Admit Versus Discharge—A Cost Analysis of Infants 29 to 60 Days Old With Febrile Urinary Tract Infection at Low Risk for Bacteremia

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ABSTRACT

BACKGROUND: Ninety percent of infants 29 to 60 days old presenting to the emergency department with fever and urinary tract infection are admitted due to fear of concomitant bacteremia. Many of these infants are at low risk for bacteremia and can be safely discharged with no heightened risk of adverse events. This study sought to estimate the potential savings from outpatient management of low-risk infants.

METHODS: A comparative cost analysis was performed using bacteremia probability estimates from a previously published prediction model. We estimated costs using a national pediatric database coupled with retrospective chart review of infants who presented to our emergency department between 2011 and 2015.

RESULTS: The relative cost savings for the discharge strategy were $80,333 ($19,127 vs $99,460; 80% savings) for each patient with bacteremia and $257,073 per 100 patients overall. Similar savings were found for charges—$304,949 ($71,421 vs $376,371; 80%) for each patient with bacteremia and $975,838 per 100 patients. Our institutional reimbursements provided an

estimated savings of $148,924 ($73,280 vs. $222,204; 67%) and $476,533 per 100 patients overall.

CONCLUSIONS: The relative cost savings from discharging rather than admitting low-risk infants with febrile urinary tract infection were significant, even accounting for expenditures associated with the return emergency room visit of initially discharged bacteremic patients. These savings are achievable without an increase in adverse events. Similar outcomes were demonstrated for hospital charges and reimbursements, further strengthening these results. This study emphasizes how risk stratification in clinical decision-making can lead to substantial cost savings without compromising patient outcomes.

KEYWORDS: adverse events; bacteremia; costs; decision analysis; infants; meningitis; prediction model; risk stratification; urinary tract infection

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WHAT'S NEW

This study estimates the potential cost savings from outpatient treatment of young infants with febrile urinary tract infection at low risk for bacteremia. Our analysis suggests that savings are substantial and can be achieved without compromising patient outcomes.

URINARY TRACT INFECTIONS account for as many as 92% of serious bacterial infections in infants less than 3 months of age.[1] The American Academy of Pediatrics recommends discharging children with otherwise uncomplicated febrile urinary tract infection (UTI) between the ages of 2 months to 2 years.[2] No guidelines exist, however, for younger infants 29 to 60 days of age presenting

with fever and positive urinalysis. These young infants are often admitted because of concern for concomitant bacteremia. The reported incidence of bacteremia with UTI among all infants in this age group is approximately 4% to 9% according to published studies.[3−11]

Prediction models have been developed to help risk-stratify young infants with UTI based on their probability of bacteremia and other complications.[5,6,10,11] A 2010 study of 1895 infants 29 to 60 days of age with febrile UTI established criteria for identifying low-risk patients (not clinically ill-appearing, no high-risk past medical history, peripheral band count <1250 cells per μL, and absolute neutrophil count $\geq$1500 cells per μL) for whom the probability of bacteremia was less than half the probability for the overall patient population

(3.2% vs 6.5%).[3] Importantly, the study found no adverse events for infants meeting the low-risk criteria, compared to a 2.8% incidence of adverse events for the overall patient population. Another study also found young age (less than 3 months) not to be an independent risk factor for bacteremia.[10]

In light of such results, Schnadower et al[3] and Dayan et al[4] proposed outpatient management as a viable option for infants with otherwise low-risk examination and laboratory findings. This suggestion would represent a major shift in a culture where approximately 90% of infants 29 to 60 days old with febrile UTI are currently admitted.[3]

The objective of this study was to perform a comparative cost analysis of admitting versus discharging infants 29 to 60 days old evaluated in the emergency department (ED) for fever and UTI who are at low risk for bacteremia and adverse events. This study emphasizes the use of risk stratification (the 4 criteria listed above) as a means to decrease cost without compromising patient outcomes.

