RESEARCH ARTICLE

Factors Associated With Potentially Preventable Pediatric Admissions Vary by Diagnosis: Findings From a Large State

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ABSTRACT

OBJECTIVES: The objective of this study was to determine characteristics associated with potentially preventable pediatric admissions as defined by the Agency for Healthcare Research and Quality.

METHODS: The Texas Inpatient Public Use Data File, an administrative database of hospital admissions, identified 747 040 pediatric admissions ages 0 to 17 years to acute care facilities between 2005 and 2008. Potentially preventable admissions included 5 diagnoses: asthma, perforated appendicitis, diabetes, gastroenteritis, and urinary tract infection. A hierarchical multivariable logistic regression model clustered by admitting hospital and adjusted for admission date estimated the patient and hospital factors associated with potentially preventable admission.

RESULTS: An average of 71 444 hospital days per year and 14.1% (N = 105 055) of all admissions were potentially preventable, generating $304 million in hospital charges per year in 1 state. Younger age (odds ratio [OR]: 2.88 [95% confidence interval (CI): 2.80–2.96]), black race (OR: 1.48 [95% CI: 1.45–1.52]) or Hispanic ethnicity (OR: 1.06 [95% CI: 1.04–1.08]), lower income (OR: 1.11 [95% CI: 1.02–1.20]), comorbid substance abuse disorder (OR: 2.03 [95% CI: 1.75–2.34]), and admission on a weekend (OR: 1.05 [95% CI: 1.03–1.06]) or to a critical access hospital (OR: 1.61 [95% CI: 1.20–2.14]) were high-risk factors for potentially preventable admission, whereas Native American race (OR: 0.91 [95% CI: 0.85–0.98]), government insurance (OR: 0.83 [95% CI: 0.89–0.96]) or no insurance (OR: 0.93 [95% CI: 0.89–0.96]), and living in a rural county (OR: 0.70 [95% CI: 0.68–0.73]) were associated factors. However, most factors varied from high to low odds depending on which of the 5 potentially preventable diagnoses was examined.

CONCLUSIONS: Potentially preventable admissions represent a high burden of time and costs for the pediatric population, but strategies to reduce them should be tailored to each diagnosis because the associated factors are not uniform across all potentially preventable admissions.

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Centers for Medicare & Medicaid Services are pushing reimbursement toward a value-based payment system rather than a volume-based payment system, and preventable admissions are an indicator of potentially low-value care.[1] Preventable admissions in children have been estimated to cost $4 billion per year across 38 states, representing a large opportunity to improve value.[2] A better understanding of the factors associated with preventable admissions is needed to generate targeted solutions to improve the value and quality of care delivered. Previous research on preventable admissions in pediatrics has used a variety of definitions for "preventable," including the Billings algorithm,[3] physician or researcher opinion,[4,5] or various single previous studies,[2,6–8] thus decreasing the generalizability of the findings.

The Agency for Healthcare Research and Quality (AHRQ) Prevention Quality Indicators include ambulatory care–sensitive conditions (ACSC) for which hospital admissions could be prevented with timely access to primary care.[9] The AHRQ Pediatric Quality Indicators released in 2006 include 5 indicators of preventable pediatric admissions for ACSCs: asthma, short-term complications of diabetes, gastroenteritis, perforated appendicitis, and urinary tract infection (UTI).[10,11] The AHRQ Pediatric Quality Indicators provide a robust definition of preventable admissions specific to pediatrics.[12] Of note, AHRQ defines each preventable admission as one that might have been prevented with timely access to primary care or improvements to social determinants of health[9] such as environmental air quality for asthma; we will therefore refer to these as potentially preventable. Thus, not every asthma or gastroenteritis admission is considered potentially preventable, and each has specific age and comorbidity exclusionary criteria.

It seems intuitive that risk factors and affected populations would differ between asthma, perforated appendicitis, and diabetes, but little is known about variations in risk factors between different potentially preventable admissions in the pediatric population. Therefore, the objective of the present study was to determine characteristics associated with potentially preventable pediatric admissions as defined according to the AHRQ and to compare and contrast how those characteristics vary depending on the type of potentially preventable admission.

METHODS

The Texas Inpatient Public Use Data File, an administrative database of all Texas hospital admissions, identified 747 040 pediatric (ages 0–17 years) admissions to acute care facilities between 2005 and 2008. Admissions to skilled nursing facilities, long-term acute care, rehabilitation facilities, psychiatric facilities, and substance abuse treatment facilities, or of patients who did not reside in the state of Texas, were excluded; also excluded were newborn admissions as identified by an admission source of "newborn" or admission to the "nursery" unit. Because the data set does not include patient identifiers, a single admission would appear twice in the data set if divided into 2 billable episodes (eg, before and after transfer); thus, patients arriving by transfer between facilities or within the same facility were excluded. Additional admissions were excluded for coding errors, such as a patient aged $<$10 years admitted to labor and delivery, or patients with a missing sex notation, which is a criterion for exclusion in the AHRQ potentially preventable admission algorithm (Fig 1).

Patient-level factors analyzed included: age; sex; race and ethnicity (which were coded separately); insurance status; and median patient income as estimated by matching patient zip code to the Internal Revenue Service individual adjusted gross income tax return data from 2005 to 2008.[13] The county of the patient's home address was used to approximate geographic factors, including rural counties, counties bordering with Mexico, and counties located in the Rio Grande Valley, an area of southern Texas with higher rates of poverty and poorer health outcomes. Secondary *International Classification of Diseases, Ninth Revision* (ICD-9) codes documented for the admission were used to calculate the Charlson comorbidity index[14] and to define comorbid substance abuse and comorbid mental illness, including schizophrenia, bipolar, depression, and anxiety, as well as childhood-onset disorders such as autism, attention-deficit/hyperactivity disorder, and mental retardation. The data set also included total charges and length of stay for each admission.

Hospital factors analyzed included the type of admission (emergent, urgent, elective, or trauma) and whether the admission day fell on a weekend. The data set was merged with the American Hospital Association annual survey stratified according to year for 2005–2008 to analyze additional hospital factors, including: status as a teaching hospital, a children's hospital, a critical access hospital, or a trauma hospital; annual volume of emergency department visits; and total number of inpatient hospital beds.

