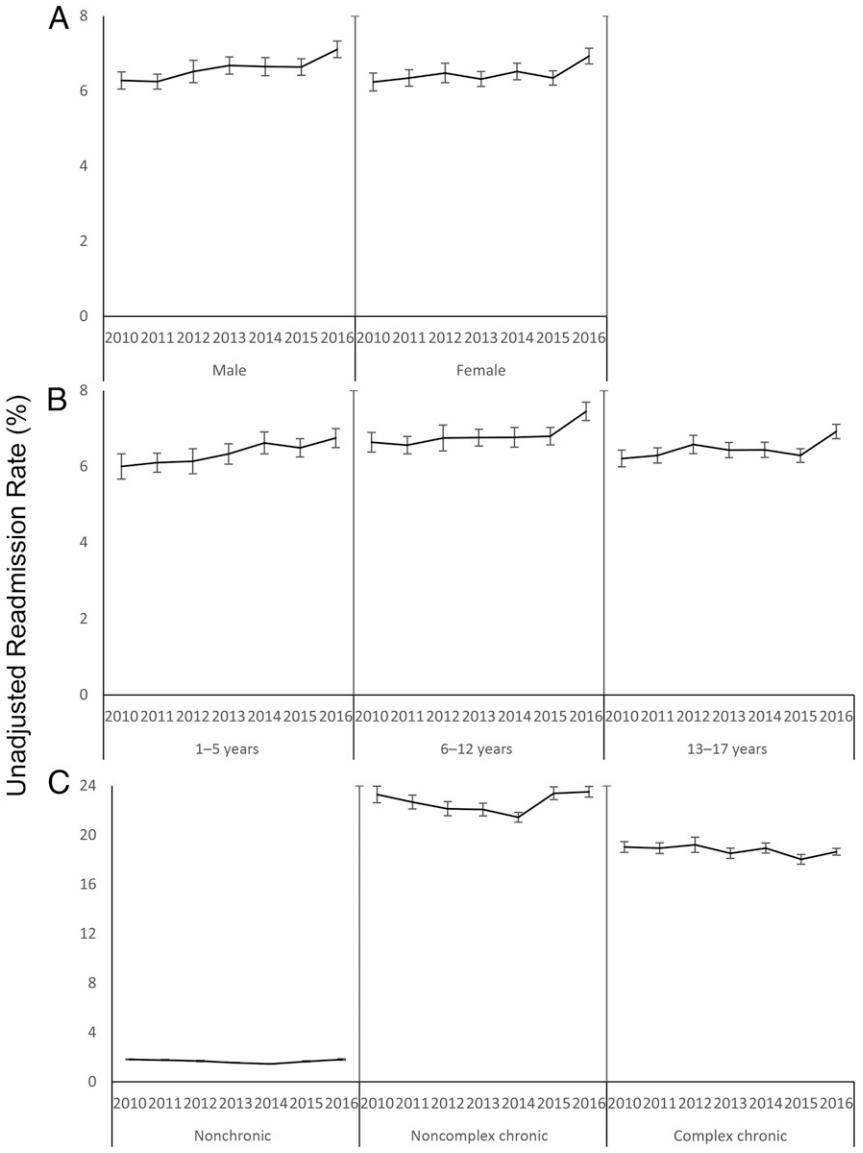

FIGURE 1
Patient-level unadjusted readmission rates stratified by (A) sex, (B) age, and (C) presence of a chronic or complex condition defined by the PMCA.

percentage of pediatric admissions with a chronic or complex condition. Second, crude patient-level 30-day readmission rates increased on average by 1.8% annually or 12.1% over the 7-year period; however, this increase was associated with higher numbers of index admissions for children with chronic conditions who have a higher risk of readmission than children without chronic conditions.[36,37] Hospital 30-day risk-adjusted readmission rates increased over time in all hospital subgroups.

We identified a downward trend in total pediatric hospitalizations but an increasing complexity of admissions, an effect that bore out in both the NRD and NIS. The decline in pediatric admissions was recently observed in 2 studies in which data from 4 states were used, demonstrating a reduction in annual pediatric admissions from 2004 to 2014 by 15%.[11,12] Previous studies have also revealed that children with complex chronic conditions increasingly account for a disproportionate number of pediatric hospitals stays and charges,[14] and preliminary data from children's hospitals have revealed that the number of admissions, bed days, and hospital charges attributable to children with chronic conditions has increased relative to those without chronic conditions.[13] In this study, we extend these findings to all hospitals treating pediatric patients. Reasons for this increase are likely multifactorial. The prevalence of children with chronic conditions may be increasing because of improved survival in the neonatal period and medical advances in care and technology ultimately leading to additional medical needs and inpatient stays.[38–40] Regardless, these findings highlight the continued need for research into medical homes, care coordination, and chronic condition management for these children at high risk.[41]