PATIENTS AND METHODS

DESIGN

This study used decision-analytic modeling to estimate and compare costs of 2 disposition decisions—admission versus discharge—for infants presenting to the ED with fever and UTI who are at low risk for bacteremia.[13] Our primary reference study was a 20-center retrospective analysis of 1895 infants 29 to 60 days old with fever and UTI that derived a prediction model for identifying infants at low risk for bacteremia and adverse events.[3] We used this study to determine assumptions and estimate bacteremia probabilities and length of stay (LOS). Our decision tree stratified admitted and discharged infants based on the presence of bacteremia, resulting in 4 categories: admitted with bacteremia, admitted without bacteremia, discharged with bacteremia, and discharged without bacteremia (Fig. 1). Respective probabilities and costs for these 4 outcomes then determined our primary outcome:

the difference in cost per positive bacteremic patient between admitting and discharging.

We assessed costs from the patient and hospital perspectives.[14] These costs included inpatient, outpatient, and ED expenses, including costs of subsequent return ED visits and admissions for patients initially discharged and brought back for positive blood cultures. We also included home nursing visits and outpatient labs for bacteremic patients discharged with a peripherally inserted central catheter line. This study was approved by the institutional review board.

PATIENT CHARACTERISTICS

Our patient population was infants 29 to 60 days old with fever and UTI at low risk for bacteremia and adverse events as defined by the reference study—that is, of the 1895 infants in the reference study, 862 infants (45%) met all 4 low-risk criteria defined as 1) not clinically ill-appearing, 2) no high-risk past medical history, 3) peripheral band count <1250 cells per μL, and 4) absolute neutrophil count ≥ 1500 cells per μL.[3] The reference study defined "clinically ill-appearing" as "an infant who was judged as ill-appearing, dehydrated, or in respiratory distress, or who had an acute concomitant disease diagnosed in the ED." "High-risk past medical history" was defined as "a history of genitourinary abnormalities, previous UTIs, bacteremia, meningitis, previous laboratory evaluation for fever, prematurity (<37 weeks gestation), or history of a severe systemic disease (complex heart, chronic lung, metabolic, or neurologic diseases)." The same criteria were applied to our decision model.

The reference study defined "bacteremia" as "growth of a pathogen in the blood culture," excluding organisms typically thought to be contaminants (ie, *Bacillus* species, *Propionibacterium acnes*, or non-*Staphylococcus aureus* species). "Adverse events" were defined as "death, shock, bacterial meningitis, ICU or step-down ICU admission or transfer, need for ventilatory support (including CPAP and BiPAP), need for surgical intervention, or any other
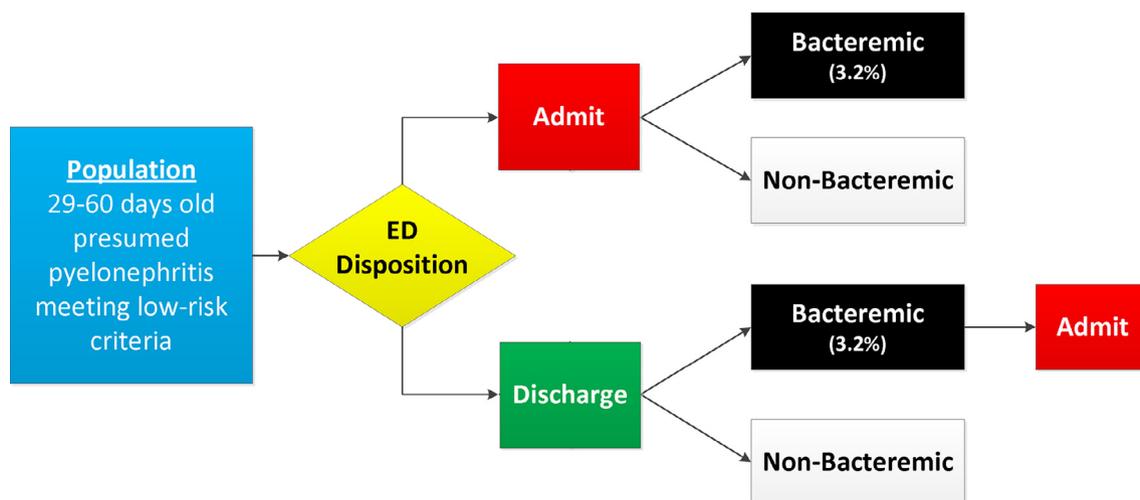