Admissions were defined as potentially preventable by using the AHRQ technical specifications for the 5 potentially preventable admissions for children (asthma, perforated appendicitis, short-term complications of diabetes, gastroenteritis, and UTI). The AHRQ specifies the definition for each of these conditions based on the ICD-9 code of the principal diagnosis for the admission, with specific exclusion factors.[9,10] For example, asthma admissions are potentially preventable only in children aged $\geq$2 years, and cases are excluded when the patient has coexisting ICD-9 codes for cystic fibrosis or congenital anomalies of the lung. Only perforated appendicitis admissions are considered potentially preventable according to the AHRQ definition. Potentially preventable diabetes admissions are ketoacidosis and hyperosmolar state, and children must be $\geq$6 years of age for the complication to be potentially preventable. Gastroenteritis admissions are coded as potentially preventable in patients aged $\geq$3 months with viral gastroenteritis alone, or for gastroenteritis with dehydration, but is not potentially preventable when bacterial in nature or in children with congenital anomalies of the gastrointestinal tract. Admissions for UTI are not potentially preventable in children $<$3 months of age,

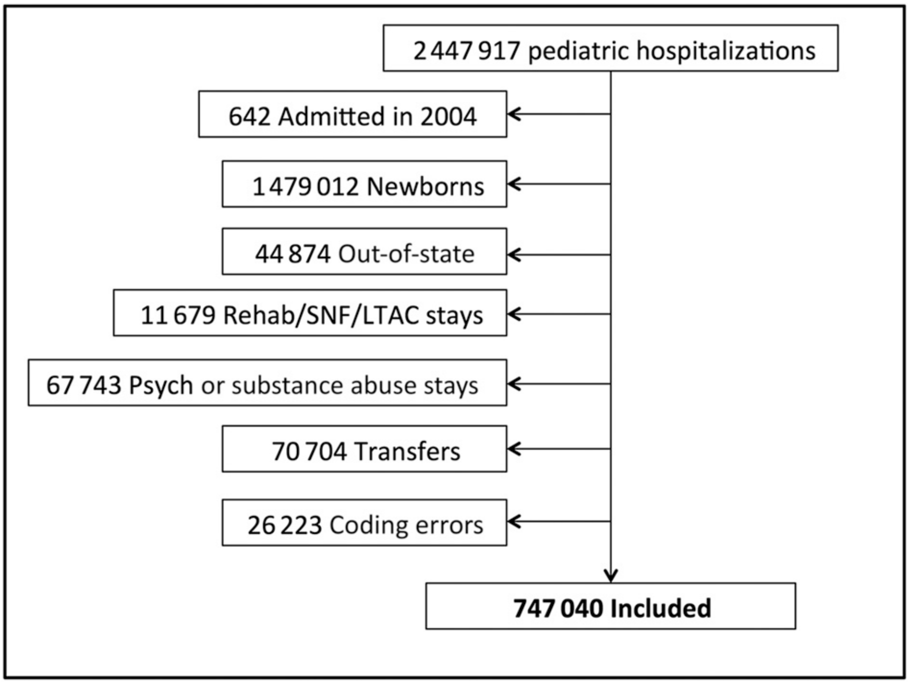

FIGURE 1 Patient inclusion algorithm. Psych, psychiatric; Rehab/SNF/LTAC, rehabilitation/skilled nursing facility/long-term acute care.

immunocompromised or transplant patients, or patients with underlying renal disease or anomalies. Patients transferred from another facility and pregnant patients are excluded from all potentially preventable definitions.

Descriptive statistics were calculated to show trends over time and associated costs and hospital days spent on potentially preventable admissions. Univariate logistic regression analyses were used to test whether there were differences in potentially preventable admissions and all other admissions for each patient and hospital variable that might plausibly affect ACSCs. A hierarchical multivariable logistic regression clustered according to admitting hospital and adjusted for year and quarter of admission estimated the odds ratios (ORs) and 95% confidence intervals (CIs) associated with potentially preventable admission for patient and hospital factors. Hospitals with <50 total admissions per year are deidentified in the Texas Inpatient Public Use Data File, leaving 1093 pediatric admissions from these small hospitals clustered as a single hospital among the 373 hospitals in the analysis. The model was then repeated separately for each of the 5 potentially preventable diagnoses. The local institutional review board determined that this research was exempt from their review as authorized by 45 CFR 46.101, category 4.

RESULTS

Rates and Costs

There were 747 040 pediatric admissions in the state of Texas in the 4-year period studied, of which 105 055 (14.1%) were potentially preventable according to the AHRQ criteria. Rates of potentially preventable admission declined overall between 2005 and 2008 (Supplemental Fig 2). Rates of asthma and gastroenteritis (seasonal diseases) varied according to quarter, whereas rates of perforated appendicitis and the other nonseasonal diagnoses remained constant throughout each year (Supplemental Fig 3). An average of 71 444 hospital days per year were attributed to the 5 AHRQ potentially preventable admissions, generating $1.2 billion in hospital charges over the 4-year study period, or $304 million per year. The AHRQ potentially preventable admissions were less expensive ($7752 median charge per admission; interquartile range: $4870–$12 978) and shorter (2-day median length of stay; interquartile range: 2–3 days) than all other admissions. The exception was perforated appendicitis, which had a longer and more expensive course than all other admissions (Table 1).

Demographic Characteristics and Results of Univariate Analysis

The percentage of potentially preventable admissions of each type within each patient and hospital characteristic group are presented in Table 2. Rates of AHRQ potentially preventable admissions were highest in children ages 5 to 9 years (22%) with the exception of gastroenteritis, which was highest in children aged <5 years. AHRQ potentially preventable admissions were also more frequent in male subjects with the exception of UTI. These admissions were more frequent along the border with Mexico, in the Rio Grande Valley, and at critical access hospitals.

Univariate comparisons are described in Table 3. Of hospitalized subjects, younger children had higher odds than teenagers aged >14 years of experiencing 1 of the AHRQ potentially preventable admissions, as

TABLE 1 Impact of Potentially Preventable Admissions in Children

Variable	Total No. (%) of Admissions	Total Length of Stay, d	Median Length of Stay (IQR)	Total Charges, $ Millions	Median Charges, $ (IQR)
Asthma	35 763 (4.8)	84 772	2 (1–3)	408	8682 (5913–13 071)
Diabetes	4868 (0.7)	12 951	2 (2–3)	74	12 799 (8260–18 319)
Gastroenteritis	39 712 (5.3)	88 923	2 (1–3)	273	5240 (3525–7915)
Perforated appendicitis	8538 (1.1)	48 782	5 (3–7)	291	27 820 (19 936–38 218)
UTI	16 174 (2.2)	50 347	3 (2–4)	171	8553 (5869–12 386)
All potentially preventable	105 055 (14.1)	285 775	2 (2–3)	1217	7752 (4870–12 978)
All other admissions	641 985 (85.9)	2 599 949	2 (2–4)	14 100	10 472 (6144–19 019)