Although the HCUP NRD and NIS are not designed for studying trends in hospital characteristics, it is interesting that the percentage of private nonprofit and metropolitan teaching hospitals treating a minimum of 30 pediatric patients increased over time in the NRD sample. These findings may be consistent with other studies revealing increased regionalization of pediatric care in these types of hospitals. Researchers for the 2 studies mentioned above reported increased regionalization in major academic hospitals over an 11-year period,[11,12] and other studies have revealed that certain pediatric surgical subspecialties (eg, cardiac surgery, otorhinolaryngology, and orthopedics) are becoming concentrated in a few high-volume centers over time.[42–45] The increasing complexity of pediatric admissions observed in our study and others may explain some of the concentration in care in teaching hospitals[13,14]; however, trends in regionalization may also be driven by hospital competition and financial incentives,

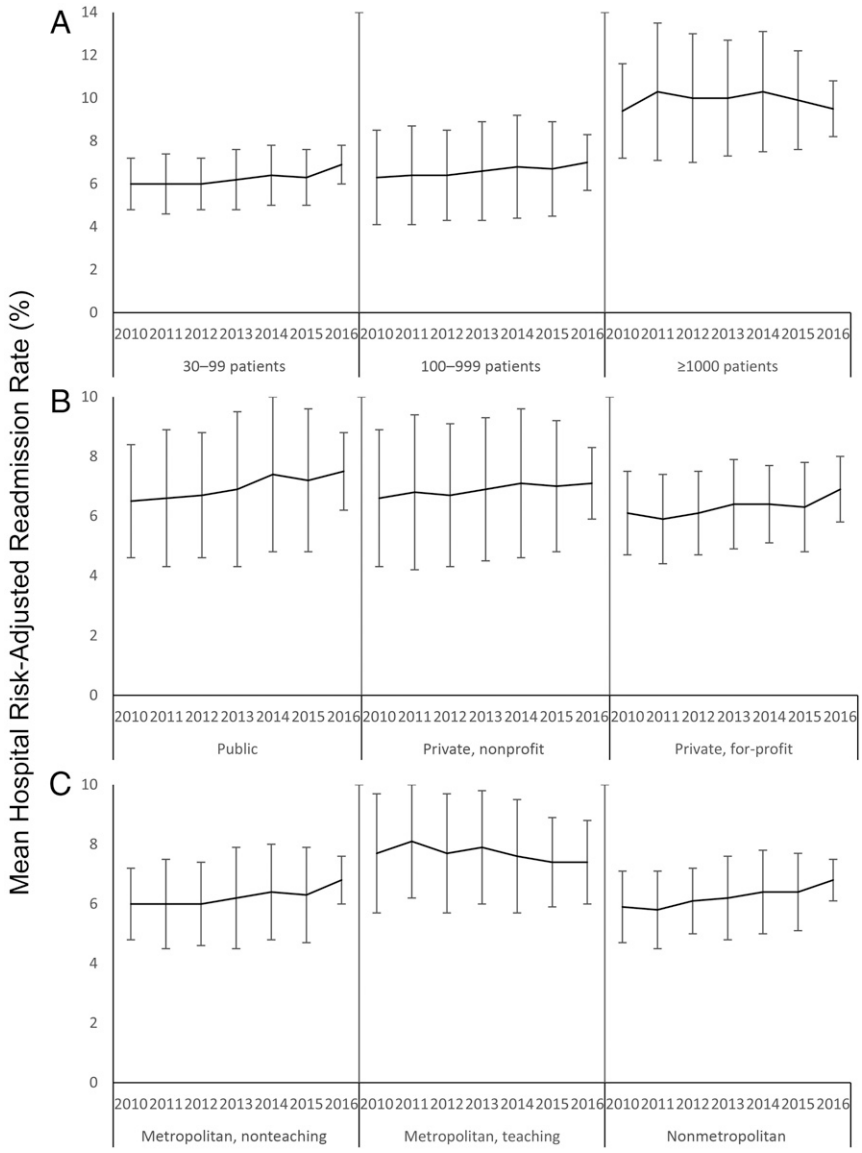

FIGURE 2
Hospital-level risk-adjusted readmission rates stratified by (A) number of pediatric admissions, (B) hospital ownership, and (C) hospital teaching status.

choices by hospitals to maintain or close their pediatric units, and parental preferences.[46]

To our knowledge, this is the first study in which temporal national-level trends in pediatric readmissions are examined across all diagnoses. The few studies that have contained examinations of trends in pediatric readmissions have been limited by single discharge diagnoses or noncontemporary data before 2010.[47–49] These studies have revealed mixed results, with some demonstrating an increase in condition-specific readmission rates[47,49,50] and others revealing reductions in readmissions over time.[47] The dearth of studies in which trends in pediatric readmissions are explored likely stems from the absence of national data before NRD.

