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Posted Date: 8 April 2024

doi: 10.20944/preprints202404.0534.v1

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Article

Hospital and Patient Characteristics Associated with Neonatal Blood Stream Infection in Inpatient Hospital Care; Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Databases (KID) 2019

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Abstract: This study aims to explore the associations between pediatric adverse events (PAEs) and hospital and patient characteristics within the inpatient hospital setting, focusing solely on the framework of pediatric quality indicators (PDIs) from the Agency for Healthcare Research and Quality (AHRQ). Specifically, the study focuses on NQI 03 Neonatal Blood Stream Infection (NBSI). The analysis utilizes discharge data from the Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Databases (KID) for the year 2019. Through this analysis, the study seeks to answer research questions regarding associations between hospital characteristics and patient characteristics with NQI 03. The methodology employs bivariate and multivariate logistic regression models to analyze patient-level encounters of NBSI. The results indicate that smaller, rural, and non-teaching hospitals exhibit significantly lower odds of NQI 03 compared to large hospitals. Various individual factors such as gender, age, race, service lines, payment sources, and major operating room procedures also demonstrate differing levels of significance in relation to NQI 03, warranting further investigation. This study provides contextual expansion on the findings and offers valuable insights into PAEs in the inpatient hospital setting, specifically focusing on NBSI within the PDIs framework. It highlights areas for developing evidence-based interventions and guidelines for clinicians and policymakers. Ultimately, the findings contribute to the growing understanding of factors influencing NBSI and emphasize the importance of targeted strategies for improving pediatric patient safety.

Keywords: neonatal blood stream infection; quality improvement; pediatric care; pediatric adverse events; Kid's Inpatient Database

1. Introduction

Adverse events (AEs) within healthcare systems, highlighted since the seminal publication of "To Err is Human" by the Institute of Medicine in 1999 [1], continue to be a focal point despite advancements in patient safety and quality [2]. This study addresses the necessity to comprehend pediatric adverse events (PAEs) within the broader patient safety context, utilizing a pediatric quality indicator (PDI) framework for assessment. Developed as part of the Agency for Healthcare Research and Quality's (AHRQ) efforts to standardize healthcare quality measurement, PDIs specifically target preventable complications and iatrogenic events in pediatric patients, as well as preventable hospitalizations for children [3]. Originally introduced in 2006 to distinguish them from patient quality indicators (PQIs), PDIs have evolved with refinements including risk adjustments, reference populations, and ICD-10 coding [3]. These indicators operate at both area and hospital levels, with hospital-level PDIs capturing potentially preventable complications or adverse events following medical conditions or procedures. This study relies on the classification provided by AHRQ to

investigate, measure, and mitigate NBSI, emphasizing the utilization of hospital-level PDIs for comprehensive understanding and improvement measures.

The incidence of AEs, often conflated with medical errors, has been a subject of debate and scrutiny [4–6]. Studies have estimated AEs to be a leading cause of death in the United States, with systemic issues contributing significantly to their occurrence [4,6]. While the focus has shifted towards understanding and mitigating systemic flaws rather than blaming individuals, challenges persist in identifying AEs and assessing their preventability, particularly within pediatric healthcare settings [6].

In pediatric healthcare, AEs pose significant challenges, with studies reporting varying rates depending on patient populations and settings [7–9]. PAEs have been linked to substantial morbidity and mortality, with certain patient groups at higher risk [7]. Despite efforts to address these issues, rates of PAEs have not decreased over time, necessitating ongoing efforts to improve patient safety through comprehensive strategies [10].

Neonatal bloodstream infections (NBSIs) are a critical area of concern within pediatric healthcare settings. AHRQ defines and measures NBSI under the PDI indicator (NQI 03), which for the year 2019 had an incidence rate of 20.23 per 1000 discharges observed from the total population of the State Inpatient Database [3]. Despite advances in medical care, NBSIs remain a significant cause of morbidity and mortality among neonates, with various risk factors including low birth weight, prolonged rupture of membranes, and mechanical ventilation [11]. Studies have identified common pathogens such as Group B Streptococcus (GBS) and Escherichia coli (E.coli) as contributing to NBSIs, with preterm infants being particularly vulnerable [12]. Additionally, the rise of multidrug-resistant gram-negative (MDR-GN) infections underscores the urgency in implementing both infection control measures and judicious antibiotic use [13]. Research has explored the effectiveness of central line "bundles" in reducing different types of NBSI in neonatal intensive care units (NICUs), highlighting the importance of evidence-based interventions in improving patient outcomes [14]. By focusing on NQI 03, the PDI that measures NBSI, this study aims to provide data capable of informing evidence-based recommendations for quality improvement efforts in pediatric inpatient settings.

