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RESEARCH ARTICLE

Medicaid, Hospital Financial Stress, and the Incidence of Adverse Medical Events for Children

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Objective. To assess the association between Medicaid-induced financial stress of a hospital and the probability of an adverse medical event for a pediatric discharge.

Data Sources. Secondary data from the Nationwide Inpatient Sample, Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project, and the American Hospital Association's *Annual Survey of Hospitals*. Study examines 985,896 pediatric discharges (children age 0–17), from 1,050 community hospitals in 26 states (representing 63 percent of the U.S. Medicaid population) between 2005 and 2007.

Study Design. We estimate the probability of an adverse event, controlling for patient, hospital, and state characteristics, using an aggregated, composite measure to overcome rarity of individual events.

Principal Findings. Children in hospitals with relatively high proportions of pediatric discharges that are more reliant on Medicaid reimbursement are more likely than children in other hospitals (odds ratio = 1.62) to experience an adverse event. Medicaid pediatric inpatients are more likely than privately insured patients (odds ratio = 1.10) to experience an adverse event.

Conclusions. Hospital reliance on comparatively low Medicaid reimbursement may contribute to the problem of adverse medical events for hospitalized children. Policies to reduce adverse events should account for differences in underlying, contributing factors of these events.

Key Words. Child and adolescent health, Medicaid, quality of care/patient safety, hospitals

National concern about the quality of children's health care, particularly about serious errors occurring in hospital settings, is growing. Recently, payers have begun to refuse reimbursement to providers for the most serious errors in hospitals. The Centers for Medicare and Medicaid Services (CMS) took the lead in October 2008, when it began using its purchasing power to reduce errors and improve quality. Accordingly, CMS started requiring hospitals to report on performance, linked such reporting to hospital payments, and instituted a policy of nonreimbursement for selected adverse events. Several state Medicaid programs and private payers, as well, refuse to reimburse hospitals for serious errors (Gever 2008). In 2010, the Patient Protection and Affordable Care Act incorporated reductions in reimbursement for specific events into both the Medicare and Medicaid programs (Henry J. Kaiser Family Foundation 2010). Clearly, the movement toward such reimbursement policies has taken hold and will likely become a permanent feature of medical payment policies.

The underlying premise of these initiatives seems to be that hospital medical staff and management have the ability to prevent the occurrence of most, if not all, of these events. Thus, withholding hospital reimbursement properly holds the hospital accountable and provides an additional incentive to prevent adverse events from occurring in the first place. While such policies seem to be driven by this premise, prior research suggests a more complicated mechanism. One seemingly clear line has been drawn, for instance, between the poor financial status of hospitals and poor health outcomes of patients (Shen 2003; Encinosa and Bernard 2005; Bazzoli et al. 2007). As hospitals experience greater financial pressure from reduced revenues, they may be forced to reduce investment in infrastructure and processes tied to quality and safety. If that is the case, then it is unclear to what extent hospital medical staff or management should be held accountable for the occurrence of adverse events.

For hospitalized children, Medicaid is the single largest payer, accounting for approximately 40 percent of pediatric discharges nationally. On average, the level of Medicaid reimbursement is approximately 70–80 percent of Medicare (Zuckerman, Williams, and Stockley 2009), each of which is generally less than private-payer reimbursement. To the extent Medicaid reimbursement may already place financial pressures on hospitals, a policy of nonreimbursement for the occurrence of preventable adverse pediatric events would seemingly only exacerbate the problem, at least for some kinds of adverse events.

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The main question this study addresses is whether the comparatively low levels of, and reliance on, Medicaid reimbursement contribute to the problem of pediatric adverse events in hospitals. In addressing this question, we attempt to distinguish between events associated with Medicaid reimbursement and those associated with other factors. Because the unit of analysis is the patient-discharge level, we also control for the Medicaid insurance status of the patient. Results of previous studies on the effect of Medicaid payer status on the probability of an adverse pediatric event are mixed (Miller, Elixhauser, and Zhan 2003; Miller and Zhan 2004; Slonim et al. 2007). However, in these studies, it was unclear to what extent Medicaid payer status was capturing the effect of Medicaid's economic impact on the hospital, because the level and reliance on Medicaid reimbursement were not accounted for at the hospital level.

In 2006, the Agency for Healthcare Research and Quality (AHRQ) released the Pediatric Quality Indicators (PDIs). These measures can be used to estimate serious safety events for hospitalized children. Prior to the release of the PDIs, studies relied on the adult-oriented Patient Safety Indicators, some of which have been shown to be inappropriate for children (Sedman et al. 2005).