IQR, interquartile range.

did boys and black, Native-American, and Hispanic subjects. Hospitalized children living in poor zip codes, in counties in the Rio Grande Valley, or on the border with Mexico had higher odds of experiencing an AHRQ potentially preventable admission rather than any other admission, whereas children living in rural areas had slightly lower odds. Privately insured children had higher odds of experiencing an AHRQ potentially preventable admission than children who were uninsured or who had government-sponsored insurance. Increasing complexity of a comorbid illness decreased the odds that an admission was for a potentially preventable AHRQ diagnosis, as did comorbid mental health or substance use disorders. Hospital factors associated with an AHRQ potentially preventable admission rather than any other admission included that the admission was emergent or urgent, that it occurred on a weekend, and that the hospital was a critical access or trauma hospital. Pediatric and teaching hospitals had lower odds of experiencing an AHRQ potentially preventable admission, as did larger hospitals with more beds and more emergency visits annually.

Results of Multivariable Analysis

Age <15 years (OR: 2.88 [95% CI: 2.80–2.96] for ages 0–4 years]; OR: 5.01 [95% CI: 4.85–5.16] for ages 5–9 years; OR: 3.03 [95% CI: 2.94–3.13] for ages 10–14 years), male sex (OR: 1.03 [95% CI: 1.01–1.04]), black race (OR: 1.48 [95% CI: 1.45–1.52]) or Hispanic ethnicity (OR: 1.06 [95% CI: 1.04–1.08]), lower income (OR: 1.11 [95% CI: 1.02–1.20]), comorbid substance abuse disorder (OR: 2.03 [95% CI: 1.75–2.34]), and an emergent (OR: 2.16 [95% CI: 2.12–2.21]) or urgent (OR: 1.44 [95% CI: 1.40–1.48]) admission on a weekend (OR: 1.05 [95% CI: 1.03–1.06]) or to a critical access hospital (OR: 1.61 [95% CI: 1.20–2.14]) remained highly correlated with the 5 AHRQ potentially preventable admissions on hierarchical multivariable analysis. Native-American race (OR: 0.91 [95% CI: 0.85–0.98]), government insurance (OR: 0.83 [95% CI: 0.82–0.84]) or no insurance (OR: 0.93 [95% CI: 0.89–0.96]), living in a rural county (OR: 0.70 [95% CI: 0.68–0.73]), having a comorbid mental health disorder (OR: 0.59 [95% CI: 0.57–0.62]), or having a higher comorbidity index (OR: 0.35 [95% CI: 0.34–0.36]) were lower risk factors (Table 4).

Variations in Multivariable Results According to Diagnosis

Some factors varied from high to low odds depending on the type of potentially preventable diagnosis tested. Admissions of patients ages 0 to 4 years had higher odds of being potentially preventable than those of patients ages 15 to 17 years for all diagnoses (OR range: 2.95 for UTI to 8.97 for gastroenteritis) except short-term complications of diabetes and perforated appendicitis (OR range: 0.10 for diabetes to 0.27 for appendicitis). Admissions of male subjects had higher odds of being potentially preventable for asthma or perforated appendicitis (OR range: 1.51 for asthma to 1.57 for appendicitis) but lower odds for UTI or short-term complications of diabetes (OR range: 0.37 for UTI to 0.84 for diabetes). Black children had higher odds of a potentially preventable admission for asthma (OR: 3.41 [95% CI: 3.29–3.52]) but no difference for short-term complications of diabetes and lower odds of potentially preventable admission for all other diagnoses (OR: 0.41–0.69). Hispanic children had higher odds of potentially preventable admission for UTI and perforated appendicitis (OR range: 1.26 for UTI to 2.14 for appendicitis) but no difference for asthma and lower odds for short-term complications of diabetes and gastroenteritis (OR range: 0.59 for diabetes to 0.91 for gastroenteritis).

Uninsured patients had lower odds of potentially preventable admissions for short-term complications of diabetes, gastroenteritis, and UTI (OR: 0.70–0.88) but higher odds for asthma and perforated appendicitis (OR range: 1.11 for asthma to 1.27 for appendicitis). Children in the lowest income quartile had higher odds of potentially preventable admission for asthma and UTI (OR range: 1.24 for asthma to 1.51 for UTI), but no difference was found for any other diagnosis type. For UTI, all income levels below the highest quartile had higher odds of potentially preventable admission than children whose families earn more than $74 999 per year, but moderate income children did not have higher odds of any other diagnosis. Among hospitalized children, those with comorbid mental health disorders had lower odds of potentially preventable admission for all diagnoses (OR: 0.33–0.69), with the exception of short-term complications of diabetes, for which they had higher odds (OR: 1.25 [95% CI: 1.13–1.38]). Comorbid substance abuse was associated with higher odds for potentially preventable asthma, short-term complications of

TABLE 2 Demographic Characteristics of Potentially Preventable Admissions According to Diagnosis (Compared With all Admissions, N = 747 040)

