Infection Control & Hospital Epidemiology (2023), **44**, 985–987
doi:10.1017/ice.2022.149

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Concise Communication

Methicillin-resistant *Staphylococcus aureus* nasal colonization in children with cerebral palsy

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Abstract

A retrospective cohort of children admitted to the pediatric intensive care unit (PICU) with cerebral palsy was matched 1:3 by age and admission year to determine odds of methicillin-resistant *Staphylococcus aureus* (MRSA) nasal colonization. Adjusted odds of MRSA nasal colonization at PICU admission were 2.6-fold higher among children with cerebral palsy.

(Received 23 February 2022; accepted 20 May 2022; electronically published 23 June 2022)

The global prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) nasal colonization in children admitted to the pediatric intensive care unit (PICU) is ~3%.[1] Importantly, MRSA colonization in children is associated with ICU outbreaks and increased surgical infections.[2–4] Specifically, MRSA-colonized children have increased risk of developing postoperative infections after gastrostomy tube placement, a common procedure in children with neuromuscular disorders (NMDs).[5] Although the mechanism remains unknown, children with NMDs are at increased risk of postoperative wound infections.[6,7] Given increased surgical infections in this population, it is important to understand whether children with NMDs, such as cerebral palsy, have higher prevalence of MRSA colonization to inform prevention strategies.[8] The purpose of our nested case–control study was to determine whether children with cerebral palsy have higher prevalence of MRSA nasal colonization at PICU admission that children without cerebral palsy.

Methods

Using a web-based query tool, we extracted a retrospective cohort of patients <18 years old with PICU admissions from January 1, 2008, to June 15, 2021, from a single tertiary-care referral center in the southeastern United States.[9] Institutional policies required assessment of MRSA nasal colonization within 48 hours of admission using polymerase chain reaction. The cohort was stratified into 2 groups based on whether the patient had an *International Statistical Classification of Diseases, Tenth Revision* (ICD-10) diagnosis of cerebral palsy associated with paralysis (ie, G80.0, G80.1, G80.2.) in the medical record.[10]

The first PICU admission after the first year of life was included; subsequent admissions were excluded. PICU admissions during the first year of life were excluded given the high PICU utilization by this cohort during that period and because cerebral palsy diagnoses may not be assigned reliably in the first year of life. Children with cerebral palsy were randomly matched 1:3 by age at PICU admission and admission year with children who did not have cerebral palsy. If a child with cerebral palsy was unable to be matched to a child of the same age, they were matched to a child one year older or younger.

The primary outcome was MRSA nasal colonization at PICU admission. Primary outcome data were confirmed through manual chart review (D.S. and R.D.). Demographic information and colonization were compared using χ^2 tests. Adjusted and unadjusted odds ratios were estimated using univariable and multivariable logistic regression. Covariates included sex, age, preferred language, race or ethnicity, state of residence, and admission year, all selected a priori. These variables were selected to guide future analyses on risk factors modulating MRSA nasal colonization prevalence in children with cerebral palsy. The study was approved by the Duke University Health System Institutional Review Board (no. Pro00107907). We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies.

Results

In total, 531 children were included in this study: 134 (25.2%) with cerebral palsy and 397 (74.8%) without cerebral palsy. Of the demographic variables collected, only sex differed between the 2 groups: 47 children (35%) with cerebral palsy were female and 178 children (45%) without cerebral palsy were female ($P = .048$). The groups did not differ by age, state of residence, preferred language, race or ethnicity, or year of admission (Table 1).

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Cite this article: Schaps D, *et al.* (2023). Methicillin-resistant *Staphylococcus aureus* nasal colonization in children with cerebral palsy. *Infection Control & Hospital Epidemiology*, 44: 985–987, https://doi.org/10.1017/ice.2022.149

Table 1. Demographic Information Stratified by Cerebral Palsy Diagnosis Status at Time of Pediatric Intensive Care Unit Admission