This study makes use of this pediatric-specific set of quality indicators. Further, unlike most recent studies of pediatric-patient safety (Slonim et al. 2007; Kronman et al. 2008; Scanlon et al. 2008), we examine adverse events for children from a national sample of pediatric discharges in community hospitals, over 3 years (2005–2007), purposefully excluding stays in pediatric (or children's) hospitals because community hospitals represent a more general, and common, setting of pediatric medical care.

THE "LOW NUMBERS" PROBLEM

The pediatric-specific PDIs have appeared in several studies assessing the quality of care for hospitalized children (Smith et al. 2007; Kronman et al. 2008; Scanlon et al. 2008). Nonetheless, questions have been raised about their usefulness in assessing quality differences among hospitals. Because the occurrence of each event is relatively rare, comparative analyses of hospital quality will generally not meet minimum thresholds of statistical power (Bardach, Chien, and Dudley 2010). Therefore, while the development of the PDIs represents an advance in the effort to understand and address the problem of avoidable errors for hospitalized children, the very nature of the PDIs (i.e., low numbers) potentially limits their usefulness in applied work.

One suggested way to overcome the low numbers problem is to create a composite measure of multiple adverse events, or PDIs (Bardach, Chien, and Dudley 2010). Indeed, AHRQ recently developed a composite version of the PDIs, which essentially combines several indicators into one measure. The composite indicator was developed, as indicated, in response to the need of researchers and policy makers to have a measure that is more discriminating in detecting differences in safety performance across providers (AHRQ 2008). Thus, in AHRQ's composite measure, we identified a conceptual solution to the challenge facing our study. In practice, our composite measure deviates from AHRQ's composite measure in that ours can be applied at the patient-discharge level.

METHODS

Data

Data for this study came from the Nationwide Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project, sponsored by AHRQ, and the American Hospital Association's (AHA) *Annual Survey of Hospitals Database.* The NIS contains a representative sample of all community hospitals in the United States, with information on every patient discharge, including demographic and payer (i.e., insurance) information, as well as diagnoses and procedures performed during the hospitalization. We used PDIs generated from the NIS, using the *AHRQ PDI* software version 4.2 (AHRQ 2010), to construct our composite PDI (CPDI). The NIS was merged with the AHA to obtain detailed information on each hospital.

To increase the number of hospitals, as well as the overall number of observations, we combined 3 years (2005–2007) of data. In general, the NIS does not represent a panel of hospitals that are observed year after year. Most hospitals were observed in only 1 year of the data. In a relatively small number of cases, though, where the same hospital appeared in more than 1 year, only the first occurrence of the hospital was retained in the sample. Thus, the sample represents a pooled cross-section of hospitals and discharges.

There is a benefit and a drawback to using the NIS and AHA data. The benefit is that these data are representative of the U.S. patient and hospital populations, and so offer the ability to obtain generalized results. The drawback is that in the case of the AHA, a large number of observations may be missing key information. In our case, lack of nurse-staffing information from 14 of the 40 states represented in the 2005–2007 NIS forced us to drop observations. We also dropped, per AHRQ recommendation, hospitals with risk pools of fewer than 30 discharges to avoid unstable PDI rates. With these limitations of the data, our initial sample of about 3 million discharges, from 2,275 nonduplicate community (nonchildren's) hospitals, was reduced to 985,896 discharges and 1,050 hospitals. Nonetheless, our final sample still represents about 20 percent of all U.S. community hospitals, spanning 26 states.

Construction of the CPDI

To create the outcome measure, the CPDI, we selected 8 of the 13 provider-level PDIs developed by AHRQ: accidental puncture or laceration, decubitus ulcer, iatrogenic pneumothorax (nonneonate), selected infections due to medical care, and four postoperative events (hemorrhage or hematoma, respiratory failure, sepsis, and wound dehiscence). Five of the PDIs were excluded because they represent an event that is either so rare that it is unlikely to be related to patient or institutional factors (foreign body left during procedure), is restricted to a particular group of patients (iatrogenic pneumothorax in neonates), is associated with a procedure not commonly performed across community hospitals (death from pediatric heart surgery), is associated with maternity or childbirth (transfusion reaction), or is not reflective of an adverse event (pediatric heart surgery volume).

The *AHRQ PDI* software creates, for all pediatric-patient (less than 18 years of age) discharge records, a field (the PDI) for each adverse event, identifying whether the patient is at risk of experiencing the adverse event (PDI = 0 or 1), and if the event occurred (PDI = 1). With this information, we created a risk pool for the CPDI. To be included in this risk pool, a discharge record had to have a PDI value of 0 or 1 for at least one of the eight chosen events. A discharge record would have been excluded from the risk pool if there were missing values (".") for all eight PDI fields (i.e., the record would have been excluded if the patient was not at risk of experiencing any of the eight adverse events during the hospital stay). Once the risk pool was created, the CPDI field was set equal to one if any of the eight component PDI fields was equal to one. If none of the eight component PDI fields was equal to one, the CPDI field was set equal to zero.