Characteristic	Asthma	Perforated Appendicitis	Diabetes	Gastroenteritis	UTI	All Potentially Preventable
No. of preventable admissions	35 763 (4.8)	8538 (1.1)	4868 (0.7)	39 712 (5.3)	16 174 (2.2)	105 055 (14.1)
Patient factors						
Age, y						
0–4[a]	16 799 (4.4)	1280 (0.3)	Excluded	31 830 (8.3)	11 120 (2.9)	61 029 (15.8)
5–9[a]	12 156 (11.6)	2920 (2.8)	935 (0.9)	4496 (4.3)	2258 (2.2)	22 765 (21.8)
10–14	5376 (5.3)	3132 (3.1)	2132 (2.1)	2090 (2.1)	1084 (1.1)	13 814 (13.7)
15–17	1432 (0.9)	1206 (0.8)	1801 (1.2)	1296 (0.8)	1712 (1.1)	7447 (4.8)
Sex						
Male	22 503 (6.2)	5221 (1.4)	2177 (0.6)	21 442 (5.6)	4809 (1.3)	56 152 (15.4)
Female	13 260 (3.5)	3317 (0.9)	2691 (0.7)	18 270 (4.8)	11 365 (2.3)	48 903 (12.8)
Race						
White	17 155 (3.9)	5615 (1.3)	3177 (0.7)	23 468 (5.3)	9992 (2.3)	59 407 (13.5)
Black	9496 (10.4)	401 (0.4)	930 (1.0)	2704 (3.0)	1004 (1.1)	14 535 (15.9)
Asian	419 (4.5)	109 (1.2)	41 (0.4)	436 (4.7)	198 (2.1)	1203 (12.9)
Native American	1207 (6.2)	172 (0.9)	53 (0.3)	1058 (5.4)	486 (2.5)	2976 (15.2)
Other	7367 (4.0)	2235 (1.2)	664 (0.4)	11 880 (6.5)	4430 (2.4)	26 576 (14.5)
Hispanic ethnicity	14 186 (4.1)	5290 (1.5)	1359 (0.4)	20 107 (5.8)	9091 (2.6)	50 033 (14.4)
Not Hispanic	21 476 (5.4)	3235 (0.8)	3503 (0.9)	19 501 (4.9)	7040 (1.8)	54 755 (13.7)
Insurance status						
Private	14 074 (5.1)	3567 (1.3)	2658 (1.0)	14 776 (5.3)	5090 (1.8)	40 165 (14.5)
Government	19 484 (4.5)	4158 (1.0)	1919 (0.5)	23 453 (5.5)	10 302 (2.4)	59 316 (13.8)
Uninsured	2176 (5.5)	808 (2.0)	289 (0.7)	1387 (3.5)	770 (1.9)	5430 (13.6)
Median income level, $						
<25 000	18 070 (4.8)	4361 (1.2)	1867 (0.5)	22 149 (5.9)	9140 (2.4)	55 587 (14.8)
25 000–49 999	15 193 (4.8)	3501 (1.1)	2491 (0.8)	15 071 (4.8)	6088 (1.9)	42 344 (13.4)
50 000–74 999	1822 (4.5)	504 (1.3)	367 (0.9)	1724 (4.3)	687 (1.7)	5104 (12.6)
≥75 000	289 (4.0)	94 (1.3)	73 (1.0)	308 (4.3)	99 (1.38)	863 (12.0)
Home in rural county	3535 (3.7)	816 (0.9)	579 (0.6)	6243 (6.6)	1955 (2.1)	13 128 (13.8)
Home in border county	5345 (3.8)	1669 (1.2)	436 (0.3)	12 318 (8.9)	4517 (3.3)	24 285 (17.5)
Home in Rio Grande Valley	5085 (3.9)	1419 (1.1)	238 (0.2)	11 086 (8.4)	4031 (3.1)	21 859 (16.7)
Charlson comorbidity index[b]	0.021 (0–6)	0.047 (0–2)	0.107 (0–4)	0.061 (0–6)	0.055 (0–6)	0.048 (0–6)
Comorbid mental health disorder	906 (2.6)	198 (0.6)	495 (1.4)	858 (1.7)	282 (0.8)	2466 (7.0)
ADHD	431 (3.3)	133 (1.0)	149 (1.1)	215 (1.6)	87 (0.7)	1015 (7.7)
Autism	78 (3.2)	23 (0.9)	19 (0.8)	91 (3.7)	19 (0.8)	230 (9.4)
Mental retardation	224 (2.9)	14 (0.2)	15 (0.2)	207 (2.7)	81 (1.0)	541 (6.9)
Schizophrenia/bipolar	63 (0.9)	14 (0.2)	138 (2.0)	48 (0.7)	55 (0.8)	318 (4.6)
Anxiety	141 (2.4)	14 (0.2)	40 (0.7)	54 (0.9)	20 (0.3)	269 (4.5)
Depression	71 (1.5)	15 (0.3)	194 (4.2)	47 (1.0)	48 (1.03)	375 (8.0)
Comorbid substance abuse	82 (3.4)	23 (1.0)	49 (2.0)	31 (1.3)	51 (2.1)	236 (9.7)

TABLE 2 Continued

Characteristic	Asthma	Perforated Appendicitis	Diabetes	Gastroenteritis	UTI	All Potentially Preventable
Hospital factors						
Admission type						
Emergent	22 876 (6.6)	6323 (1.8)	3809 (1.1)	18 613 (5.4)	9265 (2.7)	60 886 (17.5)
Urgent	6931 (4.1)	1172 (0.7)	602 (0.4)	10 078 (6.0)	3337 (2.0)	22 120 (13.1)
Elective	5832 (2.6)	996 (0.5)	425 (0.2)	10 675 (4.8)	3444 (1.6)	21 372 (9.6)
Trauma	12 (0.7)	1 (0.1)	2 (0.1)	18 (1.0)	5 (0.3)	38 (2.2)
Weekend admit	9674 (5.6)	2233 (1.3)	1233 (0.7)	9791 (5.7)	3880 (2.3)	26 811 (15.6)
No. of hospital beds (in hundreds)[c]	2.93 (1.79–4.51)	3.12 (1.96–4.58)	3.14 (2.45–4.58)	2.48 (1.60–3.66)	2.82 (1.75–4.58)	2.82 (1.71–4.19)
Annual emergency department visits (in thousands)[c]	54.6 (32.8–79.4)	56.9 (33.3–79.4)	66.2 (45.2–90.6)	37.3 (23.9–57.9)	44.4 (26.3–61.8)	46.4 (26.7–66.2)
Children's hospital	11 749 (5.8)	2928 (1.4)	2302 (1.1)	5227 (2.6)	3260 (1.6)	25 466 (12.5)
Not a children's hospital	24 014 (4.4)	5610 (1.0)	2566 (0.5)	34 485 (6.4)	12 914 (2.4)	79 589 (14.7)
Teaching hospital	8771 (4.5)	2408 (1.2)	2071 (1.1)	4061 (2.1)	3135 (1.6)	20 446 (10.4)
Not a teaching hospital	26 992 (4.9)	6130 (1.1)	2797 (0.5)	35 651 (6.5)	13 039 (2.4)	84 609 (15.4)
Critical access hospital	554 (5.4)	103 (1.0)	100 (1.0)	943 (9.2)	259 (2.5)	1959 (19.1)
Not a critical access hospital	35 209 (4.8)	8435 (1.1)	4768 (0.7)	38 769 (5.3)	15 915 (2.2)	103 096 (14.0)
Trauma hospital	20 212 (4.8)	4600 (1.1)	2881 (0.7)	24 617 (6.0)	9458 (2.3)	61 768 (15.0)
Not a trauma hospital	15 551 (4.6)	3938 (1.2)	1987 (0.6)	15 095 (4.5)	6716 (2.0)	43 287 (12.9)

Data are presented as *n* (% preventable) unless otherwise indicated. Percentage is calculated by dividing the percentage of preventable admissions presented in Table 2 by the total number of admissions in each row/category (number not presented). For example, 35 763 preventable asthma admissions represent 4.8% of all 747 040 admissions, whereas 16 799 preventable asthma admissions in patients aged 0 to 4 years represent 4.4% of all 385c758 admissions of children aged 0 to 4 years. ADHD, attention-deficit/hyperactivity disorder.

