RESEARCH ARTICLE

Central Line–Associated Bloodstream Infection Rates by Chronic Condition Groups in Children

John M. Neff, MD,[a,b] J. Mitchell Harris II, PhD,[c] James C. Gay, MD, MMHC[d]

The Deficit Reduction Act of 2005 and the Affordable Care Act of 2010 mandated that Medicaid and Medicare adopt payment-reduction policies that document hospital-acquired conditions.[1,2] Central line–associated blood stream infection (CLABSI) is one of the most prevalent, potentially preventable acquired conditions in hospitalized children.[3–5] The epidemiology of CLABSIs in PICUs and successes in reducing CLABSIs have been well described.[6–9] Although line days are a recognized way of measuring risk of CLABSIs, there is no method to identify line days in the hospital discharge administrative billing data used for public reporting. Insertions of central lines and the risk of CLABSI are likely to increase according to the complexity of underlying conditions. In the absence of documentation of line days in administrative data, stratification of patient populations by medical complexity could be a useful way to determine CLABSI risk.

Currently there is no method in administrative data reports to measure the risk of CLABSI according to underlying conditions. Diagnostic-related groups methods may provide a severity index for an admission, but they may not identify the patient's underlying conditions.

Children's hospitals care for children with many complex chronic conditions, a group that seems to be increasing more than any other category.[10]

We proposed to determine the rates of CLABSI in 3 similar children's hospitals according to patient complexity groups by using the 3M Health Information Systems' clinical risk groups (CRGs).[11] CRGs have already been used and validated as a method to stratify patients into complex chronic condition groups in children's hospitals and health plan administrative data.[10,12] We explore whether such stratification can provide reportable rates of CLABSI that reflect populations at risk. We have divided our population into 2 age groups, <1 year and ≥ 1 year, because of a presumed increase in susceptibility to infection of children younger than 1.

METHODS

Case and Hospital Selection

In identifying CLABSIs, we used only those cases reported by infection control department surveillance following Centers for Disease Control and Prevention (CDC) guidelines[13–15]. We used the 3 children's hospitals for this study that we used in our previous publication on the validity of *International Classification of Diseases,*

[a]*Seattle Children's Hospital, Center for Child Health, Development, and Behavior, and* [b]*Department of Pediatrics, University of Washington School of Medicine, Seattle Washington;* [c]*Children's Hospital Association, Washington, District of Columbia; and* [d]*Department of Pediatrics, Vanderbilt University School of Medicine, Nashville, Tennessee*

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Address correspondence to John M. Neff, MD, 9575 NE Shipping Lane, Kingston, WA 98346. E-mail: john.neff@seattlechildrens.org

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Ninth Revision, Clinical Modification codes for CLABSI reporting: University of Michigan C. S. Mott Children's Hospital, Monroe Carell Jr Children's Hospital at Vanderbilt, and Seattle Children's Hospital.[14,16] All patient discharges from January 1, 2008, to December 31, 2010, for the 3 hospitals were submitted to the Children's Hospital Association Comparative Case Mix Data Program through a standard universal billing submission process by using CDC/National Network criteria.[16,17] Data analysis was only for 2010.

Denominator Stratification

CRGs were used to stratify the study population according to condition complexities to determine CLABSI rates. CRG methodology has been previously described.[11] CRGs stratify patients into 9 hierarchical, mutually exclusive health status groups: (1) nonchronic acute, (2) nonchronic significant acute, (3) minor chronic, (4) multiple minor chronic, (5) moderate chronic or dominant chronic in only 1 body system, (6) moderate chronic or dominant chronic in 2 body systems, (7) dominant chronic in ≥3 body systems, (8) malignancies in active therapy, and (9) catastrophic, including conditions that are progressive, solid organ transplantation, or long-term dependency on technology.