While it is possible a patient could have experienced more than one adverse event during the hospital stay, our composite indicator records whether the patient experienced *any* adverse event during the stay. Therefore, our composite measure reflects the number of pediatric discharges with adverse events as opposed to the total number of adverse events. In calculating the measure this way, we took a conservative approach to the number of adverse events because we assumed, in all instances, that multiple adverse events for the same discharge were related to one another (i.e., due to the same underlying cause) and therefore should be considered only one event.

As discussed, the purpose of the CPDI was to overcome the “low numbers” problem associated with the individual PDIs, by creating a more general but more frequently occurring indicator of an adverse event. However, simply combining PDIs into a single measure would not necessarily increase frequency if the risk pools of the component PDIs were largely mutually exclusive. In that case, the increase in the number of events would be offset by a corresponding increase in the size of the risk pool. As it turns out, and as shown in Table 1, there is a substantial amount of overlap in the risk pools of the eight PDIs that comprise the CPDI. For each PDI, an overwhelming percentage (over 90 percent for all except one of the PDIs) of the risk pool includes the same group of discharges as the PDI with the largest risk pool, accidental puncture, or laceration. Therefore, in creating the CPDI, we created a measure that better captures the frequency of adverse events, over a given patient-discharge population, than each of the individual PDIs. As indicated by the difference in the rates between accidental puncture and the CPDI, the increase in frequency is about fivefold.

Table 1: Composite Pediatric Quality Indicator (PDI) and Component Rates and Proportion of Component PDIs in Common Risk Pool (Nationwide Inpatient Sample, 2005–2007)

PDIs	*Rate Per 1,000*	*Proportion of Discharges in Common Risk Pool (N = 985,896), %*
PDI #01: Accidental puncture or laceration	0.82	100
PDI #02: Decubitus ulcer	4.20	97
PDI #05: Iatrogenic pneumothorax (nonneonate)	0.20	99
PDI #08: Postop hemorrhage or hematoma	2.65	92
PDI #09: Postop respiratory failure	10.91	90
PDI #10: Postop sepsis	19.14	89
PDI #11: Postop wound dehiscence	1.12	99
PDI #12: Selected infection due to medical care	2.62	99
Composite PDI	4.23	—

Patient-Discharge Variables

At the patient-discharge level, we included age, gender, income (measured by the median income of the patient's residential zip code), and insurance-payer status (i.e., private, public, self pay/uninsured). These factors have generally been included in prior studies of pediatric-patient safety in hospitals (e.g., Miller, Elixhauser, and Zhan 2003; Slonim et al. 2007; Smith et al. 2007). At this level, the key variable of interest is insurance-payer status, specifically children covered by Medicaid.

We also included measures capturing severity of illness, using the All-Patient Refined Diagnosis-Related Group (APR-DRG) severity-of-illness measure (from 3M Health Information Services) on the NIS, and the patient's level of risk of experiencing an adverse event. The risk variable, generated by the *AHRQ's PDI* software for several of the PDIs (McDonald et al. 2006), is a measure of risk based on the number and type (minor or major) of therapeutic procedures. For those PDIs in which the *AHRQ* software does not create the risk indicator, we assumed, in all cases, "low" risk (i.e., a highly preventable event). We coded a discharge as "high" risk if it was at high risk for any one of PDIs.

Hospital-Level Variables

At the hospital level, the key explanatory variable is the proportion of total discharges, both pediatric and adult, that are covered by Medicaid. The measure includes adult discharges because it serves as a proxy for hospital financial stress. While Medicaid is the primary insurer for approximately 40 percent of all pediatric discharges, pediatric discharges, generally represent a small proportion of total hospital discharges overall. Therefore, creating a measure based only on the hospital's pediatric Medicaid share would not necessarily be a good reflection of the hospital's financial status.

Other hospital-level factors included in the analysis, and hypothesized to be determinants of patient safety, are hospital size, teaching status, location (rural versus urban), ownership (private nonprofit, private for-profit, public), volume of pediatric discharges, and nurse-to-patient ratio. An increase in the nurse-to-patient ratio has generally been found to improve hospital outcomes (Needleman et al. 2002, 2006; Kane et al. 2007), with the most recent example being the mandated minimum nurse-to-patient ratios in California (Aiken et al. 2010). For our measure, we calculated the number of full-time equivalent registered nurses divided by the hospital's average daily census. For hospital bed size, we used AHRQ's three-valued categorical variable for small (1), medium (2), and large (3) hospitals, which considers region (Northeast, Midwest, South, West), as well as teaching status and location (rural or urban). Because we already separately included teaching status and location in the model, the bed size variable captures the combined effect of size and region. The volume of pediatric discharges is the number of nonnewborn pediatric discharges. Pediatric volume and hospital bed size account for the hypothesized relationship between hospital volume and patient outcomes (Jenkins et al. 1995; Hannan et al. 1998; Marcin et al. 2008; Kahn, Ten Have, and Iwashyna 2009).