We found that pediatric 30-day readmission rates are increasing at both the patient and hospital level; however, the increase in patient-level readmission rates could be explained by the increasing medical complexity of patients. The difference in directionality between the risk-adjusted patient-level and hospital-level analyses are likely explained by a few key analytic differences. First, different risk-adjustment methods (PMCA algorithm versus absolute number of conditions on record) were used for the 2 analyses. Second, patient-level analyses examined an absolute rate over time, whereas hospital-level analyses examined mean readmission rates across hospitals, which may be skewed upwards by outliers. Third, nonrandom clustering of patients within hospitals may lead to different findings than those at the patient level.

As readmissions have come to the forefront of US health care policy, pediatric readmissions reduction has become a priority. Funded by the Agency for Healthcare Research and Quality and CMS, the Pediatric Quality Measures Program established readmission and other quality metrics for pediatrics,[51,52] and hospitals have started implementing pediatric-specific interventions aimed at reducing readmissions.[26,27,53,54] As the complexity of pediatric inpatients increases, it is important for such efforts to target patients with medical complexity to have a positive impact on pediatric readmissions.

Similarly, our findings highlight the need for collaborative efforts across hospitals to identify best practices for improving patient outcomes. Although risk-adjusted hospital 30-day readmission rates increased over time in most hospital subgroups, a decrease in readmission rates over time was observed in metropolitan teaching hospitals despite these hospitals often caring for patients with medical complexity. Collaboratives across hospitals like Solutions for Patient Safety may help to reduce pediatric readmission rates in all hospitals.[25]

One possible limitation of this study is the exclusion of observation stays and emergency visits. Data from the

Pediatric Health Information System database revealed a sizeable increase in the number of observation stays from 2004 to 2009, suggesting that the inclusion of observation stays would increase the absolute number of hospital admissions in our analysis.[55] However, the effect of observation stays on readmissions is less clear. Data from Medicare populations suggest that hospitals are not using observation stays to reduce their inpatient readmission rates reported to CMS despite significant financial pressure to do so.[56,57] Although these data do not exist for pediatrics, it seems less likely that physicians would be inclined to admit patients under observation stays to avoid readmission penalties. Therefore, the inclusion of observation stays in our analysis might increase the total number of readmissions but would be unlikely to alter trends in readmission rates after inpatient admissions.

In addition, we were unable to examine individual hospital trends over time because hospitals could not be linked across years. Thus, we could not determine whether high- or low-performing hospitals in 2010 retained this status in 2016. Second, the HCUP NIS changed its sampling strategy in 2012. Although we used updated NIS weights developed specifically for analyzing trends, our sensitivity analyses, particularly the hospital trends, may have been affected by this change. Third, we were unable to identify out-of-hospital deaths and patients who were readmitted within 30 days to a hospital out of state from the index admission. Fourth, we excluded December index admissions to allow for the full 30-day readmission window. This approach will underestimate the total number of index admissions in a given year but should not affect trends. Finally, we excluded admissions for children <1 year of age, limiting our ability to draw inferences on this population. Given the large numbers of missing data, we opted to exclude this population because of the potential for unstable estimates with wide margins of error.

CONCLUSIONS

Our findings suggest that the delivery of pediatric care is changing. Total numbers of pediatric admissions are declining; however, the complexity of pediatric patients cared for by hospitals is increasing. Although pediatric readmission rates appear to be rising, this increase is associated with increasing numbers of patients with medical complexity who are at higher risk of readmission. These findings highlight the need for continued research on ways to reduce hospital use in children with chronic conditions and the opportunity for partnerships across hospitals to optimize care for this high-risk population.

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ABBREVIATIONS

CI: confidence interval
CMS: Centers for Medicare and Medicaid Services
HCUP: Healthcare Cost and Utilization Project
NIS: Nationwide Inpatient Sample
NRD: Nationwide Readmissions Database
PMCA: Pediatric Medical Complexity Algorithm

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