For the purposes of this study, the CRG status groups were further combined into the following 5 study groups that matched the CRG hierarchy:

- Study group 1: nonchronic (CRG status groups 1 and 2)
- Study group 2: noncomplex chronic (CRG status groups 3–5)
- Study group 3: complex chronic (CRG status groups 6 and 7)
- Study group 4: malignancies (CRG status group 8)
- Study group 5: progressive chronic or dependent on technology or transplantation (CRG status group 9)

Children in study group 1, nonchronic, may be healthy or may have a serious acute condition that is not likely to persist beyond a 12-month period. Children in study group 2, noncomplex chronic, most commonly have asthma, noncomplex seizure disorders, or attention-deficit/hyperactivity disorders. Children in study group 3, complex chronic, have significant chronic conditions in >1 body system, such as diabetes type 1 with a neurologic disorder, or developmental delay with complex seizure disorders. Children in study group 4 have bloodborne or solid tumor malignancies. Study group 5 includes children who have progressive chronic conditions, solid organ transplantation, complex immune deficiency, muscular dystrophy, complex chromosomal anomalies, dependency on mechanical respiratory support, or total parenteral nutrition support. Many of these children will have acquired or congenital immune disorders.

The CRG software used hospital discharge data from 3 years (2008, 2009, and 2010) to assign each individual patient hospitalized in 2010 to a single hierarchical CRG status group based on the complexity of that individual's underlying health conditions. The CRG status group assignment was then combined in a nonduplicate fashion to 1 of the 5 study groups and then divided further into those <1 and ≥1 year before examining CLABSI rates.

The percentage of hospitalizations with CLABSIs were calculated for each of the 5 study groups; χ^2 analyses and Fisher's exact tests were performed to identify statistical differences between the rates of infection of the different groups.

RESULTS

The 3 institutions in 2010 had 35 687 patient discharges and 138 CLABSIs. The overall CLABSI rate was 0.387%. There are significant variations in rates according to CRG status, ranging from 0.008% (1/13 219) for study group 1, nonchronic, to 1.604% (59/3678) for study group 5, progressive chronic or dependent on technology. Rates increased between each CRG study group: study group 2, noncomplex chronic 0.134% (14/10 472); study group 3, complex chronic 0.625% (38/6081); and study group 4, malignancies 1.162% (26/2237), and were significantly different from each other ($P < .05$) with the exception between study group 4, malignancies 1.162% (26/2237), and study group 5, progressive chronic or dependent on technology 1.604% (59/3678) ($P = .178$) (Fig 1).

For patients younger than 1 year, there were 13 991 discharges and 74 CLABSIs, an overall CLABSI rate of 0.529%. There was significant variation across the CRG study groups, ranging from 0.011% (1/9237) for study group 1, nonchronic, to 4.264% (31/727) for study group 5, progressive chronic or dependent on technology. Rates were significantly different from each other and increased between each study group ($P < .05$): study group 2, noncomplex chronic 0.473% (12/2539); study group 3, complex chronic 1.959% (28/1429); study group 4, malignancies 3.390% (2/59), except in 2 instances between study group 4, malignancies 3.39% (2/59), and study group 5, progressive chronic or dependent on technology 4.264% (31/727) ($P = 1.00$), and between study group 3, complex chronic 1.959% (28/1429), and study group 4, malignancies 3.39% (2/59) ($P = .335$).

For patients ≥1 year who were hospitalized in 2010 (Fig 1), there were 21 696 discharges and 64 CLABSIs, for an overall CLABSI rate of 0.295%. This rate was lower than for patients <1 year but generally followed the same pattern across CRG study groups. Rates ranged from 0.0% (0/3982) for study group 1, nonchronic, to 0.949% (28/2951) for study group 5, progressive chronic or dependent on technology, with the CLABSI rate for study group 4, malignancies, being highest at 1.102% (24/2178). Rates increased between each status group: study group 2, noncomplex chronic 0.025% (2/7933); study group 3, complex chronic 0.215% (10/4652); study group 4, malignancies, 1.102% (24/2178). Most comparisons between CRG groups were significantly different from each other (most $P < .001$), with the exceptions between study group 4, malignancies 1.102% (24/2178), and study group 5, progressive chronic or dependent on technology 0.949% (28/2951) ($P = .69$), and between, study group 1, nonchronic 0.0% (0/3982) and complex chronic 0.025% (10/4652) ($P = .44$).