Because the Medicaid discharge rate is a proxy for hospital financial stress, it was important to control for other factors that might be correlated with this measure and pediatric adverse events. We also included, therefore, the hospital's nonnewborn pediatric-discharge rate because of Medicaid's dominant role as a payer of pediatric hospitalizations. Indeed, in this sample, the correlation coefficient between the Medicaid and pediatric-discharge rate is relatively high (0.46). Medicaid discharge rate could also be confounded with the pediatric case mix of the hospital, as well as the average income of patients. To control for the hospital's pediatric case mix, we again used the APR-DRG severity-of-illness measure. For each hospital, case mix was calculated as the average APR-DRG for all annual, nonnewborn pediatric discharges of the hospital. To control for average income, we calculated, over all discharges, the average median income of patient zip code.

Finally, in recognizing that *AHRQ's PDI* software relies on the secondary diagnoses fields of hospital administrative data, we controlled for the coding practices of hospitals by including measures of the average number of diagnoses and procedure fields that are coded on hospital-discharge records. In doing this, we controlled for variation in PDI rates that are due simply to differences in hospital administrative practice.

State-Level Variable

While financial pressure due to reliance on Medicaid reimbursement may have effects on patient safety, there may also be effects due to differences in reimbursement within the Medicaid program. Therefore, to control for the state-level variation in Medicaid reimbursement, we used the 2008 fee-for-service (FFS) Medicaid fee index for hospital visits, provided by Zuckerman, Williams, and Stockley (2009). While the year of these fees falls outside the time period of our study (2005–2007), they likely approximate fees during that time period.

Statistical Analyses

To assess the association between the explanatory variables and the likelihood of an adverse event, we conducted bivariate (ANOVA) comparisons of the CPDI rates across quartiles for all continuous explanatory variables. Based on the results, we converted these continuous measures into categorical variables. For Medicaid discharge rate and the average number of procedures coded on discharge records, the bivariate analysis indicated a three-valued categorical variable, combining the first and second quartiles into a single category. For pediatric-discharge rate and average APR-DRG severity index (case mix), we created a two-category variable, combining the first, second, and third quartiles into a single category. For nurse-to-patient ratio, we combined the third and fourth quartiles into a single category, and for the remaining continuous measures, including the state-level Medicaid reimbursement index, the average of median zip code income, average number of diagnoses coded on discharge records, and pediatric volume, we combined the second and third quartiles (in the case of pediatric volume, there were only three initial values because there were no observations for the first quartile of hospitals).

Our multivariate model, a multi-level logistic regression, assessed the association between Medicaid reimbursement and the odds of an adverse event, controlling for patient-discharge and other hospital characteristics. The model also controlled for the state Medicaid fee index, other state fixed effects, and year fixed effects. To account for the hierarchical (i.e., multi-level) structure of the model, we estimated the model using robust standard errors, accounting for possible correlation of discharges within the same hospital. All analyses were conducted using *Stata*, v. 10.1 (StataCorp 2009).

RESULTS

Bivariate Analysis of Key Hospital-Level Variables

Table 2 shows the means and unadjusted CPDI rate per 1,000 at-risk discharges, by quartiles for each of five, key hospital-level variables: hospital-level Medicaid discharge rate, pediatric-discharge rate, nurse-to-patient ratio, and the state-level Medicaid reimbursement index. The table also displays the

Table 2: Sample Means and Unadjusted Composite Pediatric Quality Indicators (CPDI) Rates of Key Hospital-Level Variables, by Variable Quartiles

Quartiles Based On*	Medicaid Discharge Rate				Pediatric-Discharge Rate				Nurse-to-Patient Ratio				2008 State Medicaid FFS Reimbursement Rate Index			
	1st†	*2nd*†	*3rd*	*4th*	*1st*†	*2nd*†	*3rd*†	*4th*	*1st*	*2nd*	*3rd*†	*4th*†	*1st*	*2nd*†	*3rd*†	*4th*
Mean of variable	0.04	0.11	0.18	0.34	0.02	0.05	0.07	0.17	0.42	1.23	1.90	4.21	0.70	1.04	1.26	1.40
Discharges at risk of CPDI (*N*)‡	97,961	173,161	282,940	431,834	6,409	105,472	231,703	642,312	199,703	284,269	300,412	201,512	388,445	358,339	123,148	115,964
Percent of total *N*, %	9.9	17.6	28.7	43.8	0.7	10.7	23.5	65.2	20.3	28.8	30.5	20.4	39.4	36.3	12.5	11.8
Percent of sample hospitals,§ %	12.3	25.1	31.4	31.1	5.3	28.8	32.0	33.9	24.5	25.7	25.3	24.5	33.0	36.0	13.9	17.0
CPDI rate per 1,000	1.95	2.43	4.29	5.43	1.40	1.22	1.53	5.73	3.02	4.15	4.88	4.57	3.95	4.67	4.89	3.10