Figure 1. *Decision tree comparing admission and discharge strategies.*

substantial clinical complications." "Positive urinalysis" was defined as "any organism visualized on Gram stain, trace or greater leukocyte esterase or nitrite on dipstick or lab urinalysis, or greater than 5 white blood cells on microscopy." Also in the reference study, a "positive urine culture" was one that "grew a single pathogen" and in which "colony counts met at least 1 of 3 criteria: 1) ≥1000 colony-forming units (CFU)/mL for urine cultures obtained by suprapubic aspiration, 2) ≥50,000 CFU/mL from a catheterized specimen, or 3) ≥10,000 and <50,000 CFU/mL from a catheterized specimen in association with positive urinalysis results."

PROBABILITY ESTIMATES

According to the prediction model derived from our reference study, infants meeting all 4 low-risk criteria had a predicted probability of bacteremia of 3.2% (95% confidence interval [CI], 2.2−4.6) and a predicted probability of adverse events of 0% (95% CI, 0−0.35).[3] These probabilities were derived using 2 separate binary recursive partitioning analyses to identify a group of infants at very low risk for adverse events and a group of infants at very low risk for bacteremia.

COST, CHARGE, AND REIMBURSEMENT ESTIMATES

To create a list of standard items associated with managing these infants, we searched for patients at our institution (a tertiary, academic, urban, pediatric hospital) in

each of the following 4 clinical categories: 1) admitted/non-bacteremic, 2) admitted/bacteremic, 3) discharged/non-bacteremic, and 4) discharged/bacteremic. We queried the electronic health record for infants diagnosed with febrile UTI and meeting the relevant risk criteria. Our query covered the time period between January 2011 and December 2015. No patients 29 to 60 days old at our institution were in the discharged/bacteremic category. To capture patients in this category, we searched for infants up to 365 days old. Three additional patients were obtained using this older age group, resulting in a sample of 20 patients. The number of patients in each clinical category was 9 admitted/non-bacteremic, 3 admitted/bacteremic, 6 discharged/non-bacteremic, and 2 discharged/bacteremic.

We then obtained itemized billing data from our institution's financial department on the 20 patients and compiled a list of typical items and services associated with the management of infants with febrile UTI with and without bacteremia (Table 1). After creating a list of these items and services, we determined costs and charges from 2 sources: 1) Healthcare Cost and Utilization Project Kids' Inpatient Database (HCUP-KID),[15] which is based on national hospital data and was used to estimate inpatient costs and charges per day for infants with fever and UTI without bacteremia (Table 1); and 2) *Medical Fees 2016*,[16] which provides relative value unit-based Medicare fee schedules and usual, customary, and reasonable values and was used to estimate costs and charges of ED

Table 1. Standard Items and Services Associated With Management

Expenses	Costs	Charges
Base inpatient expense for infant with febrile UTI*		
Inpatient expenses (includes ED expenses), amount per day	$1333	$5061
Additional expenses for bacteremic patients†		
Inpatient expenses		
Infectious diseases consult	$111	$257
PICC line-insertion fee	$1336	$3092
Fluoro-guided vascular access fee	$71	$243
Ultrasound-guided vascular access fee	$32	$112
Post-PICC placement chest x-ray	$28	$96
Case-management consultation	$43	$120
Outpatient expenses		
Home nursing 2x/wk for 2 wk (4 visits total)	$736	$1204
Outpatient labs 1x/wk for 2 wk (2 draws total)		
CBC	$21	$62
CMP	$28	$100
ED expenses for discharged/bacteremic infants		
Urinalysis, complete	$4	$25
Urine reducing substance	$3	$4
Urine culture and Gram stain	$11	$31
Blood culture	$14	$78
Blood Gram stain	$6	$23
CBC complete and differential	$11	$31
IV line placement	$57	$114
Pathology evaluation	$22	$63
ED physician fee	$119	$562
ED facility fee	$65	$335