This study utilizes the 2019 HCUP Kid's Inpatient Database (KID) database to assess one PAE, NBSI, recognizing the importance of current and comprehensive data in understanding healthcare trends. The study also relies on AHRQ hospital-level indicator (NQI 03), measured at the patient encounter level to gauge patient harm and safety. By focusing on a specific PDI and utilizing the most recently available nationwide database, the study aims to overcome disparities in AE reporting, particularly in pediatric populations, underscoring the need for comprehensive research and interventions.

The study aims to address this knowledge gap by utilizing a high-incidence PDI as an overview of overall quality and pediatric patient safety. Specifically, it addresses the following research questions:

1. Are specific hospital characteristics (region, teaching status, rurality, ownership, size) associated with NQI 03?
2. Are specific patient characteristics (age, gender, payor, race, previous major operation, service line of provider associated with hospital visit) associated with NQI 03?

2. Materials and Methods

This observational study employs a population-based retrospective cohort design. We extracted data from the Health Care Utilization Project (HCUP) KID dataset, 2019, obtained from the Agency for Healthcare Research and Quality (AHRQ) [15]. HCUP data are created for billing and research purposes and is based on administrative data to inform policies nationwide [15]. The KID is the largest public pediatric inpatient, all-payer database that contains approximately 3 million unweighted pediatric discharges each year [15].

This study utilizes a population-based retrospective cohort design which allows for the measurement of outcomes and the relationship between variables. The population set available for the year 2019 encompasses national estimates of hospital inpatient stays for patients 21 and younger

[15]. The number of states included in the KID database is 48 plus the District of Columbia sampled from 4,000 U.S. community hospitals including non-federal, short-term, specialist, and general hospitals yet excludes rehabilitation hospitals and those as attachment units of other institutions [15]. The KID database has been available every three years beginning from 1997 to 2012 and from 2016 to 2019, however, it was not available for the year 2015 due to the transition to ICD-10-CM/PCS coding, which is utilized for this study [15]. The KID data file is structured around two elements the discharge-level files which include core files, severity file, and diagnosis and procedure groups files, while the hospital-level files include information on hospital characteristics [15].

2.1. Variables

The main dependent variable in this study is whether neonatal bloodstream infection occurred (Yes=1; No=0). The independent variables for this study were divided into two main categories, hospital characteristics, and patient characteristics as follows:

- Hospital characteristics: hospital bed size (coded as 1: Small, 2: Medium, 3: Large); hospital location (1: Rural 2: Urban nonteaching 3: Urban teaching); hospital region (1: Northeast 2: Midwest 3: South 4: West); hospital ownership (1: Government, non-federal (public) 2: Private, not-for-profit (voluntary) 3: Private, investor-owned (proprietary)).
- Patient characteristics included, gender (0: Male 1: Female); race (1: White 2: Black 3: Hispanic 4: Asian/Pacific Islander 5: Native American 6: Other); service line (1: Maternal and Neonatal 2: Mental health/substance use 3: Injury 4: Surgical 5: Medical); payment type (1: Medicare 2: Medicaid 3: Private insurance 4: Self-pay 5: No charge 6: Other); and operation on record (0: No major operating room procedure on record 1: Major operating room procedure on record).

2.2. Analysis

The analyses were conducted using the application of AHRQ PDIs to HCUP KID database for the year 2019, the AHRQ QI SAS software that is created by AHRQ for this purpose must be used [3]. For this study, the SAS QI® v2020 was used, which has been adopted to be used with SAS Version 9.4 as a personal computer-based, single-user application, was utilized along with the specific population file for the v2020 provided by AHRQ [3]. To model the dichotomous dependent variables, logistic regression analyses were used. We computed odds ratios and adjusted odds ratios. The statistical models utilized inpatient discharges as the units of analysis. Logistic regression allows for the estimation of odds ratios, which indicate the likelihood of an event occurring (e.g., the occurrence of a PDI) based on the values of the independent variables. This model, alongside the software, provided important insights into the associations between these variables to inform strategies for quality improvement and patient safety, as well as guide future research and interventions in pediatric healthcare settings. This study was exempted from full institutional review board under protocol H23359 since it utilizes secondary data wherein human subjects cannot be identified.