*Medicaid and pediatric-discharge rate quartiles based on the "universe" of nonduplicate community (nonpediatric) hospitals in the 2005–2007 NIS (2,275 total hospitals). Nurse-to-patient ratio quartiles based on the number of nonmissing observations in the 2005–2007 AHA (1,384 total hospitals). State Medicaid FFS reimbursement rate index quartiles based on 49 of the 50 states (Tennessee does not have an FFS component in its Medicaid program) reported in Zuckerman, Williams, and Stockley (2009).
†Quartiles combined.
‡There are a total of 985,896 at-risk discharges (i.e., the sample).
§There are a total of 1,050 hospitals in the sample. FFS, fee-for-service.

number (N) and percent of at-risk discharges, and the percent of sample hospitals, by quartiles of each variable. For the Medicaid and pediatric-discharge rates, the quartile categories are based on the "universe" of community, nonpediatric hospitals (n = 2,275) that were initially available in the 2005–2007 NIS. For the nurse-to-patient ratio, the universe is only 1,384 hospitals because of missing information on the AHA database from 14 of the 40 states represented in the 2005–2007 NIS. For the state-level variable, Medicaid FFS reimbursement rate index, the quartiles are based on 49 of the 50 states (Tennessee does not have an FFS component in its Medicaid program) reported in Zuckerman, Williams, and Stockley (2009).

Figures in the table reflect only the 1,050 hospitals in the final sample of discharges. The reduction in hospitals from the 2,275 in the 2005–2007 NIS reflects the exclusion of hospitals due to missing observations on nurse-to-patient ratio, as well as the concentration of pediatric discharges that are at risk of an adverse event (with a minimum of 30 at-risk discharges) in a relatively small number of hospitals. Consequently, the distribution of the final sample of hospitals for each variable is not a uniform 25 percent across all quartile categories. At both the patient-discharge and hospital levels, the distribution of the sample tends to be skewed toward the highest quartiles.

Indeed, because of the high concentration of discharges in the fourth quartile by pediatric-discharge rate (65.2 percent), as well as the high frequency of adverse events (i.e., CPDI) in this quartile (5.73 per 1,000 discharges), we wanted to determine whether effects in this relatively dense portion of the sample differed from the overall sample. Therefore, in the multivariate model, we interacted each, the Medicaid discharge rate and the nurse-to-patient ratio, two key measures of hospital quality, with the pediatric-discharge rate to identify their impact in the most relevant portion of the data. The interaction of the Medicaid and pediatric-discharge rate also facilitated identifying the effect of the Medicaid discharge rate, which could be obscured because of its high correlation with the pediatric-discharge rate.

Main Multivariate Results

The results of the logistic regression are presented in Table 3. The overall fit of the model is good for cross-sectional analysis (pseudo R^2 = 0.301). At the patient-discharge level, Medicaid payer status is associated with a 10 percent increase in the odds of an adverse event (OR = 1.10), relative to a privately insured patient, and is statistically significant at the 5 percent level. In addition, the level of risk of experiencing an adverse event (OR = 9.54), severity of

Table 3: Logistic Regression Model (Nationwide Inpatient Sample, 2005–2007)