[a] Due to exclusionary criteria, patients with asthma aged <2 years, gastroenteritis <3 months, and UTI <3 months were excluded from the 0- to 4-year-old category for these columns. Children aged <6 years with diabetes were also excluded from the 5- to 9-year-old category.

[b] Mean (range).

[c] Median (interquartile range).

diabetes, and UTI (OR: 1.47–3.24) but did not change the odds for perforated appendicitis or gastroenteritis. Increasing scores on the Charlson comorbidity index was the only patient factor associated with lower odds of potentially preventable admission for all diagnoses (OR: 0.14–0.67 per point).

Associated.hospital factors also varied according to diagnosis. Admissions at children's hospitals had higher odds of being potentially preventable for asthma and perforated appendicitis (range of ORs between diagnoses: 1.27–1.27). whereas those at critical access hospitals had higher odds for asthma, gastroenteritis, and UTI (range of ORs between diagnoses: 1.73–1.78). Admissions at teaching hospitals had lower odds of being potentially preventable only for asthma, perforated appendicitis, and gastroenteritis (OR: 0.58–0.79).

DISCUSSION

This study found that 14% of pediatric admissions in the state of Texas were potentially preventable, generating $304 million in charges annually. Younger age, male sex, black race or Hispanic ethnicity, lower income, comorbid substance abuse disorder, and admission to a critical access hospital were associated with higher odds that an admission was potentially preventable; government or no insurance, living in a rural county, having a comorbid mental health disorder, and having more comorbid disease were associated with lower odds.

Minority race has previously been correlated with potentially preventable admission and other poor outcomes,[3,15] but Medicaid insurance,[15,16] rural residence,[17] and mental health disorders[18] also typically correlate with poor outcomes; the opposite was found here. However, most factors varied from high to low odds depending on which of the 5 potentially preventable diagnoses was examined. The 5 diagnoses are different in their etiologies and contributing factors, and preventability relies on primary and preventative care before hospital admission.[9] Asthma and diabetes admissions are acute exacerbations of chronic illness, and prevention involves patient education on environmental and dietary triggers, and

TABLE 3 Unadjusted ORs of Characteristics Associated With Potentially Preventable Admissions

Characteristic	All Potentially Preventable	Asthma	Perforated Appendicitis	Diabetes	Gastroenteritis	UTI
Patient factors						
Age, y						
0–4[a]	3.75 (3.66–3.84)	11.25 (10.66–11.88)	0.93 (0.86–1.00)	Combined with 5–9 y group	10.74 (10.15–11.35)	2.68 (2.54–2.82)
5–9[a]	5.56 (5.41–5.72)	14.20 (13.41–14.98)	3.68 (3.44–3.94)	0.77 (0.71–0.84)	5.37 (5.05–5.72)	1.99 (1.87–2.12)
10–14	3.17 (3.07–3.26)	6.06 (5.72–6.43)	4.10 (3.83–4.38)	1.85 (1.73–1.97)	2.53 (2.36–2.71)	0.98 (0.91–1.06)
15–17	Ref					
Male sex	1.24 (1.22–1.26)	2.08 (2.04–2.13)	1.86 (1.78–1.94)	0.95 (0.89–1.00)	1.24 (1.22–1.27)	0.44 (0.42–0.45)
Race						
White	Ref					
Black	1.22 (1.19–1.24)	2.72 (2.65–2.80)	0.32 (0.29–0.35)	1.31 (1.22–1.41)	0.54 (0.52–0.57)	0.48 (0.45–0.51)
Asian	0.95 (0.90–1.02)	1.29 (1.17–1.43)	1.01 (0.84–1.23)	0.68 (0.50–0.92)	0.88 (0.79–0.96)	0.94 (0.81–1.08)
Native American	1.15 (1.11–1.20)	1.71 (1.61–1.82)	0.72 (0.61–0.83)	0.38 (0.29–0.50)	1.02 (0.95–1.08)	1.10 (1.00–1.20)
Other	1.09 (1.07–1.11)	1.04 (1.02–1.07)	0.97 (0.92–1.02)	0.51 (0.47–0.55)	1.23 (1.20–1.26)	1.07 (1.03–1.11)
Hispanic	1.06 (1.04–1.07)	0.79 (0.77–0.81)	2.00 (1.91–2.09)	0.47 (0.44–0.50)	1.20 (1.17–1.22)	1.50 (1.45–1.54)
Insurance status						
Private	Ref					
Government	0.94 (0.93–0.95)	0.88 (0.87–0.90)	0.75 (0.71–0.78)	0.46 (0.44–0.49)	1.02 (1.00–1.04)	1.31 (1.26–1.35)
Uninsured	0.93 (0.90–0.96)	1.08 (1.03–1.13)	1.58 (1.47–1.71)	0.75 (0.67–0.85)	0.64 (0.60–0.68)	1.05 (0.91–1.13)
Median income level, $						
<25 000	1.28 (1.19–1.37)	1.32 (1.17–1.48)	0.96 (0.78–1.18)	0.53 (0.42–0.67)	1.40 (1.25–1.57)	1.79 (1.47–2.19)
25 000–49 999	1.14 (1.06–1.22)	1.29 (1.13–1.45)	0.90 (0.73–1.10)	0.2 (0.65–1.04)	1.12 (1.00–1.26)	1.41 (1.15–1.72)
50 000–74 999	1.06 (0.98–1.15)	1.18 (1.04–1.34)	1.00 (0.80–1.25)	0.93 (0.73–1.20)	1.00 (0.88–1.13)	1.24 (1.00–1.53)
≥75 000	Ref					
Home in rural county	0.97 (0.95–0.99)	0.74 (0.71–0.77)	0.72 (0.67–0.77)	0.93 (0.85–1.01)	1.29 (1.26–1.33)	0.94 (0.89–0.98)
Home in border county	1.38 (1.36–1.40)	0.77 (0.75–0.80)	1.09 (1.03–1.15)	0.44 (0.40–0.49)	2.06 (2.01–2.11)	1.72 (1.66–1.78)
Home in Rio Grande Valley	1.28 (1.26–1.30)	0.78 (0.75–0.80)	0.95 (0.90–1.01)	0.25 (0.22–0.28)	1.89 (1.85–1.94)	1.57 (1.52–1.63)
Charlson comorbidity index[b]	0.39 (0.38–0.40)	0.20 (0.19–0.22)	0.41 (0.38–0.45)	0.76 (0.71–0.81)	0.50 (0.48–52)	0.47 (0.44–0.50)
Comorbid mental health disorder	0.47 (0.45–0.49)	0.30 (0.28–0.32)	0.30 (0.26–0.34)	1.48 (1.36–1.62)	0.29 (0.27–0.32)	0.35 (0.31–0.40)
ADHD	0.50 (0.47–0.54)	0.44 (0.40–0.49)	0.60 (0.50–0.71)	1.20 (1.02–1.41)	0.29 (0.25–0.33)	0.29 (0.24–0.36)
Autism	0.64 (0.56–0.73)	0.66 (0.52–0.82)	0.82 (0.55–1.24)	1.20 (0.76–1.88)	0.69 (0.56–0.85)	0.35 (0.23–0.56)
Mental retardation	0.45 (0.42–0.50)	0.46 (0.41–0.53)	0.12 (0.07–0.21)	0.23 (0.14–0.39)	0.48 (0.42–0.55)	0.47 (0.38–0.59)
Schizophrenia/bipolar	0.30 (0.26–0.33)	0.15 (0.13–0.18)	0.14 (0.09–0.20)	3.20 (2.87–3.57)	0.12 (0.09–0.17)	0.36 (0.28–0.47)
Anxiety	0.30 (0.26–0.33)	0.32 (0.27–0.38)	0.13 (0.08–0.23)	0.76 (0.56–1.02)	0.16 (0.12–0.21)	0.15 (0.10–0.24)
Depression	0.53 (0.48–0.59)	0.31 (0.24–0.39)	0.28 (0.17–0.46)	6.83 (5.90–7.91)	0.18 (0.13–0.24)	0.47 (0.35–0.62)
	0.66 (0.58–0.75)	0.15 (0.13–0.18)	0.17 (0.12–0.25)	1.09 (0.90–1.32)	0.23 (0.16–0.33)	0.97 (0.73–1.28)