Variable	Cerebral Palsy (N=134), No. (%)	No Cerebral Palsy (N=397), No (%)	*P* Value[a]
Sex			
Female	47 (35)	178 (45)	.048
Male	87 (65)	219 (55)	
Age, mean y (95% CI)	7.53 (6.63–8.43)	7.53 (7.01–8.05)	.998
State of residence			
In state	125 (93)	354 (89)	.166
Out of state	9 (7)	43 (11)	
Preferred language			
English	126 (94)	364 (92)	.380
Other	8 (6)	33 (8)	
Race/Ethnicity			
White	56 (42)	148 (37)	.744
Black	54 (40)	163 (41)	
Hispanic	12 (9)	42 (11)	
Other/Not reported	12 (9)	44 (11)	
Year			
2008	1 (1)	3 (1)	1.0
2009	4 (3)	12 (3)	
2010	2 (2)	6 (2)	
2011	5 (4)	15 (4)	
2012	10 (8)	30 (8)	
2013	14 (11)	42 (11)	
2014	6 (5)	18 (5)	
2015	9 (7)	27 (7)	
2016	21 (16)	63 (16)	
2017	16 (12)	48 (12)	
2018	19 (14)	56 (14)	
2019	10 (8)	30 (8)	
2020	11 (8)	33 (8)	
2021	6 (4)	14 (4)	

Note. CI, confidence interval.
[a]*P* value generated by χ^2 test.

Table 2. Univariable and Multivariable Logistic Regression of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Nasal Colonization Status at Time of Pediatric Intensive Care Unit (PICU) Admission

Variable	Odds Ratio	95% CI	*P* Value
Univariable Logistic Regression Model			
Cerebral palsy	2.50	1.35–4.65	.0037
No cerebral palsy	Ref	Ref	
Multivariable[a] Logistic Regression Model			
Cerebral palsy	2.57	1.36–4.85	.0031
No cerebral palsy	Ref	Ref	
Sex			
Female	0.87	0.46–1.65	.670
Male	Ref	Ref	Ref
Age	1.07	0.99–1.15	.088
State of residence			
In state	0.78	0.28–2.17	.637
Out of state	Ref	Ref	Ref
Preferred language			
English	0.83	0.12–5.72	.849
Other	Ref	Ref	Ref
Race/Ethnicity			
White	Ref	Ref	Ref
Black	0.97	0.50–1.88	.20
Hispanic	0.28	0.04–1.93	.28
Other/Not reported	0.51	0.14–1.88	.71
Year of PICU admission	0.83	0.73–0.94	.003

Note. CI, confidence interval.
[a]Multivariable model is adjusted for sex, state of residence, preferred language, race or ethnicity, age at PICU admission, and year of PICU admission.

The prevalence of MRSA nasal colonization at PICU admission was higher for children with cerebral palsy than for children without cerebral palsy: 20 (14.9%) versus 26 (6.6%; $P = .0029$).

Unadjusted odds of MRSA nasal colonization at PICU admission after the first year of life were 2.5-fold higher among children with cerebral palsy than for those without cerebral palsy (odds ratio [OR], 2.50; 95% confidence interval [CI], 1.35–4.65; $P = .0037$). After adjusting for sex, age, preferred language, race or ethnicity, state of residence, and admission year, odds of MRSA nasal colonization at PICU admission after the first year of life were ~2.6-fold higher among children with cerebral palsy than those without cerebral palsy (OR, 2.57; 95% CI, 1.36–4.85; $P = .0031$). Odds of MRSA colonization decreased by 17% for each calendar year (Table 2). Otherwise, sex, age, state of residence, preferred language, and race or ethnicity were not significant covariates (Table 2).

Discussion

After matching for age and year of admission, children with cerebral palsy had 2.6-times higher adjusted odds of MRSA nasal colonization at PICU admission. Given the association between colonization and surgical infections in children with NMDs, increased MRSA colonization may be contributing to higher rates of postsurgical infection.[4,6,7] Our findings clarify MRSA epidemiology in this high-risk cohort and may inform prevention strategies, decolonization, and outbreak management as has been successful in other high-risk populations.[8] Why MRSA prevalence in our matched cohort is nearly double reported rates remains unclear and likely reflects local epidemiology. Also, the referenced population captures a global variety of children requiring critical care who may not typically have frequent exposures to healthcare settings or require devices, which are reasons proposed for higher prevalences in patients with cerebral palsy.[1]