	Composite PDI,[‡] N = 985,896		
Independent Variables[†]	*Odds Ratio*	*p-Value*	*95% Confidence Interval*
Discharge level			
High risk	9.54	.00*	8.38–10.87
Severity of illness (APR-DRG severity index)			
Minor (reference)	—	—	—
Moderate	2.07	.00*	1.81–2.37
Major	8.61	.00*	7.58–9.77
Extreme	35.72	.00*	30.23–42.21
Age			
0–4 (reference)	—	—	—
5–9	0.94	.24	0.84–1.04
10–14	1.07	.25	0.95–1.20
15–17	1.40	.00*	1.24–1.59
Male	1.00	.91	0.93–1.08
Quartile of zip code median income			
First quartile (reference)	—	—	—
Second quartile	0.98	.57	0.90–1.06
Third quartile	0.96	.34	0.89–1.04
Fourth quartile	0.87	.01*	0.79–0.97
Insurance			
Private (reference)	—	—	—
Medicaid	1.10	.01*	1.02–1.17
Uninsured	0.82	.12	0.63–1.05
Other	1.09	.20	0.96–1.24
Hospital level			
Case mix (pediatric avg. APR-DRG severity index)			
Less than fourth quartile (reference)	—	—	—
Fourth quartile	1.41	.00*	1.21–1.65
Average of median zip code income			
First quartile (reference)	—	—	—
Second and third quartiles	1.25	.16	0.91–1.71
Fourth quartile	1.20	.33	0.83–1.73
Pediatric-discharge rate			
Less than fourth quartile (reference)	—	—	—
Fourth quartile	1.10	.68	0.71–1.70
Medicaid discharge rate			
Main effects			
Less than third quartile (reference)	—	—	—
Third quartile	0.76	.07	0.56–1.02
Fourth quartile	0.78	.20	0.53–1.15
Interaction with pediatric-discharge rate (fourth quartile)			
Less than third quartile (reference)	—	—	—
Third quartile	1.62	.00*	1.17–2.26
Fourth quartile	1.46	.06	0.98–2.16
Nurse-to-patient ratio			
Main effects			

continued

Table 3. *Continued*

Independent Variables[†]	*Composite PDI,*[‡] *N* = 985,896 *Odds Ratio*	*p-Value*	*95% Confidence Interval*
First quartile (reference)	—	—	—
Second quartile	0.81	.39	0.51–1.30
Third and fourth quartiles	1.49	.05	0.99–2.24
Interaction with pediatric-discharge rate (fourth quartile)			
First quartile (reference)	—	—	—
Second quartile	1.56	.09	0.93–2.60
Third and fourth quartiles	0.87	.55	0.56–1.36
Average diagnostic codes			
First quartile (reference)	—	—	—
Second and third quartiles	0.93	.37	0.81–1.08
Fourth quartile	0.83	.15	0.65–1.07
Average procedure codes			
Less than third quartile (reference)	—	—	—
Third quartile	1.43	.02*	1.05–1.94
Fourth quartile	1.49	.02*	1.08–2.07
Hospital bed size			
Small (reference)	—	—	—
Medium	1.37	.01*	1.10–1.70
Large	1.18	.14	0.95–1.47
Teaching	1.36	.00*	1.13–1.64
Urban	0.68	.04*	0.48–0.98
Ownership			
Private, nonprofit (reference)	—	—	—
Private, for-profit	0.77	.08	0.58–1.03
Public	0.93	.31	0.81–1.07
Pediatric volume (discharges)			
Less than fourth quartile (reference)	—	—	—
Fourth quartile	1.25	.11	0.95–1.63
State level			
2008 State Medicaid Reimbursement Rate index			
First quartile (reference)	—	—	—
Second and third quartile	0.94	.82	0.58–1.55
Fourth quartile	0.40	.01*	0.20–0.81
Pseudo R^2	0.301		

*Significantly different from reference group ($p \leq .05$).
†Controls for state and year fixed effects; standard errors corrected for clustering of discharges within hospital.
‡Indicates any occurrence of following indicators:
PDI #01 Accidental puncture and laceration.
PDI #02 Decubitus ulcer.
PDI #05 Iatrogenic pneumothorax.
PDI #08 Postop hemorrhage or hematoma.
PDI #09 Postop respiratory failure.
PDI #10 Postop sepsis.
PDI #11 Postop wound dehiscence.
PDI #12 Selected infection due to medical care. APR-DRG, All-Patient Refined Diagnosis-Related Group; PDI, Pediatric Quality Indicators.

illness (OR = 2.07, OR = 8.61, and OR = 35.72), age (OR = 1.40 for age 15–17), and income (OR = 0.87 for fourth quartile) are all statistically significant relative to their reference categories.

At the hospital level, the main effect of Medicaid discharge rate, our proxy for hospital financial stress, is not statistically significant. However, within the relatively large fourth quartile of hospitals by pediatric-discharge rate, a child in a third-quartile hospital by Medicaid discharge rate is 62 percent more likely to experience an adverse event than a child in a hospital below the median (OR = 1.62). Because the main effect on Medicaid discharge rate for the third quartile is not statistically significant (implied odds of 1), these results indicate (multiplying the interaction by the main term) that children in hospitals in the highest quartile by pediatric-discharge rate, and in the third quartile by Medicaid discharge rate, are substantially more likely to experience an adverse event than all other hospitalized children.

For the other key measure of hospital quality, nurse-to-patient ratio, we find no statistically significant relationship between this measure and the odds of an adverse pediatric event. Among other hospital-level variables, though, we find average APR-DRG severity index (OR = 1.41), average number of procedure codes at the third and fourth quartiles (OR = 1.43 and OR = 1.49, respectively), medium-size hospital (OR = 1.37), teaching status (OR = 1.36), and urban location (OR = 0.68) to be statistically significant.