3. Results

The descriptive analysis of the HCUP KID dataset (2019) provides valuable insights into the distribution and characteristics of hospitals and patients in the sample. The analysis includes the three main categories of the independent variables: hospital characteristics such as bed size, location, region, and ownership; patient characteristics like gender, race, service line, payment source, and the presence of operations. Together, these findings serve as a foundation for understanding the profile of hospitals and patients under consideration and pave the way for further analysis and interpretation of the data.

Most hospitals in the sample were classified as large (60.7%), followed by medium (24.0%) and small (15.2%) in terms of bed size. Regarding location, most hospitals were classified as urban teaching hospitals (82.3%), followed by urban non-teaching hospitals (11.6%) and rural hospitals (6.1%). In terms of hospital region, the largest proportion was in the South (38.3%), followed by the West (22.0%), Midwest (22.6%), and Northeast (17.1%). Hospital ownership was predominantly

private, not-for-profit entities (77.1%), with public hospitals accounting for 11.8% and private, investor-owned hospitals accounting for 11.0%.

The mean age of patients at admission was (5.58) years, with a minimum age of 0 years and a maximum age of 20 years (standard deviation = 7.574). Approximately 51.4% of patients in the sample were female, while 48.6% were male. The largest racial group among patients was White (45.6%), followed by Black (16.6%), Hispanic (19.7%), Asian/Pacific Islander (4.0%), Native American (.9%), and Other (6.1%). The most common service line for hospitals in the sample was Maternal and Neonatal (55.6%), followed by Medical (27.4%), Mental health/substance use (6.8%), Surgical (7.1%), and Injury (3.2%). Regarding payment source, many patients had Medicaid (50.7%), followed by private insurance (41.1%), self-pay (4.3%), Medicare (0.3%), other (3.3%), and no charge (0.1%). Most patients in the sample did not have any operation recorded (88.0%), while the remaining (12.0%) underwent a major operation.

The QI in question (NQI 03) was taken at the numerator level to produce events/occurrences rather than a rate. The analysis conducted using the FREQ Procedure on the KID 2019 database, specifically examining the neonatal population segmented by age (AGE_NEONATE), revealed that most neonates, approximately 78.61%, did not display NBSI, amounting to 1,833,049 cases (Table 2). Conversely, a significant proportion of the neonatal population, accounting for 21.39%, did exhibit NBSI, totaling 498,829 cases. These statistics offer valuable insights into the occurrence of NBSI among neonates in the specified year's database as it solely focuses on the neonatal population and not pediatric patients. It is worth noting that there were 14 missing cases in this analysis.

Table 2. Associations between the HCUP KID database for the year 2019 and NQI 03 Logistic Regression Bivariate & Multivariate analysis.

NBSI	Frequency	Percent	Cumulative Frequency	Cumulative Percent
NBSI absent	1833049	78.61	1833049	78.61
NBSI present	498829	21.39	2331878	100.00

Note: The FREQ Procedure Neonatal Blood Stream Infection in the KID 2019 database taken from the neonatal population (AGE_NEONATE).

Overall, these descriptive statistics provided a comprehensive overview of both hospital and patient distribution and characteristics within our sample. These findings helped us draw up a map of our understanding of hospital and patient profiles under consideration and lay the foundation for further analysis and interpretation of the data.

In the bivariate logistic regression analysis, several patient and hospital characteristics were examined for their association with events of NBSI. With the sample population being restricted to the Neonate variable, the results revealed distinct relationships that pertain to that age of classification.

For patient characteristics (Table 3), gender did not reveal a significant association (p=0.5876), indicating that there was no significant difference in the odds of infection between genders.

Table 3. NQI 03 Neonatal Blood Stream Infection Events (PPNQ03), Logistic Regression (Bivariate analysis) for patient characteristics, 2019.

Patient Characteristics								
Variables		Estimate	SE	Wald Chi-Square	P-value	OR	Wald 95% confidence limits for OR	
Gender	Female	-0.0909	0.00231	1544.9792	0.5876	0.998	0.992	1.005
	Male ^s	--	--	--	--	--	--	--
Age								
Race	Black	0.3737	0.00474	6210.2915	<.0001	1.453	1.440	1.467
	Hispanic	0.3005	0.00456	4335.7171	<.0001	1.351	1.339	1.363