DISCUSSION

The measurement of hospital CLABSI rates have been used primarily for

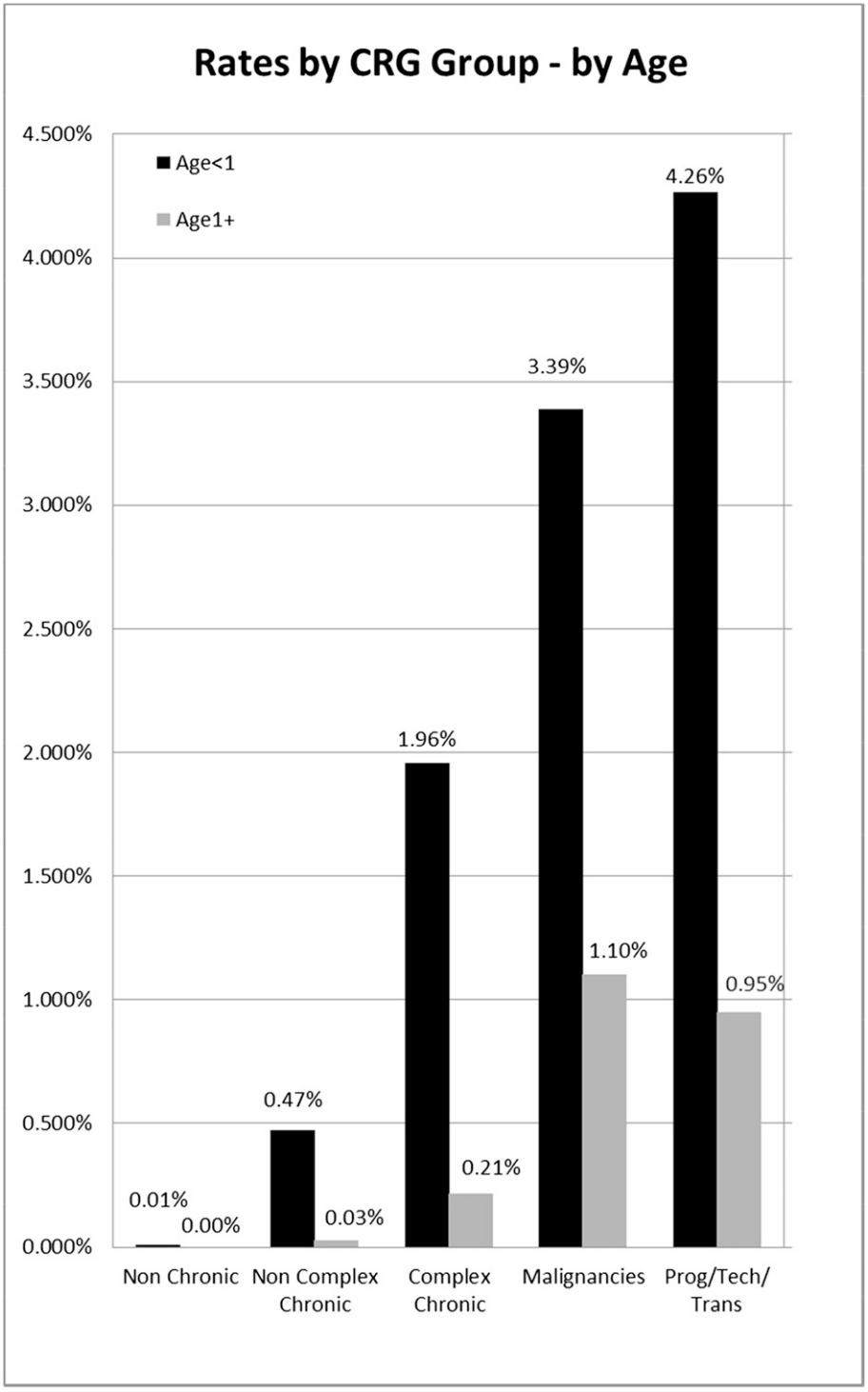

FIGURE 1 CLABSI rates by CRG study group and age.

performance improvement, not public reporting. Now a number of states have legislation requiring public reports of infection rates.[18] This focus on CLABSI highlights the need to make sure hospital reports are adequately risk adjusted to control for patient characteristics. Line days is a commonly practiced way to measure the risk of CLABSI, but has not been adapted for general use in administrative data. Cataloging central line days is a burdensome process when the information is collected manually. Other methods of stratification have not been evaluated.