At the state level, we find that hospitalized children in states in the highest quartile based on the Medicaid FFS reimbursement index for hospital services (i.e., states with the highest reimbursements) are 60 percent less likely than hospitalized children in the lowest quartile to experience an adverse event (OR = 0.40). There is no statistically significant difference between the lowest quartile states and those in the second and third quartiles.

Sensitivity Analyses

Delving deeper into the Medicaid results, we estimated alternative versions of the model, each time removing one of the component PDIs from the CPDI. This was done to determine whether the main results were dominated by one or some subset of the PDIs. These results are presented in Table 4.

The first column shows the effects at the patient-discharge level, revealing that there is very little change in the effect of Medicaid payer status across the different specifications except for when PDI #01, accidental puncture or laceration, is removed. In that instance, the odds ratio falls considerably and is no longer statistically significant. This result indicates that much of the rela-

Table 4: Sensitivity Analyses of Medicaid Measures

	Discharge Level		*Hospital Level*								*State Level*			
	Medicaid		*Medicaid Discharge Rate Third Quartile*				*Medicaid Discharge Rate Fourth Quartile*				*Medicaid FFS Reimbursement Rate Index*			
	Relative to Private		*Main Effect*		*Interaction with Fourth Quartile Pediatric-Discharge Rate*		*Main Effect*		*Interaction with Fourth Quartile Pediatric-Discharge Rate*		*Second and Third Quartiles*		*Fourth Quartile*	
Effect of Removing	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*
Accidental puncture or laceration (PDI #01)	1.04	.28	0.66	.04*	1.95	.00*	0.80	.35	1.56	.07	2.18	.00*	0.38	.06
Decubitus ulcer (PDI #02)	1.09	.01*	0.75	.07	1.64	.00*	0.67	.06	1.71	.01*	1.01	.97	0.37	.01*
Nonneonate iatrogenic pneumothorax (PDI #05)	1.11	.00*	0.76	.09	1.63	.01*	0.81	.30	1.41	.10	1.76	.08	0.69	.46
Postop hemorrhage or hematoma (PDI #08)	1.11	.00*	0.78	.11	1.58	.01*	0.80	.28	1.41	.09	0.93	.77	0.40	.01*

continued

Table 4. *Continued*

	Discharge Level		*Hospital Level*								*State Level*			
	Medicaid		*Medicaid Discharge Rate Third Quartile*				*Medicaid Discharge Rate Fourth Quartile*				*Medicaid FFS Reimbursement Rate Index*			
	Relative to Private		*Main Effect*		*Interaction with Fourth Quartile Pediatric-Discharge Rate*		*Main Effect*		*Interaction with Fourth Quartile Pediatric-Discharge Rate*		*Second and Third Quartiles*		*Fourth Quartile*	
Effect of Removing	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*	*Odds Ratio*	*p-Value*
Postop respiratory failure (PDI #09)	1.09	.02*	0.76	.07	1.66	.00*	0.74	.14	1.57	.03*	0.74	.19	0.40	.01*
Postop sepsis (PDI #10)	1.08	.04*	0.72	.05*	1.81	.00*	0.80	.29	1.46	.08	0.84	.50	0.38	.01*
Postop wound dehiscence (PDI #11)	1.10	.01*	0.75	.06	1.62	.00*	0.78	.22	1.45	.07	0.96	.87	0.41	.01*
Selected infection due to medical care (PDI #12)	1.16	.01*	0.82	.22	1.32	.13	0.71	.10	1.31	.21	4.96	.00*	0.83	.75

*Statistically significant ($p \leq .05$). FFS, fee-for-service.

tionship of Medicaid at the patient-discharge level is with this particular adverse event.

The next sets of results, at the hospital level, show the effects of the Medicaid discharge rate, which include the main effects as well as the effects of the interaction with the fourth quartile of pediatric-discharge rate. In looking at the interaction for the third quartile by Medicaid discharge rate, which was the only statistically significant measure in the main model, we see that when accidental puncture (PDI #01) is removed, the main effect is statistically significant and indicates that the odds of an adverse event decrease by 34 percent (OR = 0.66). However, the interaction of this variable with the fourth quartile of pediatric-discharge rate is positive and significant (OR = 1.95), which means the combined (i.e., overall) effect, taking the product of these two odds ratios, is still positive (OR = 1.28). The same is true when postoperative sepsis (PDI #10) is removed, leading to an overall increase in the odds of 30 percent (OR = 1.30). In addition, the effect of the third quartile by Medicaid discharge rate is reduced, and becomes statistically insignificant, when selected infection due to medical care (PDI #12) is removed, indicating that selected infection is particularly sensitive to the Medicaid discharge rate in third-quartile hospitals.