	Asian/Pacific Islander	0.3514	0.00731	2309.3090	<.0001	1.421	1.401	1.442
	Native American	-0.6356	0.0211	905.0704	<.0001	0.530	0.508	0.552
	Others	0.2732	0.00656	1735.7776	<.0001	1.314	1.297	1.331
	White ^s	--	--	--	--	--	--	--
Service line	Maternal and Neonatal	-0.5369	0.0154	1212.1621	<.0001	0.585	0.567	0.603
	Mental health/substance use	0.2149	0.2036	1.1139	0.2912	1.240	0.832	1.848
	Injury	0.2358	0.0915	6.6453	0.0099	1.266	1.058	1.515
	Surgical	0.5785	0.0286	409.9134	<.0001	1.783	1.686	1.886
	Medical ^s	--	--	--	--	--	--	--
Payment Source	Medicare	-0.4039	0.0385	109.8998	<.0001	0.668	0.619	0.720
	Medicaid	0.2659	0.00837	1009.4189	<.0001	1.305	1.283	1.326
	Private insurance	0.4226	0.00837	2548.9116	<.0001	1.526	1.501	1.551
	No charge	-0.5472	0.0518	111.5880	<.0001	0.579	0.523	0.640
	Other	0.4556	0.0126	1304.3793	<.0001	1.577	1.539	1.617
	Self-pay ^s	--	--	--	--	--	--	--
Operation on record	Major operating room procedure on record	0.6831	0.0125	3003.8294	<.0001	1.980	1.932	2.029

Abbreviations: CL, confidence limits; OR, odds ratio.; Note: The bold p indicates significance (vs. reference category) at $p < 0.05$; The symbol ^s indicates the reference category.

Regarding race, it was found to be strongly associated with NBSI events ($p < 0.0001$). The variable showed variations among different racial categories, when compared to the reference category "White," all other races displayed significantly higher odds ratios. For instance, the OR for Black patients was 1.453 (95% CI: 1.440-1.467), indicating 45.3% higher odds of infection compared to Whites. Whereas Hispanic patients (OR=1.351; 95% CI: 1.339 to 1.363) showed 35.1% higher odds of infection compared to Whites. Moreover, while Asian/Pacific islanders (OR=1.421; 95% CI: 1.401 to 1.442) showed 42.1% higher odds of infection compared to Whites, Native Americans (OR=0.530; 95% CI: 0.508 to 0.533) showed an inverse relationship with 53% lower odds of infection compared to Whites. Other races (OR=1.314; 95% CI: 1.297 to 1.331) showed a 31.4% increase odds of infection.

In terms of the service line, indicating the type of medical service provided, a significant association with NBSI was found ($p < 0.0001$, $p < .5$ Injury), except for Mental Health/Substance abuse ($p=0.2912$) when compared to the "Medical" service line. The odds ratio (OR) for the "Surgical" service line was particularly high at 1.783 (95% CI: 1.686 to 1.886), indicating a significantly higher risk of 78.3% compared to the reference category Medical. Maternal and Neonatal services showed the lowest odds of infection (OR=0.585; 95% CI: 0.567 to 0.603) with 58.5% lower odds of infection when compared to Medical, followed by Injury (OR=1.266; 95% CI: 1.058 to 1.515) with a higher odd of infection amounting to 26.6% when compared to Medical.

Regarding payment source, significance was associated with NBSI when compared to "Self-pay" ($p < 0.0001$), where Medicare (OR=0.668; 95% CI: 0.619 to 0.720) showed 33.2% lower odds of infection. No charge (OR=0.579; 95% CI: 0.523 to 0.640) also showed a 42.1% lower odds of infection when compared to Self-pay, whereas Private Insurance (OR=1.526; 95% CI: 1.501 to 1.551), Medicaid (OR=1.305; 95% CI: 1.283 to 1.326) and Other (OR=1.577; 95% CI: 1.539 to 1.617) all showed higher odds of infection (52.6%, 30.5%, 57.7% respectively) when compared to the odds of infection of Self-pay patients.

Regarding major operating room procedure, Neonate patients had a significantly higher odds (OR=1.980; 95% CI: 1.932 to 2.029) of infection when compared to patients without such procedures.

This amounted to a nearly twofold 98% higher odds of infection, drawing attention to the concentration of risk present in operative circumstances.

For hospital characteristics (Table 4), all were found to be significantly associated with NBSI ($p < 0.0001$). Hospital bed size demonstrated a significant association with Small-sized hospitals showing an odds ratio of 0.442 (95% CI: 0.438-0.446), indicating a 55.8% lower likelihood of infection events when compared to the reference, Large-sized hospitals. Medium-sized hospitals had an OR of 0.755 (95% CI: 0.749-0.760), representing a 24.5% lower risk. These findings suggest that larger hospitals may face higher infection risks compared to smaller and medium-sized hospitals.