TABLE 3 Continued

Characteristic	All Potentially Preventable	Asthma	Perforated Appendicitis	Diabetes	Gastroenteritis	UTI
Comorbid substance abuse						
Hospital factors						
Admission type						
Emergent	2.00 (1.96–2.03)	2.65 (2.58–2.73)	4.13 (3.86–4.41)	5.83 (5.28–6.45)	1.12 (1.09–1.15)	1.74 (1.67–1.81)
Urgent	1.41 (1.39–1.44)	1.63 (1.57–1.69)	1.58 (1.45–1.72)	1.90 (1.68–2.15)	1.26 (1.22–1.29)	1.28 (1.22–1.34)
Elective	Ref					
Trauma	0.21 (0.15–0.29)	0.20 (0.11–0.36)	0.10 (0.01–0.72)	0.47 (0.12–1.89)	0.21 (0.13–0.33)	0.18 (0.08–0.44)
Weekend admit	1.17 (1.16–1.19)	1.26 (1.23–1.29)	1.19 (1.13–1.25)	1.15 (1.08–1.22)	1.10 (1.07–1.13)	1.06 (1.02–1.10)
No. of hospital beds (in hundreds)[c]	0.96 (0.956–0.961)	1.00 (0.996–1.004)	1.01 (1.005–1.02)	0.98 (0.97–0.99)	0.90 (0.899–0.907)	0.97 (0.97–0.98)
Annual emergency department visits (in thousands)[c]	0.998 (0.998–0.998)	1.00 (1.00–1.00)	1.00 (1.002–1.003)	1.01 (1.005–1.006)	0.99 (0.987–0.988)	0.996 (0.996–0.997)
Children's hospital	0.84 (0.83–0.85)	1.35 (1.32–1.38)	1.41 (1.35–1.48)	2.42 (2.29–2.56)	0.39 (0.38–0.40)	0.67 (0.64–0.69)
Teaching hospital	0.64 (0.63–0.66)	0.87 (0.85–0.89)	1.06 (1.01–1.11)	2.00 (1.89–2.12)	0.31 (0.30–0.32)	0.67 (0.64–0.70)
Critical access hospital	1.46 (1.39–1.54)	1.21 (1.11–1.32)	0.93 (0.76–1.13)	1.63 (1.34–1.99)	1.83 (1.71–1.96)	1.18 (1.04–1.33)
Trauma hospital	1.21 (1.19–1.22)	1.06 (1.04–1.08)	0.95 (0.91–0.99)	1.18 (1.11–1.25)	1.36 (1.33–1.38)	1.16 (1.12–1.19)

Data are presented as OR (95% CI) unless otherwise indicated. ADHD, attention-deficit/hyperactivity disorder.
[a] Due to exclusionary criteria, patients with asthma aged <2 years, gastroenteritis <3 months, and UTI <3 months were excluded from the 0- to 4-year-old category for these columns. Children aged <6 years with diabetes were also excluded from the 5- to 9-year-old category.
[b] Mean (range).
[c] Median (interquartile range).

regular ambulatory visits to adjust preventative medication dosages. Gastroenteritis and UTI are infectious conditions that may not be preventable, but with timely initiation of antibiotics for UTIs or antiemetic agents and oral hydration for gastroenteritis, they could be treated in the outpatient setting. This scenario requires both an astute caregiver and quick access to a sick appointment, which is limited in small or busy practices and those with no after-hours appointments.[19] Similarly, appendicitis rupture can only be prevented with early diagnosis and referral for surgical management. Qualitative exploration with parents and physicians about progression versus early prevention of each of the 5 conditions may provide areas for systemic improvement or further research into their prevention.