Our study had several limitations. We did not evaluate potential factors leading to increased colonization such as previous admissions, medical device use, or prior MRSA infection because these

https://doi.org/10.1017/ice.2022.149 Published online by Cambridge University Press

were inconsistently reported. Additionally, our study focused on single-center data; however, the results remain generalizable given reliable MRSA screening over a 14-year period. Furthermore, we excluded data from the first year of life, a time when there may have been exposures that contribute to the outcome. Rather, our study generates key questions about whether environmental exposures or cerebral palsy pathophysiology contributes to the increased MRSA nasal colonization prevalence we observed in patients with cerebral palsy. Future studies can confirm our findings and determine contributory factors to inform risk-factor modification. Other vulnerable groups should be assessed to determine disparities in colonization with MRSA or other multidrug-resistant organisms.

Children with cerebral palsy have higher odds of MRSA nasal colonization at PICU admission than children without cerebral palsy. Our findings should serve as a call to action to determine factors leading to increased MRSA nasal colonization in children with cerebral palsy, whether colonization translates to increased morbidity, mortality, or healthcare expenditures, and whether current preoperative antimicrobial prophylaxis practices are effective in this group. Programs such as tailored surgical infection bundles, targeted MRSA screening during pre-operative evaluations, and increased surveillance, may reduce this disparity.

Acknowledgments. We thank our colleagues in the Duke Department of Pediatrics and the Duke Center for Antimicrobial Stewardship and Infection Prevention for their support.

Financial support. No specific funding was provided for this study.

Conflicts of interest. The authors have no conflicts of interest relevant to this article. D.J.A. has received grants from the Agency for Healthcare Research and Quality (AHRQ), the Centers for Disease Control and Prevention (CDC), and the National Institutes of Health (NIH)/National Institute of Allergy and Infectious Diseases (NIAID). D.J.A. has received royalties for authorship from UpToDate Online. I.C.K has received grant funding from NIH and CDC Epicenter. I.C.K has received consulting fees from Wayfair and IPEC Experts.

References

1. Zervou FN, Zacharioudakis IM, Ziakas PD, Mylonakis E. MRSA colonization and risk of infection in the neonatal and pediatric ICU: a meta-analysis. *Pediatrics* 2014;133:e1015–e1023.
2. Milstone AM, Carroll KC, Ross T, *et al.* Community-associated methicillin-resistant *Staphylococcus aureus* strains in pediatric intensive care unit. *Emerg Infect Dis* 2010;16:647–655.
3. Geva A, Wright SB, Baldini LM, *et al.* Spread of methicillin-resistant *Staphylococcus aureus* in a large tertiary NICU: network analysis. *Pediatrics* 2011;128:e1173–e1180.
4. Kalra L, Camacho F, Whitener CJ, *et al.* Risk of methicillin-resistant *Staphylococcus aureus* surgical site infection in patients with nasal MRSA colonization. *Am J Infect Control* 2013;41:1253–1257.
5. Mainie I, Loughrey A, Watson J, Tham TC. Percutaneous endoscopic gastrostomy sites infected by methicillin-resistant *Staphylococcus aureus*: impact on outcome. *J Clin Gastroenterol* 2006;40:297–300.
6. Sullivan BT, Abousamra O, Puvanesarajah V, *et al.* Deep infections after pediatric spinal arthrodesis: differences exist with idiopathic, neuromuscular, or genetic and syndromic cause of deformity. *J Bone Joint Surg Am* 2019;101:2219–2225.
7. Schaps D, Leraas HJ, Rice HE, Tracy ET. Surgical site infection in children with neuromuscular disorders after laparoscopic gastrostomy: a propensity-matched NSQIP-P analysis. *Surg Infect* 2022;23:226–231.
8. Huang SS, Singh R, McKinnell JA, *et al.* Decolonization to reduce post-discharge infection risk among MRSA carriers. *N Engl J Med* 2019;380:638–650.
9. Horvath MM, Rusincovitch SA, Brinson S, Shang HC, Evans S, Ferranti JM. Modular design, application architecture, and usage of a self-service model for enterprise data delivery: the Duke Enterprise Data Unified Content Explorer (DEDUCE). *J Biomed Inform* 2014;52:231–242.
10. World Health Organization. *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*, Second *Edition.* Geneva: WHO; 2004.

https://doi.org/10.1017/ice.2022.149 Published online by Cambridge University Press