Recent studies point to both extrinsic potentially modifiable factors, and intrinsic nonmodifiable factors influencing CLABSI rates.[19–21] The duration, placement, and number of central lines are extrinsic risk factors, items that providers can potentially alter to lower the risk of infection during line insertion or maintenance. A patient's age and underlying disease conditions are intrinsic risk factors, patient characteristics that are generally not modifiable by the provider. Although line days may vary according to provider practices, the underlying conditions are a consistent measurement of susceptibility. Payment programs could account for the variations in patients according to age and underlying conditions.

In this study, we demonstrated how patient complexity groups and age can be used to provide statistically significant rates for CLABSI. CRGs can risk adjust to specific clinical subgroups but that will need to be the focus of future studies. Children <1 year in this study population of 3 tertiary care children's hospitals had significantly higher rates of CLABSI (0.529%) compared with those ≥1 (0.295%), paralleling a previous study looking at all complications of surgical central lines.[22] This is reflected in all of the chronic condition groups. In both those <1 and ≥1 year, the rates of CLABSI are highest in the 2 study groups of malignancies (study group 4) and progressive chronic and dependent on technology (study group 5).

The strengths of this study are that we demonstrated a novel way of measuring the risk of CLABSI in children that reflects the complexity of conditions admitted to a children's hospital. This could provide an accurate way of measuring the risk of CLABSI in lieu of patient line days. The limitations of this study are as follows. (1) The 3 children's hospitals selected for this study may not be representative. These hospitals are similar teaching hospitals that accept referrals from large geographic areas. They performed significant numbers of central line placements and used CDC-validated CLABSI reports.[14] Future studies should include a broader sample. (2) We have not compared our classification to duration of line days. Until line days are readily available in administrative data, we feel that the method that we have described will be an improvement on what is currently available in administrative reporting systems. (3) We have not compared CRGs to the performance of other risk adjustment methods, specifically diagnostic-related groups. We have demonstrated the use of CRGs and the importance of stratifying by underlying chronic condition groups and feel that CRGs can be used in isolation or in combination with other risk adjustment methods. (4) We have shown that the rates for CLABSI are very different in children <1 year compared with ≥1 year, but have not shown that this method adds any value over stratification by admissions to ICUs. Comparison of this age stratification should be done to various levels of infant/NICU admissions.

For the next steps, we recommend a study that compares a chronic condition risk adjustment tool and age stratification to line days and admission to ICUs in a large multihospital data set.

CONCLUSIONS

In this study we examined the rates of CLABSI in 3 children's hospitals according to age <1 and ≥1 year and patient complexity groups by using the 3M CRGs. Children's hospitals care for a large population of children with many complex chronic conditions, a group at higher susceptibility to CLABSI. Our study illustrates the use of a risk adjustment tool in determining CLABSI rates for public reporting or pay for performance. The use of a risk adjustment strategy focusing on a patient's underlying condition and age group could be a method to report provider performance in the absence of reported line days in administrative data.