Table 4. NQI 03 Neonatal Blood Stream Infection Events (PPNQ03), Logistic Regression (Bivariate analysis) for hospital characteristics.

Hospital Characteristics								
Variables		Estimate	SE	Wald Chi-Square	P-value	OR	Wald 95% CLfor OR	
Hospital bed size	Small	-0.8163	0.00485	28347.8775	<.0001	0.442	0.438	0.446
	Medium	-0.2816	0.00389	5232.2092	<.0001	0.755	0.749	0.760
	Large§	--	--	--	--	--	--	--
Hospital location	Rural	-2.6062	0.0106	60150.4947	<.0001	0.074	0.072	0.075
	Urban nonteaching	-0.7646	0.00466	26946.8518	<.0001	0.466	0.461	0.470
	Urban teaching§	--	--	--	--	--	--	--
Hospital region	Northeast	-0.0741	0.00555	178.5115	<.0001	0.929	0.919	0.939
	Midwest	-0.2399	0.00509	2217.5831	<.0001	0.787	0.779	0.795
	South	0.1026	0.00435	556.8232	<.0001	1.108	1.099	1.118
	West§	--	--	--	--	--	--	--
Hospital ownership	Public	-0.3219	0.00690	2177.1313	<.0001	0.725	0.715	0.735
	Private, not-profit	0.0247	0.00499	24.5644	<.0001	1.025	1.015	1.035
	Private, investor-owned§	--	--	--	--	--	--	--

Abbreviations: CL, confidence limits; OR, odds ratio.; Note: The bold p indicates significance (vs. reference category) at $p < 0.05$.; The symbol § indicates the reference category.

Hospital location also displayed a significant relationship with NBSI. Rural hospitals had the lowest OR of 0.074 (95% CI: 0.072-0.075), indicating a 92.6% lower risk of infection events compared to urban teaching hospitals (reference category). Urban nonteaching hospitals had an OR of 0.466 (95% CI: 0.461-0.470), signifying a 53.4% lower risk, when compared to urban teaching hospitals, showcasing the importance of considering hospital location when looking at neonatal infection.

Regarding hospital location, the odds ratios for the Northeast, Midwest, and South regions were estimated to be 0.929 (95% CI: 0.919-0.939), 0.787 (95% CI: 0.779-0.795), and 1.108 (95% CI: 1.099-1.118), respectively. These figures represent a 7.1% lower risk in the Northeast, a 21.3% lower risk in the Midwest, and an 10.8% higher risk in the South, compared to the West (reference category).

Furthermore, hospital ownership exhibited a significant relationship with NBSI. Public hospitals had an odds ratio of 0.725 (95% CI: 0.715-0.735), indicating a 27.5% lower risk compared to the Private-investor owned. Private, not-for-profit hospitals had an odds ratio of 1.025 (95% CI: 1.015-1.035), suggesting a 2.5% increased risk when compared to Private- investor-owned hospitals. These results imply that hospital ownership may influence infection risks, with public hospitals showing a lower risk compared to private, not-for-profit hospitals.

Following along with the multivariate analysis, this study sought to present associations with the variables while controlling for other factors. The associations for patient characteristics remained largely consistent, though gender (female) did show a significant association ($P = 0.0158$) with an adjusted odds ratio (AOR) of 1.009 (95% CI: 1.002-1.015), suggesting a 0.9% increased risk compared

to males. This showed that there is a statistically significant difference between males and females in terms of infection odds when other variables are controlled for.

In terms of race, all races showed significant associations with NBSI when compared to White race and controlling for other variables. Being Black was associated with 16.6% higher odds of infection (AOR=1.166; 95% CI: 1.154 to 1.178) when compared to White and controlling for other variables, while Hispanics had 7.7% higher odds than Whites when controlling for other variables (AOR= 1.077; 95% CI: 1.066 to 1.087) and Asian/Pacific Islander had 4.3% higher odds (AOR= 1.043; 95% CI: 0.962 to 0.990) when compared to White patients and controlling for other variables. The category “Others” was associated with 5.2% higher odds when compared to Whites (AOR=1.052; 95% CI: 1.038 to 1.066), while Native American (AOR=0.795; 95% CI: 0.761 to 0.831) showed an inverse relationship with 20.5% lower odds of infection when compared to Whites and controlling for other variables; remaining consistent with the findings of the bivariate analysis. These findings highlight the prominence of certain racial disparities in the risk of infection.