Fourteen percent of pediatric admissions were potentially preventable according to the AHRQ definition in Texas, much higher than in Tennessee, where 4.8% were potentially preventable according to the AHRQ definition.[12] The prevalence of potentially preventable admissions in Texas according to the AHRQ definition (limited to 5 diagnoses) also differs from that found by using other definitions which may be more or less inclusive, such as Florida where 7% were potentially preventable,[7] the 33% rate found in 38 states,[2] the 28% rate at a single center based on admitting physician opinion,[8] and an 11% to 15% rate in New York.[3] The $304 million in charges and 71 444 hospital days per year attributed to potentially preventable admissions in this study in Texas, the nation's second largest state with 8.5% of the US population,[20] are proportional with estimates of $4 billion and 1 million hospital-days in 1 year in the 38 states in the Kids' Inpatient Database.[2]

Similar to previous studies,[2,3,12] we found that black and Hispanic children had higher odds of potentially preventable admissions than white children who were hospitalized. Race and ethnicity have also been reported as risk factors for pediatric readmissions[21,22] and potentially preventable admissions for adults.[23] However, asthma was the only diagnosis in which black race increased the odds that the admission was

TABLE 4 Multivariable Analysis of Factors Associated With Potentially Preventable Admissions in Children

Characteristic	All Potentially Preventable Admissions	Asthma	Perforated Appendicitis	Diabetes	Gastroenteritis	UTI
Patient factors						
Age, y						
0–4[a]	2.88 (2.8–2.96)[e]	3.29 (3.10–3.49)[e]	0.27 (0.24–0.29)[e]	Combined 0–9 y group[b]	8.97 (8.44–9.52)[e]	2.95 (2.79–3.13)[e]
5–9[a]	5.01 (4.85–5.16)[e]	10.96 (10.32–11.64)[e]	2.55 (2.34–2.75)[e]	0.10 (0.09–0.10)[e]	5.14 (4.81–5.50)[e]	2.47 (2.30–2.64)[e]
10–14	3.03 (2.94–3.13)[e]	4.92 (4.62–5.24)[e]	3.17 (2.94–3.42)[e]	1.06 (0.98–1.13)	2.60 (2.42–2.80)[e]	1.25 (1.15–1.36)[e]
15–17	Ref					
Male sex	1.03 (1.01–1.04)[e]	1.51 (1.48–1.55)[e]	1.57 (1.50–1.65)[e]	0.84 (0.79–0.89)[e]	1.00 (0.98–1.03)	0.37 (0.35–0.38)[e]
Race						
White	Ref					
Black	1.48 (1.45–1.52)[e]	3.41 (3.29–3.52)[e]	0.41 (0.36–0.45)[e]	1.02 (0.94–1.11)	0.69 (0.66–0.72)[e]	0.58 (0.54–0.62)[e]
Asian	0.95 (0.89–1.02)	1.13 (1.01–1.25)[e]	1.25 (1.01–1.54)[e]	0.70 (0.51–0.97)[e]	0.81 (0.72–0.90)[e]	0.94 (0.80–1.10)
Native American	0.91 (0.85–0.98)[e]	0.92 (0.83–1.02)	0.65 (0.48–0.88)[e]	1.23 (0.84–1.79)	1.04 (0.94–1.16)	0.81 (0.68–0.95)[e]
Other	0.97 (0.95–0.99)[e]	1.00 (0.96–1.04)	0.90 (0.84–0.97)[e]	0.99 (0.90–1.10)	0.96 (0.92–0.99)[e]	0.86 (0.82–0.91)[e]
Hispanic	1.06 (1.04–1.08)[e]	1.02 (0.98–1.06)	2.14 (2.01–2.28)[e]	0.59 (0.54–0.64)[e]	0.91 (0.88–0.95)[e]	1.26 (1.21–1.33)[e]
Insurance status						
Private	Ref					
Government	0.83 (0.82–0.84)[e]	0.88 (0.86–0.91)[e]	0.89 (0.84–0.94)[e]	0.71 (0.66–0.76)[e]	0.77 (0.75–0.79)[e]	1.04 (1.00–1.09)[e]
Uninsured	0.93 (0.89–0.96)[e]	1.11 (1.05–1.17)[e]	1.27 (1.16–1.38)[e]	0.83 (0.72–0.95)[e]	0.70 (0.66–0.74)[e]	0.88 (0.81–0.96)[e]
Median income level, $						
<25 000	1.11 (1.02–1.20)[e]	1.24 (1.09–1.42)[e]	1.12 (0.89–1.42)	0.83 (0.65–1.08)	0.88 (0.78–1.01)	1.51 (1.21–1.89)[e]
25 000–49 999	1.09 (1.00–1.18)[e]	1.13 (0.99–1.28)	1.02 (0.81–1.28)	0.89 (0.70–1.15)	0.94 (0.83–1.07)	1.42 (1.14–1.78)[e]
50 000–74 999	1.03 (0.95–1.12)	1.05 (0.92–1.20)	1.04 (0.82–1.33)	0.97 (0.74–1.27)	0.93 (0.81–1.06)	1.30 (1.03–1.64)[e]
≥75 000	Ref					
Home in rural county	0.70 (0.68–0.73)[e]	0.59 (0.56–0.63)[e]	0.89 (0.81–0.99)[e]	0.95 (0.84–1.07)	0.82 (0.78–0.86)[e]	0.76 (0.70–0.82)[e]
Charlson comorbidity index[c]	0.35 (0.34–0.36)[e]	0.14 (0.13–0.15)[e]	0.37 (0.34–0.40)[e]	0.67 (0.62–0.72)[e]	0.54 (0.52–0.56)[e]	0.54 (0.51–0.58)[e]
Comorbid mental health disorder	0.59 (0.57–0.62)[e]	0.52 (0.49–0.56)[e]	0.33 (0.29–0.39)[e]	1.25 (1.13–1.38)[e]	0.69 (0.63–0.75)[e]	0.65 (0.57–0.73)[e]
Comorbid substance abuse	2.03 (1.75–2.34)[e]	3.24 (2.54–4.13)[e]	1.09 (0.72–1.65)	1.47 (1.09–2.00)[e]	1.31 (0.91–1.88)	2.21 (1.65–2.96)[e]
Hospital factors						
Admission type						
Emergent	2.16 (2.12–2.21)[e]	2.14 (2.07–2.22)[e]	4.82 (4.46–5.20)[e]	7.42 (6.60–8.34)[e]	1.42 (1.38–1.46)[e]	2.01 (1.91–2.10)[e]
Urgent	1.44 (1.40–1.48)[e]	1.47 (1.41–1.54)[e]	1.77 (1.61–1.96)[e]	2.27 (1.97–2.61)[e]	1.28 (1.24–1.33)[e]	1.23 (1.16–1.30)[e]
Elective	Ref					
Trauma	0.31 (0.22–0.43)[e]	0.36 (0.20–0.64)[e]	0.14 (0.02–0.99)[e]	0.60 (0.15–2.44)	0.37 (0.23–0.59)[e]	0.29 (0.12–0.70)[e]
Weekend admit	1.05 (1.03–1.06)[e]	1.11 (1.08–1.14)[e]	0.98 (0.94–1.04)	0.97 (0.90–1.04)	1.05 (1.02–1.08)[e]	0.96 (0.92–0.99)[e]
No. of hospital beds (per 100)[d]	1.00 (0.99–1.02)	0.96 (0.94–0.98)[e]	0.99 (0.96–1.02)	0.96 (0.91–1.01)	1.03 (1.01–1.05)[e]	0.97 (0.95–0.99)[e]
Children's hospital	1.05 (0.94–1.16)	1.27 (1.08–1.49)[e]	1.27 (1.01–1.59)[e]	1.41 (0.97–2.04)	0.94 (0.76–1.15)	0.92 (0.74–1.13)
Teaching hospital	0.99 (0.88–1.11)	0.78 (0.64–0.97)[e]	0.58 (0.43–0.76)[e]	1.31 (0.95–1.80)	0.79 (0.64–0.99)[e]	1.03 (0.85–1.26)
Critical access hospital	1.61 (1.20–2.14)[e]	1.73 (1.19–2.52)[e]	0.96 (0.60–1.54)	1.51 (0.74–3.08)	1.78 (1.22–2.59)[e]	1.75 (1.23–2.49)[e]

Data are presented as OR (95% CI).