REFERENCES

1. Centers for Medicare and Medicaid Services. Hospital-acquired conditions (present on admission indicator). Available at: www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HospitalAcqCond/index.html. Accessed May 7, 2015
2. Medicaid.gov. Provider preventable conditions. Available at: www.medicaid.gov/medicaid-chip-program-information/by-topics/financing-and-reimbursement/provider-preventable-conditions.html. Accessed May 7, 2015
3. Pittet D, Tarara D, Wenzel RP. Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. *JAMA*. 1994;271(20):1598–1601
4. Richards MJ, Edwards JR, Culver DH, Gaynes RP; National Nosocomial Infections Surveillance System. Nosocomial infections in pediatric intensive care units in the United States. *Pediatrics*. 1999;103(4). Available at: www.pediatrics.org/cgi/content/full/103/4/e39
5. Wisplinghoff H, Seifert H, Tallent SM, Bischoff T, Wenzel RP, Edmond MB. Nosocomial bloodstream infections in pediatric patients in United States hospitals: epidemiology, clinical features and susceptibilities. *Pediatr Infect Dis J*. 2003;22(8):686–691
6. Miller MR, Griswold M, Harris JM II, et al. Decreasing PICU catheter-associated bloodstream infections: NACHRI's quality transformation efforts. *Pediatrics*. 2010;125(2):206–213
7. Niedner MF, Huskins WC, Colantuoni E, et al. Epidemiology of central line-associated bloodstream infections in the pediatric intensive care unit. *Infect Control Hosp Epidemiol*. 2011;32(12):1200–1208
8. Bundy DG, Gaur AH, Billett AL, He B, Colantuoni EA, Miller MR; Children's Hospital Association Hematology/Oncology CLABSI Collaborative. Preventing CLABSIs among pediatric hematology/oncology inpatients: national collaborative results. *Pediatrics*. 2014;134(6). Available at: www.pediatrics.org/cgi/content/full/134/6/e1678
9. Shepherd EG, Kelly TJ, Vinsel JA, et al. Significant reduction of central-line associated bloodstream infections in a network of diverse neonatal nurseries. *J Pediatr*. 2015;167(1):41–46.e1–e3

10. Berry JG, Hall M, Hall DE, et al. Inpatient growth and resource use in 28 children's hospitals: a longitudinal, multi-institutional study. *JAMA Pediatr*. 2013;167(2):170–177
11. Hughes JS, Averill RF, Eisenhandler J, et al. Clinical Risk Groups (CRGs): a classification system for risk-adjusted capitation-based payment and health care management. *Med Care*. 2004;42(1):81–90
12. Neff JM, Clifton H, Popalisky J, Zhou C. Stratification of children by medical complexity. *Acad Pediatr*. 2015;15(2):191–196
13. Patrick SW, Davis MM, Sedman AB, et al. Accuracy of hospital administrative data in reporting central line-associated bloodstream infections in newborns. *Pediatrics*. 2013;131(suppl 1):S75–S80
14. Harris JM II, Gay JC, Neff JM, Patrick SW, Sedman A. Comparison of administrative data versus infection control data in identifying central line-associated bloodstream infections in children's hospitals. *Hosp Pediatr*. 2013;3(4):307–313
15. Tukey MH, Borzecki AM, Wiener RS. Validity of ICD-9-CM codes for the identification of complications related to central venous catheterization. *Am J Med Qual*. 2015;30(1):52–57
16. National Healthcare Safety Network (NHSN). Centers for Disease Control and Prevention Web site. Central line–associated infection (CLABSI). Available at: www.cdc.gov/HAI/bsi/bsi.html. Accessed May 7, 2015
17. Case mix program database. National Association of Children's Hospitals and Related Institutions. https://www.childrenshospitals.org/Programs-and-Services/Data-Analytics-and-Research/Pediatric-Analytic-Solutions/Inpatient-Essentials. Accessed May 20, 2016
18. Committee to Reduce Infection Deaths Web site. State reporting requirements. Available at: http://hospitalinfection.org/resources/state-infection-laws/state-law-summary. Accessed May 20, 2016
19. The Joint Commission. Preventing central line–associated bloodstream infections: useful tools, an international perspective. November 20, 2013. Available at: www.jointcommission.org/assets/1/6/CLABSI_Toolkit_Tools_Directory_linked.pdf. Accessed July 7, 2015
20. Tokars JI, Klevens RM, Edwards JR, Horan TC. Measurement of the impact of risk adjustment for central line-days on interpretation of central line-associated bloodstream infection rates. *Infect Control Hosp Epidemiol*. 2007;28(9):1025–1029
21. Burke JP. Infection control—a problem for patient safety. *N Engl J Med*. 2003;348(7):651–656
22. Fallon SC, Kim ME, Fernandes CJ, Vasudevan SA, Nuchtern JG, Kim ES. Identifying and reducing early complications of surgical central lines in infants and toddlers. *J Surg Res*. 2014;190(1):246–250

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