Examining the service line, Mental health/Substance use ($p=0.5706$) remained insignificant as was in the bivariate analysis, however “Injury” service line ($p=0.6389$) also became insignificant when compared to the “Medical” service line and controlling for other variables. Maternal and Neonatal services, however, showed a significant association with NBSI events with an AOR of (0.682; 95% CI: 0.661 to 0.704), indicating 31.8% lower odds of infection when comparing to the medical service line and controlling for other variables. Surgical service line also showed significance, with AOR of (0.929; 95% CI: 0.871 to 0.991) and 7.1% lower odds of infection than medical service lines and controlling for other variables.

Moving on to payment sources, when compared to Self-pay and controlling for other variables, all payment sources showed significance ($p<0.0001$) with NBSI events. Both Medicare (AOR= 0.672; 95% CI: 0.621 to 0.727) and No charge (AOR= 0.670; 95% CI: 0.603 to 0.744) displayed 32.8% lower odds of infection. On the other hand, Medicaid (AOR= 1.079; 95% CI: 1.060 to 1.098) Private Insurance (AOR= 1.228; 95% CI: 1.207 to 1.250) and Other (AOR= 1.361; 95% CI: 1.326 to 1.397) showed higher odds of infection (7.9%, 22.8%, 36.1%, respectively). These findings mirror those of the bivariate analysis and suggest that certain payment sources may confer a protective effect against infection.

Meanwhile, a Major operating room on record (AOR= 1.457; 95% CI: 1.414 to 1.501) was associated with 45.7% higher odds of infection when compared to no major operation on record and controlling for other variables, further mirroring bivariate findings, and consistently showing the vulnerability of repeat patients to infection.

Among hospital characteristics, small and medium bed sized hospitals (AOR= 0.421; 95% CI: 0.417 to 0.426, AOR=0.730 95% CI: 0.724 to 0.736, respectively) consistently showed significantly ($p<0.0001$) lower odds of infection (57.9%, 27%, respectively) when compared to large hospitals and controlling for other variables which could be related to the type of services offered in small and medium sized hospitals as opposed to larger ones. Nonetheless, hospital location also played a significant role ($p<0.0001$) with Rural (AOR= 0.672; 95% CI: 0.621 to 0.727) and Urban nonteaching (AOR= 0.672; 95% CI: 0.621 to 0.727) both showing lower odds (92.4%, 53.9%, respectively) of infection when compared to Urban teaching hospitals. These results were consistent with the bivariate analysis and displayed an increased risk in environments associated with urbanism and teaching.

When examining hospital region (all $p<0.0001$), the South region (AOR= 1.141; 95% CI: 1.131 to 1.152) was associated with 14.1% higher odds of infection compared to the reference category (West region) whereas the Northeast (AOR= 0.816; 95% CI: 0.807 to 0.826), and the Midwest (AOR= 0.899; 95% CI: 0.889 to 0.909) were found to be significantly associated with lower odds of infection (18.4%, 10.1%, respectively) when compared to the West and controlling for other variables.

Regarding hospital ownership both Public (AOR= 0.733; 95% CI: 0.723 to 0.744) and Private not-for-profit (AOR= 0.948; 95% CI: 0.948 to 0.968) hospitals were found to be significantly associated ($p<0.0001$) with lower odds of infection (26.7%, 4.2%, respectively) than Private- investor-owned hospitals when controlling for other variables. It is of note that the relationship associated with Private not-for-profit hospitals became inverse when controlling for other variables in the

multivariate analysis, suggesting that there are other factors impacting the relationship with infection events in these types of hospitals.

The findings of the above bivariate and multivariate logistic regression analyses examined the association between various patient and hospital characteristics and the occurrence of NBSI events in neonates. In the bivariate analysis, gender did not show a significant association with NBSI events, while race, service line, payment source, major operating room procedure, hospital bed size, hospital location, hospital region, and hospital ownership were all significantly associated with NBSI events. When controlling for other factors in the multivariate analysis, the associations for patient characteristics remained largely consistent. Gender (female) showed a significant association with a slightly increased risk of NBSI compared to males. Race, service line, payment source, major operating room procedure, hospital bed size, hospital location, hospital region, and hospital ownership all maintained significant associations with NBSI events. However, there were some changes in the magnitude of the associations in the multivariate analysis compared to the bivariate analysis.

Both the bivariate and multivariate analyses showed that various patient and hospital characteristics have significant associations with NBSI events, suggesting that these characteristics play a role in the occurrence of NBSI and should be considered when considering preventative measures. Nonetheless, there were several possible reasons for the relationships observed between the variables and NBSI events. For patient characteristics, the significant association between race and NBSI events may be due to differences in genetic susceptibility, access to healthcare, or exposure to risk factors among different racial groups. The associations with payment source may reflect differences in healthcare access, quality of care, or underlying health conditions associated with different insurance types.