UTI indicates urinary tract infection; ED, emergency department; PICC, peripherally inserted central catheter; CBC, complete blood count; CMP, comprehensive metabolic panel; IV, intravenous.
*Healthcare Cost and Utilization Project Kids' Inpatient Database 2012.
†2016 medical and lab fee schedule.

expenses and additional inpatient and outpatient expenses associated with the presence of bacteremia.

The HCUP-KID database did not separately categorize infants 29 to 60 days old, so we queried the immediate superset (29−365 days old) and used those data to estimate inpatient costs and charges for treating infants with "fever" and "UTI," "without [other diagnoses]." Corresponding billing codes on items for ED evaluation and additional inpatient and outpatient items associated with confirmed bacteremia were taken from the list compiled on the 20 patients and converted into average national costs and charges using *Medical Fees 2016*. Charges for lab tests are also included in *Medical Fees 2016*, and costs for labs are also provided in annual lab-fee schedules published by the Centers for Medicare and Medicaid Services.

Reimbursements described in this study are based directly on our institution's raw data for the 20 patients obtained via retrospective review and do not necessarily reflect national reimbursement rates. Reimbursements may vary widely depending on patients' insurance and other funding sources.

OUTCOMES

Our primary outcome was the difference in costs per bacteremic patient between admission and discharge strategies. Secondary outcomes were differences in charges and reimbursements per bacteremic patient for admission and discharge strategies.

ASSUMPTIONS

Our reference study reported data showing that disposition is not a predictor of bacteremia in young infants with febrile UTI.[3] Secondary analysis of the study identified clinical site as the only factor highly associated with outpatient management of these infants.[12] We therefore assumed that the probability of bacteremia is the same for infants regardless of admission or discharge. Our reference study also reported that inpatient LOS was 2 to 5 days. We estimated a LOS of 2 days for non-bacteremic patients and 5 days for bacteremic patients. Of note, LOS for the 20 patients at our institution supports these assumptions (ie, non-bacteremic LOS median of 2 days, bacteremic LOS median of 5 days). Our reference study also revealed that, of the infants discharged and later found to have bacteremia, none suffered adverse events. We therefore assumed that the inpatient LOS for bacteremic patients initially admitted was the same as the inpatient LOS for bacteremic patients who were initially discharged and then returned.

SENSITIVITY ANALYSIS

A one-way sensitivity analysis was conducted for the assumption that inpatient LOS is the same for bacteremic patients initially admitted compared to bacteremic patients initially discharged who subsequently returned to the ED and were admitted later.

Table 2a. Absolute Costs, Charges, and Reimbursements Per Infant in Each Clinical Category

Type of Patient	Costs	Charges	Reimbursements
Admitted bacteremic	$9384	$31,859	$21,273
Admitted non-bacteremic	$2978	$11,389	$6642
Discharged bacteremic	$9695	$33,125	$14,538
Discharged non-bacteremic	$312	$1266	$1942

Values for costs and charges are based on national averages. Reimbursements are based on values from the study institution only.

Table 2b. Relative Costs, Charges, and Reimbursements to Catch 1 Patient with Bacteremia

Strategy	Costs	Charges	Reimbursements
Admit all patients	$99,460	$376,371	$222,204
Discharge all patients	$19,127	$71,422	$73,280
Discharge savings	$80,333	$304,949	$148,924

Numbers reflect amount for 31 infants and reflect weighted amounts based on 3.2% probability of bacteremia. Values for costs and charges are based on national averages. Reimbursements are based on values from the study institution only.