It should also be mentioned that when decubitus ulcer (PDI #02) and postoperative respiratory failure (PDI #09) are removed, there is a positive and statistically significant effect on the interaction terms (OR = 1.71 and OR = 1.57, respectively) in the fourth quartile by Medicaid discharge rate. Thus, we find some evidence of adverse effects in hospitals under, presumably, the greatest financial stress (i.e., highest quartile), effects that are perhaps masked in the main results.

For the state-level measure, Medicaid FFS reimbursement rate index, the fourth quartile becomes statistically insignificant when accidental puncture (PDI #01), nonneonate iatrogenic pneumothorax (PDI #05), and selected infection (PDI #12) are removed. Moreover, in removing accidental puncture and selected infection, the results become nonmonotonic, with the odds of an adverse event actually increasing in the second- and third-quartile states. Thus, within the Medicaid program, there seems to be no clear relationship between reimbursement levels and adverse events.

Robustness Check

As a check on the robustness of our main results, we dropped nurse-to-patient ratio because it was statistically insignificant and contributed to a substantial loss of observations in the main model. Results of this regression, showing

Table 5: Medicaid Results without Nurse-to-Patient Ratio (Nationwide Inpatient Sample, 2005–2007)

	Composite PDI, N = 1,449,289		
Independent Variables	*Odds Ratio*	*p-Value*	*95% Confidence Interval*
Discharge level			
Insurance			
Private (reference)	—	—	—
Medicaid	1.07	.02*	1.01–1.13
Hospital level			
Medicaid discharge rate			
Main effects			
Less than third quartile (reference)	—	—	—
Third quartile	0.79	.13	0.57–1.08
Fourth quartile	0.71	.06	0.50–1.01
Interaction with pediatric-discharge rate (fourth quartile)			
Less than third quartile (reference)	—	—	—
Third quartile	1.36	.07	0.98–1.90
Fourth quartile	1.46	.04*	1.02–2.07
Pseudo R^2	0.306		

*Significantly different from reference group ($p \leq .05$). PDI, Pediatric Quality Indicators.

only the pediatric-discharge and hospital-level Medicaid measures, are presented in Table 5.

At the patient-discharge level, the odds ratio on Medicaid payer status is little changed from the main model (OR = 1.07) and still statistically significant. However, at the hospital level, there are changes in the two interaction terms, with the odds ratio on the third-quartile interaction term lower than in the main model (OR = 1.36) and no longer significant at the 5 percent level, while the fourth-quartile interaction term is approximately the same as in the main model (OR = 1.46) but is now statistically significant.

It is important to note that, while we include 14 more states by dropping nurse-to-patient ratio, these additional states have a disproportionately low number of Medicaid enrollees compared with the original 26 states. Thus, in this larger dataset, it is possible that Medicaid discharge rate actually serves as a weaker proxy for hospital financial stress than it does in the main model.

DISCUSSION

Using a unique composite measure of pediatric safety based on AHRQ's PDIs, we find that a child is at increased risk of an adverse event if he or she is an inpatient in a hospital that is in the highest quartile based on pediatric-discharge rate and also has a relatively high reliance on Medicaid reimbursement, measured by the overall proportion of Medicaid discharges in the hospital. We also find that, consistent with some previous studies, children covered by Medicaid insurance are at greater risk of an adverse event than children covered by private insurance. However, this risk seems much smaller than the risk we find associated with reliance on Medicaid reimbursement at the hospital level. Our sensitivity analyses reveal that Medicaid payer status may be closely associated with a particular outcome, accidental puncture, or laceration, while reliance on Medicaid reimbursement may be closely associated with another, selected infection due to medical care.

Thus, these results have important policy implications. The National Quality Forum has recently endorsed accidental puncture as a patient safety event (NQF 2010), and selected infection due to medical care is the central focus of new state and federal initiatives, in particular, the recently enacted health reform legislation, the Affordable Care Act, to reduce or deny payments for medical errors and other adverse events. Our results suggest, however, that adverse events may be in part due to factors outside the control of hospital management and medical staff and that Medicaid itself may be playing a contributing role in the occurrence of some of these events.

Although our study is limited by its cross-sectional design, which does not allow for inferences on causality, our results suggest, at a minimum, that policies intended to address the problem of adverse events in hospitals should not necessarily apply a "one size fits all" approach. The disaggregated results in our sensitivity analyses indicate that Medicaid reimbursement may be a contributing factor for some adverse outcomes, but not others. Indeed, for some adverse events, providers can and should prevent them and therefore be held accountable. For others, a more supportive and collaborative approach may be needed.

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Appendix SA1: Author Matrix.

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