In terms of hospital characteristics, the significant associations with hospital bed size and location could be attributed to differences in resources, staffing, infection control measures, or patient volume. The relationships with hospital region may reflect regional differences in infection control practices, healthcare infrastructure, or patient demographics. The association with hospital ownership may be influenced by differences in funding, management practices, or quality control measures.

Overall, these findings suggest that patient and hospital characteristics play a significant role in NBSI events and addressing these factors could help reduce the risk of infection in neonates.

Table 5. NQI 03 Neonatal Blood Stream Infection Events (PPNQ03), Logistic Regression (Multivariate analysis).

Variable		Estimate	SE	Wald Chi-Square test	P-value	AOR	Wald 95% CL for AOR	
Intercept		-0.4337	0.0194	501.5069	<.0001	0.648	-	-
Age								
Sex	Female	0.00847	0.00351	5.8222	0.0158	1.009	1.002	1.015
	Male ^s	--	--	--	--	--	--	--
Race	Black	0.1535	0.00517	881.5084	<.0001	1.166	1.154	1.178
	Hispanic	0.0739	0.00503	215.7485	<.0001	1.077	1.066	1.087
	Asian/Pacific Islander	0.0423	0.00759	31.0443	<.0001	1.043	0.962	0.990
	Native American	-0.2294	0.0225	103.8504	<.0001	0.795	0.761	0.831
	Others	0.0508	0.00683	55.2842	<.0001	1.052	1.038	1.066
	White ^s	--	--	--	--	--	--	--
Service line	Maternal and Neonatal	-0.3831	0.0161	567.0396	<.0001	0.682	0.661	0.704
	Mental health/ substance use	-0.1174	0.2069	0.3217	0.5706	0.889	0.593	1.334
	Injury	-0.0435	0.0928	0.2201	0.6389	0.957	0.798	1.148
	Surgical	-0.0737	0.0329	5.0169	0.0251	0.929	0.871	0.991
	Medical ^s	--	--	--	--	--	--	--

Payment Source	Medicare	-0.3971	0.0402	97.5495	<.0001	0.672	0.621	0.727
	Medicaid	0.0759	0.00881	74.1780	<.0001	1.079	1.060	1.098
	Private insurance	0.2057	0.00884	542.0145	<.0001	1.228	1.207	1.250
	No charge	-0.4010	0.0538	55.6353	<.0001	0.670	0.603	0.744
	Other	0.3081	0.0133	538.8821	<.0001	1.361	1.326	1.397
	Self-pay [§]	--	--	--	--	--	--	--
Operation on record	Major operating room procedure on record	0.3762	0.0153	605.3762	<.0001	1.457	1.414	1.501
Hospital bed size	Small	-0.8640	0.00502	29669.8567	<.0001	0.421	0.417	0.426
	Medium	-0.3144	0.00408	5930.7825	<.0001	0.730	0.724	0.736
	Large [§]	--	--	--	--	--	--	--
Hospital location	Rural	-2.5734	0.0108	57294.8291	<.0001	0.076	0.075	0.078
	Urban nonteaching	-0.7742	0.00477	26318.7635	<.0001	0.461	0.457	0.465
	Urban teaching [§]	--	--	--	--	--	--	--
Hospital region	Northeast	-0.2032	0.00591	1181.1937	<.0001	0.816	0.807	0.826
	Midwest	-0.1065	0.00558	364.6463	<.0001	0.899	0.889	0.909
	South	0.1321	0.00474	777.7836	<.0001	1.141	1.131	1.152
	West [§]	--	--	--	--	--	--	--
Hospital ownership	Public	-0.3099	0.00735	1780.3272	<.0001	0.733	0.723	0.744
	Private, not- profit	-0.0433	0.00536	65.1875	<.0001	0.958	0.948	0.968
	Private, investor-owned [§]	--	--	--	--	--	--	--

Abbreviations: CL, confidence limits; AOR, adjusted odds ratio.; Note: The bold p indicates significance (vs. reference category) at p<0.05.; The symbol § indicates the reference category.

4. Discussion

This study focused on assessing the characteristics associated with NQI 03 (NBSI) in pediatric patients within inpatient hospital settings. Using discharge data from the 2019 HCUP KID database, the study aimed to analyze the association of hospital and patient characteristics with NBSI at the patient level, employing logistic regression for analysis.