Table 2c. Relative Costs, Charges, and Reimbursements Per 100 Infants

Type of Patient	Costs	Charges	Reimbursements
Admitted bacteremic	$30,029	$101,949	$68,074
Admitted non-bacteremic	$288,270	$1,102,438	$642,946
Admit total	$318,299	$1,204,387	$711,020
Discharged bacteremic	$31,024	$106,000	$46,522
Discharged non-bacteremic	$30,202	$122,549	$187,965
Discharge total	$61,226	$228,549	$234,487
Discharge savings	$257,073	$975,838	$476,533

Numbers reflect weighted amounts based on 3.2% probability of bacteremia. Values for costs and charges are based on national averages. Reimbursements are based on values from the study institution only.

RESULTS

The absolute costs per patient were $9695 for infants discharged with bacteremia, $9384 for infants admitted with bacteremia, $2978 for infants admitted without bacteremia, and $312 for infants discharged without bacteremia (Table 2a).

COST SAVINGS

Based on a probability of bacteremia of 3.2%, the number needed to treat to yield 1 patient with bacteremia was 31; therefore, the cost of admitting all patients to catch 1 patient with bacteremia was $99,460 (Table 2b). The equivalent cost for discharging all patients was $19,127, resulting in cost savings of $80,333 (80%). Admission of non-bacteremic patients accounted for 90% of admission costs ($90,076/$99,460) and 76% of costs overall
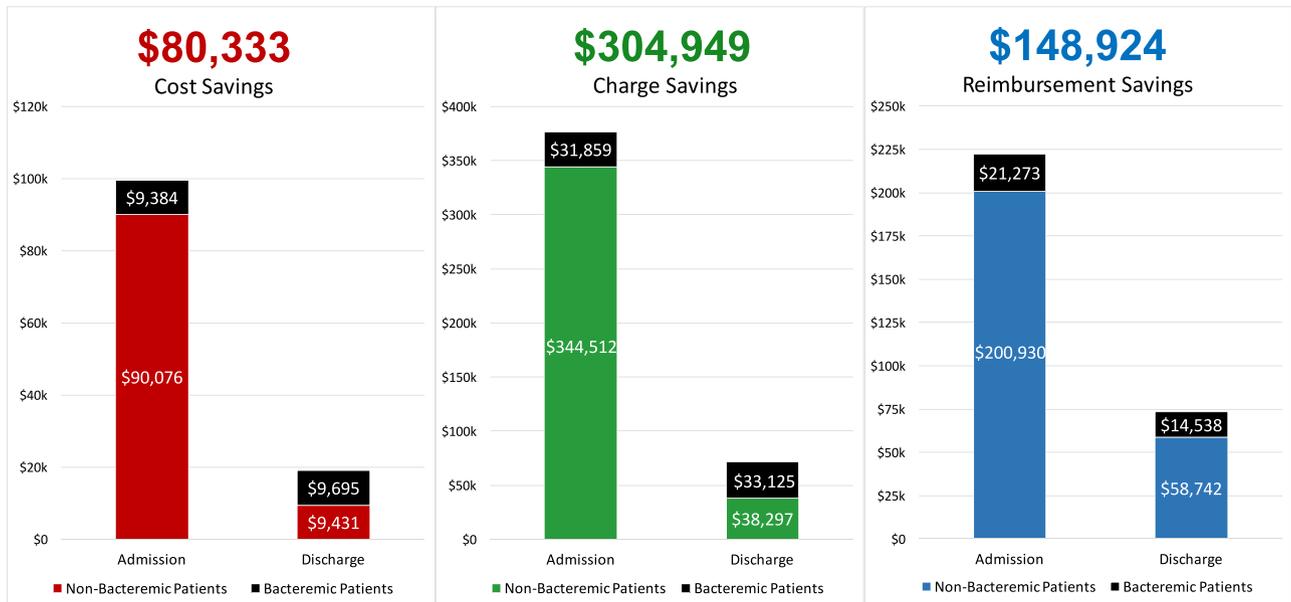
Figure 2. *Relative costs, charges, and reimbursements to catch a single patient with bacteremia.*

($90,076/$118,586) (Fig. 2). Accounting for the probability of bacteremia in this low-risk group, the cost savings for discharging infants with febrile UTI was $257,073 per 100 patients overall (Table 2c).