[a] Due to exclusionary criteria, patients with asthma aged <2 years, gastroenteritis <3 months, and UTI <3 months are excluded from the 0- to 4-year-old category for these columns. Children aged <6 years with diabetes are also excluded from the 5- to 9-year-old category.

[b] According to AHRQ criteria, patients aged <5 years were excluded from potentially preventable diabetes admission.

[c] Odds per additional point.

[d] Odds per additional 100 beds.

[e] Statistically significant.

potentially preventable, and black subjects actually had lower odds than white subjects that their admissions for all other diagnoses were potentially preventable except for diabetes, which was not significantly different. Similarly, Hispanic subjects had twice the odds of having perforated appendicitis and 26% higher odds of having a potentially preventable UTI than non-Hispanic subjects, but they had lower odds of having a potentially preventable diabetes or gastroenteritis admission. The variability in specific diagnosis frequencies could relate to biological differences in disease prevalence or severity[24] or provider stereotyping of the conditions prevalent in different races.[25] Inequalities in access to care may also contribute but would be expected to be more equal across conditions.

Surprisingly, privately insured children had the highest odds that their admission was potentially preventable, with government insurance decreasing odds by 27% and being uninsured decreasing odds by 7%, whereas previous research has shown that uninsured[6] or publicly insured[12] children are more likely to have potentially preventable admissions than privately insured children. Patients with private insurance theoretically have better access to primary and preventative care[26] and, therefore, lower rates of potentially preventable admissions. However, the increased odds for the privately insured found in the present study may be a measure of overuse as it is possible that hospitals have a monetary incentive to admit rather than discharge patients with a payment source, similar to findings in the adult trauma population.[27] The influence of insurance on access to care also varies geographically based on different availability of local resources in rural, urban, or underserved urban areas, such as federally qualified health centers or rural health clinics,[28] which was not captured in this study.

The relationship between where patients reside and potentially preventable admissions was also highlighted in our study. Unlike previous studies,[5,29] living in a rural county decreased the odds that an admission was potentially preventable for all diagnoses except diabetes. In addition, low income as measured according to residence in a zip code with low median income increased the odds of potentially preventable admission for UTI and asthma, as similarly reported in previous pediatric research[5,6] (particularly on asthma[30]) and in adults.[23]

For patients with comorbid illness, admissions had lower odds of being potentially preventable. This finding may be a result of the exclusion of many patients with comorbid illnesses (eg, cystic fibrosis) from the AHRQ algorithm for potentially preventable diagnosis, but this population has a high risk for readmission, which suggests that these readmissions also may not be preventable in a frailer population.[22,31,32] Our study found that younger children had higher odds than teenagers of having a potentially preventable admission. A previous study, however, found the opposite, with age >11 years associated with potentially preventable admissions.[6] This finding may have to do with the specificity of AHRQ definitions, which consider certain age groups to always have a nonpreventable cause, or with the age groups most at risk for particular diagnoses. It is unclear why male subjects are more likely to experience a potentially preventable admission, but this outcome was also reported in a previous nationwide study.[2]

Certain hospital factors were also associated with potentially preventable admissions, with children's hospitals (asthma and perforated appendicitis) and critical access hospitals (asthma, gastroenteritis, and UTI) having higher odds. Teaching hospitals, conversely, had lower odds of having potentially preventable admissions for asthma, perforated appendicitis, and UTI. It is uncertain whether this correlation is due to the nature of these hospitals or to the patient populations they serve. For children's hospitals, it may relate to referral patterns. However, although hospital policies and cultures do affect admission decisions, many potentially preventable admissions occur through lack of appropriate outpatient care before hospital presentation,[9] and this finding more likely relates to the population of patients attending these hospitals and their access to outpatient care before hospital attendance.

The present study looked retrospectively at an administrative data set and is limited by the factors included in the data set, which were not selected with our study question in mind. This data set was further limited because it does not include a patient tracker. Therefore, the same patient may have had several admissions during the 4-year study period that were analyzed independently. More than 20 000 admission records (1.1% of all records) were removed due to coding errors. Although we tested the integrity of the data for all obvious coding errors, other errors may remain. Coding of an admission as potentially preventable or nonpreventable depends on which ICD-9 codes were billed for the admission and which was chosen as the principal diagnosis. Administrative practices vary as to whether these codes are determined by the treating physician or by a trained coding and billing staff. It is possible that the reported principal diagnosis was not always the main reason for admission due to these variations in billing and coding practices.

In addition, the data come from a single state that may have unique factors, such as proximity to the border with Mexico, a large Hispanic population, and the highest uninsured rate in the nation, which differentiate it from the broader US population. Although we attempted to control for hospital and local factors such as hospital size and rural location, there are likely other explanatory factors that were not available in the Texas or American Hospital Association administrative files. Finally, the AHRQ system is one of several potentially preventable algorithms that exist and have been used in the past,[2–8] and there is likely disagreement about whether all of the AHRQ conditions coded are truly preventable and whether it represents an all-inclusive list of preventable admissions. Nevertheless, the AHRQ has set a national standard, and the data originate from a large population over several years and provide new information on factors that should be targeted in efforts to reduce potentially preventable pediatric admissions.

CONCLUSIONS

As payments shift from fee-for-service programs to reward value through quality, reduced costs, and reduced resource utilization,[1,33] health care providers and payers must focus on improving metrics such as potentially preventable admission for reimbursement. This study found that all AHRQ pediatric potentially preventable admissions are not equivalent. Future research should test these differences in a broader national sample and use the results to create targeted programs to reduce potentially preventable admissions for each type of diagnosis.

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