The study also aimed to evaluate the validity of utilizing NQI 03 as a framework for understanding NBSI and designing targeted interventions. The findings highlight the multifactorial nature of NBSI and emphasize the importance of considering patient demographics and hospital characteristics when assessing the risk of NBSI. The study contributes to the existing literature by providing empirical evidence on the relationship between these factors and the occurrence of NBSI.

One significant finding of this study was the role of gender in predicting NBSI. Gender exhibited some significance in predicting NBSI, indicating that it may play a role in screening, especially concerning NBSI, yet indicating that further consideration needs to be given to gender in relation to various confounding factors. Thus, adding more nuance to previous studies that targeted the role of gender in PAEs [16].

The study also uncovered disparities among racial groups, with various racial categories showing differential odds of experiencing NBSI. These findings highlight the need for further research into the underlying factors contributing to these disparities and their implications for regional and demographic healthcare strategies.

The type of medical service provided was significantly associated with NBSI risks, with surgical service lines carrying higher risks for NBSI. This emphasizes the importance of tailored interventions and heightened vigilance in high-risk service lines.

Payment source also played a significant role, with Medicaid and private insurance demonstrating associations with NBSI risks. While many studies have stressed the impact of financial stress on hospital quality of care and patient outcomes [17], a further point of investigation brought on by this study is the impact of private insurance, and “other payment sources” which were found to be much more significantly associated with the occurrence of NBSI. This highlights the importance

of understanding the impact of different payment sources on NBSI occurrence and necessitates further investigation into the implications for hospital operations and patient outcomes especially with the expansion of Medicaid under the Affordable Care Act [18].

Additionally, hospital characteristics such as size, teaching status, rurality, region, and ownership exhibited varying associations with NBSI risks. These findings underscore the influence of healthcare infrastructure and organizational resources on NBSI occurrence, necessitating tailored interventions based on hospital types and population trends. It is noteworthy that the results of this study align with previous research indicating that the acquisition of hospitals by private equity firms tends to correlate with heightened occurrences of hospital-acquired adverse events [19]. This trend persists even when considering the probability of a lower-risk demographic among Medicare beneficiaries admitted to such hospitals, implying a lower standard of inpatient care quality [19].

4.1. Public Health Implications & Recommendations

Building upon existing research, this study affirms the validity of using NQI 03 as a framework for understanding and addressing NBSI in pediatric care. The findings underscore the importance of targeted interventions to enhance pediatric patient safety, with implications for addressing health disparities, improving infection control measures, considering regional variations, and investigating hospital ownership.

4.2. Strengths & Limitations

Strengths of the study include the use of a large and comprehensive database, enabling extensive analysis, and logistic regression to identify independent associations. However, limitations include the reliance on administrative data, potential unmeasured confounding factors, and the study's focus on a specific timeframe, which may not capture the most recent trends.

4.3. Recommendations for Future Research

Future research should include longitudinal studies to explore temporal relationships, qualitative research to gain insights into stakeholders' perspectives, and investigations into specific interventions aimed at reducing NBSI. Additionally, further exploration of the impact of different payment sources on hospital operations and NBSI occurrence is warranted.

5. Conclusions

In conclusion, this study contributes to the understanding of pediatric patient safety by identifying significant associations between patient and hospital characteristics and NBSI. By leveraging NQI 03 as a framework, healthcare providers and policymakers can develop evidence-based strategies to enhance pediatric patient safety and mitigate the occurrence of NBSI. Further research is needed to delve deeper into the identified associations and validate the effectiveness of targeted interventions in reducing NBSI.

Author Contributions: Conceptualization, Michael Samawi; Methodology, Gulzar Shah and Linda Kimsey; Software, Michael Samawi; Formal analysis, Michael Samawi; Investigation, Michael Samawi; Resources, Gulzar Shah; Data curation, Gulzar Shah; Writing – original draft, Michael Samawi; Writing – review & editing, Linda Kimsey, Kristie C. Waterfield and Susan Hendrix; Supervision, Gulzar Shah and Linda Kimsey.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to this study use a retrospective data. We extracted data from the Health Care Utilization Project (HCUP) KID dataset, 2019, obtained from the Agency for Healthcare Research and Quality (AHRQ).

Informed Consent Statement: Informed consent was waived due to this study use a retrospective data and cannot be identified.

Data Availability Statement: This study uses the HCUP KID dataset (2019), developed through a Federal-State-Industry partnership in sponsorship by AHRQ. Data is available at <https://hcup-us.ahrq.gov/databases.jsp>.

Conflicts of Interest: The authors declare no conflicts of interest.

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