CHARGE SAVINGS

In our analysis of national charges, the savings from discharging was $304,949, also 80%, for each patient with bacteremia ($71,422 vs $376,371) (Table 2b). Admission of non-bacteremic patients accounted for 92% of admission charges ($344,512/$376,371) and 77% of charges overall ($344,512/$447,792) (Fig. 2). The charge savings for discharging infants with febrile UTI was $975,838 per 100 patients overall (Table 2c)

REIMBURSEMENT SAVINGS

Finally, an analysis of our institution's reimbursements demonstrated savings of $148,924, or 67%, for each patient with bacteremia ($73,280 vs $222,204) (Table 2b). Admission of non-bacteremic patients accounted for 90% of admission reimbursements ($200,930/$222,204) and 68% of overall reimbursements ($200,930/$295,482) (Fig. 2). The reimbursement savings for discharging infants with febrile UTI was $476,533 per 100 patients overall (Table 2c).

One-way sensitivity analysis around the assumption that inpatient LOS is the same for bacteremic patients admitted compared to bacteremic patients discharged and returned revealed a 1.6% decrease in cost savings per additional inpatient day for initially discharged patients (Fig. 3).

DISCUSSION

This is the first cost analysis of disposition decisions for young infants presenting to the ED with fever and UTI. Our analysis provides evidence that discharging infants 29 to 60 days of age with febrile UTI who meet low-risk

criteria for bacteremic and adverse events results in significant cost savings. These savings are demonstrated because most of the costs associated with managing low-risk young infants are spent on admission of non-bacteremic patients. Similar outcomes are demonstrated for hospital charges and reimbursements, which confirm our findings for costs. These savings are maintained even when accounting for additional factors associated with bacteremic patients initially discharged who later return when blood cultures result positive.

We emphasize that the savings are achieved without an increased risk of subsequent adverse events, due to the use of risk-stratification criteria published by Schnadower et al[3] showing a predicted adverse-event probability of 0% in patients meeting the criteria. When analyzing absolute costs per patient, the difference in costs for bacteremic patients admitted and bacteremic patients discharged was accounted for by the cost of a repeat ED visit for discharged patients. No additional costs were incurred, because these patients do not return more ill.[3]

According to our sensitivity analysis, changes in LOS for bacteremic patients do not significantly affect cost differences, demonstrating a 1.6 % (~$1300) decrease in cost savings per each additional inpatient day. This is because the number needed to treat is high. The savings from discharging non-bacteremic patients outweighs the cost increase of a longer LOS. To reverse the net cost savings, each bacteremic patient who is initially discharged and later admitted would have to stay in the hospital ~60 days longer than patients initially admitted. This is related to the fact that bacteremic patients meeting low-risk criteria do not have more complications when discharged. The Schnadower et al[3] 2010 database revealed that, among infants meeting all 4 low-risk criteria for bacteremia, none suffered adverse events, regardless of whether admitted or discharged.
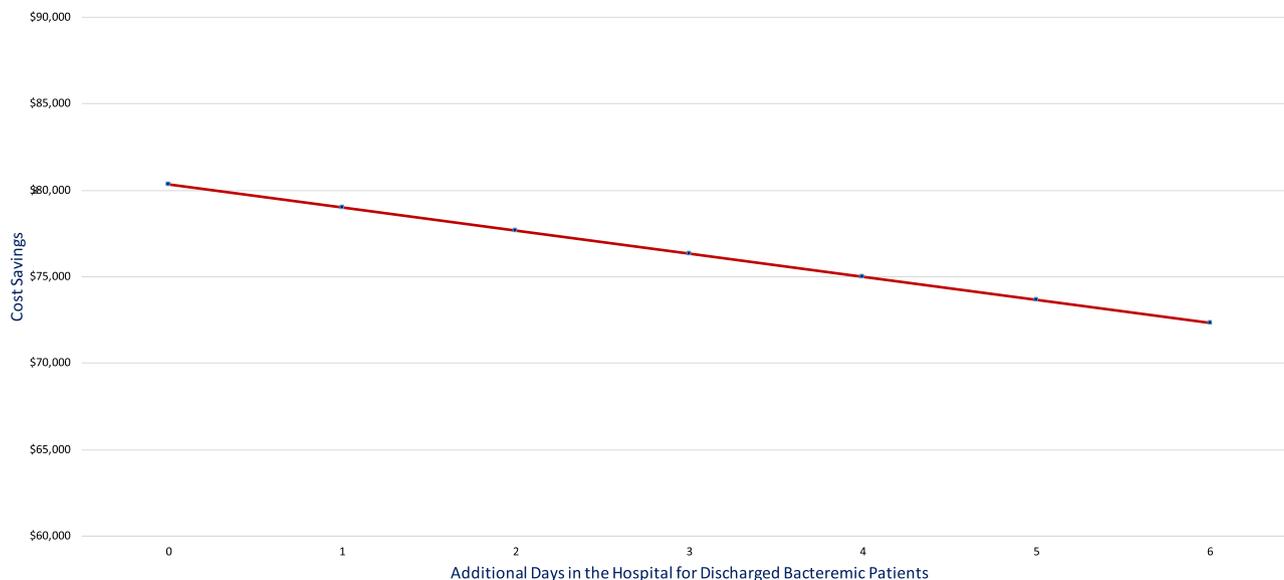
Figure 3. *Sensitivity analysis of length of stay assumptions for discharged bacteremic patients.*

Another concern for young infants with bacteremic UTI is related to unclear risk of long-term renal injury and the utility of admitting to obtain renal ultrasound (RUS) and voiding cystourethrogram (VCUG) more quickly. However, a study by Chang et al[17] does not support special consideration for obtaining imaging for bacteremic UTI infants. Their analysis of 254 infants <3 months of age with bacteremic UTI demonstrated that the risks of RUS and VCUG abnormalities were 55% and 33%, respectively, which is on par with averages reported for all infants with UTI (ie, RUS, 21%−62%; VCUG, 21%−52%). Roman et al[9] showed similar results. Performing these studies in an inpatient rather than outpatient environment is not cost effective and often avoidable.

As we approach an era with improved remote monitoring, there is opportunity for cost savings with other similar patient populations where observation can be done at home rather than in the hospital setting. The use of telemedicine and patient engagement can tighten this relationship between a patient and a care team and allow monitoring for changes in clinical status from afar. Although this study focused on low-risk patients, there is potential even for the higher risk groups, where there are still ample cost savings associated with the discharge strategy. It is important to develop a culture where communication and ongoing assessment are not terminated when a patient leaves the walls of the ED. If a payer reallocated the cost savings to build a telemedicine program, there is potential for even greater cost savings. In our study, a payer would save more than $250,000 for every 100 patients with febrile UTI by taking a discharge-first approach. Perhaps we should be investing in ED-to-home communication, not hospitalization.

LIMITATIONS

A potential limitation to this study is that the probabilities for bacteremia and adverse events in low-risk infants were taken from a single retrospective study and

prediction model that has not been validated prospectively. More studies are needed to validate this model, but we note that the prediction model's estimated bacteremia probability of 6.5% for all (not just low-risk) young infants is within the 4% to 9% range (median 6.9%) found in previous studies.[3−11] The prediction model's finding of low probability of bacteremia and no adverse events among low-risk infants is also supported by other studies. Velasco et al[5] published a prediction model for invasive bacterial infection in infants less than 90 day old with fever and abnormal urinalysis, with subsequent validation of these results. The risk of invasive bacterial infection, defined as isolation of non-contaminant bacterial pathogen in blood or cerebrospinal fluid, was reduced from 6.5% to 0% when their criteria were met. We chose not to use probabilities from this prediction model, as it includes neonates as well as infants 2 to 3 months old, for whom published guidelines for treatment already exist.

Other studies support the premise that young infants with bacteremia are no more likely to develop sequelae. Paquette et al[18] questioned whether lumbar puncture should be performed in all infants 30 to 90 days old with abnormal urinalysis. Of 57 infants with abnormal urinalysis, one had concomitant *Escherichia coli* bacteremia and meningitis; however, the infant was 71 days old, was not well appearing, had a low peripheral white blood cell count at 2.9×10^9/L, and therefore was not low risk according to our criteria. In Morley et al,[8] 0 out of 11 infants (ages 13−54 days old) with positive blood cultures (with and without UTI) had positive cerebrospinal fluid cultures.

The probability estimates of the prediction model, therefore, appear to be well supported by the literature. Risk stratification provides value by enabling emergency rooms to focus resources for hospitalization and intravenous antibiotics on higher-risk patients, recognizing that discharged infants receive a course of oral antibiotics as outpatients and most institutions have a system in place to

follow up on cultures within 24 hours to have patients return if results dictate. Consequently, not only are adverse events extremely low probability in our target patient population, but their likelihood is also unlikely to be affected by moving to a discharge strategy.

The foregoing considerations also address a related potential objection to this study—that our model lacks an adverse-events arm. The cost of treating adverse events does not affect our analysis unless there is a substantial difference in adverse-event probabilities between admission and discharge strategies. Because there is no evidence of such a difference, the costs related to adverse events, if any, cancel each other out in the cost analysis. We recognize that, in theory, our reference study could underestimate adverse events or bacteremia among initially discharged patients (eg, if those patients returned to a different emergency room) due to its retrospective rather than longitudinal design. For that reason, we believe a longitudinal prospective validation of the predictive model we rely upon would be welcome in the medical literature. Indeed, our study shows that such further research is well justified.

For our study, we relied on a retrospective chart analysis of 20 patients from a single institution to determine typical treatment items and services. Although practice variation across institutions will affect cost, charge, and reimbursement totals, we note that our institution, a large pediatric research institution, employs evidence-based practices that are standard of care. More importantly, our cost and charge estimates for each element of care are based on national standardized rates (HCUP-KID database and *Medical Fees 2016*), not on our specific institution's costs and charges. Because the savings we present are largely driven by hospital bed costs, which are determined by LOS and the cost of a hospital bed, we addressed variation in LOS in a sensitivity analysis, discussed above. Our comparison of standardized costs and charges and own-institution reimbursements shows that the order of magnitude of savings is not dependent on billing idiosyncrasies of our institution.

We did not take into account indirect expenses including follow-up visits with primary physicians and subspecialists, lost wages, transportation costs, or nonmonetary costs. Such expenses are speculative, and accounting for them would be more likely to support rather than undermine our results. However, disparities among patients related to access to follow-up care, parental preference, and parental reliability should be factored into physicians' disposition decisions.

A final limitation of the study is the fact that the HCUP-KID database, which we used to estimate inpatient costs for uncomplicated fever and UTI (ie, without bacteremia and adverse events), did not provide data specifically for age of interest in our study. However, there is no reason to believe that costs for an uncomplicated inpatient stay for infants 29 to 60 days old with fever and UTI would be less than that of infants 29 to 365 days old.

Conclusions

Most of the costs associated with managing young infants presenting to the ED with fever and urinary tract infection are for admission of non-bacteremic patients. Risk stratification using criteria established in the literature enables outpatient management of low-risk infants, leading to substantial savings without compromising patient outcomes.

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