

Prevalence, Clinical Profile and Risk Factors of Nosocomial Infection in Ayder Pediatric Intensive Care Unit, Tigray, Ethiopia

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Background: Hospital-acquired infection (HAI) is a significant cause of increased morbidity and mortality amongst hospitalized patients and represents a considerable health and economic burden worldwide. However, evidence about HAI in pediatric ICU is limited.

Objective: To identify the prevalence of hospital-acquired infection (HAI), clinical profile, and its risk factors for nosocomial infection in patients admitted to the pediatric intensive care unit (PICU).

Methodology: From a two-year retrospective chart review admitted from 2019 to 2020 to the PICU, 223 patients were selected by systematic random sampling. Data were analyzed in SPSS version 23.0. P-values <0.05 were considered significant for all tests.

Results: Forty-five (20.2%) patients developed nosocomial infection (NI). The median age was 4 years with 25–50th IQR of (0.6–9). About invasive procedures done, the most common was nasogastric tube (57%), followed by mechanical ventilation (17.9%) and urinary catheter (13.9%). The main focus of the infection was chest (53.3%), followed by bloodstream infection (22%) and gastrointestinal infection (9%). The odds of HAI were 3.3 times higher among under-five compared to those aged between 5 and 18 years (AOR: 3.3, 95% CI = 1.4–8.0, $p = 0.008$). The odds of HAI were also 4.1 times higher in those who stayed for more than two weeks compared to those who stayed in the pediatric ICU 2 to 14 days (AOR: 4.1, 95% CI = 2.0–8.6, $p < 0.001$). The mean duration of mechanical ventilation in those patients with and without NI was 1.65 days and 13.96 days, respectively (AOR = 3.46, 95% CI = 1.44–9.81, $p = 0.02$). Patients who started antibiotics at admission and patients who were on nasogastric tube feeding were also statistically significant risk factors for developing NI (AOR = 2.67, 95% CI = 1.37–9.64, $p = 0.02$; AOR = 2.45, 95% CI = 1.64–6.53, $p = 0.03$).

Conclusion: The rate of infection in this study was higher compared to some developing countries. Younger age and prolonged length of hospital stay were found to be significant risk factors for HAI.

Keywords: prevalence, PICU, NI, risk factor

Introduction

Hospital-acquired infection (HAI) is a substantial public health problem that occurs during the patient care process.^{1,2} The occurrence of HAI in intensive care units (ICU) is much higher in developing than developed countries. The recently reviewed and published data in World Health Organization (WHO) showed that in low and middle-income countries, the incidence of HAI in ICU is 2–3 times higher than in high-income countries.³ In another review on HAI done in Africa by the WHO, there were significant differences in the prevalence and incidence, though it ranges from 2.5% to 14.8%.^{4,5} The average prevalence is significantly higher in high than low-quality studies (15.5% vs 8.5%, respectively).⁴ The European Centre for Disease Prevention and Control reports an average prevalence of 7.1% in European countries.⁵

Different studies report the incidence of HAI in Pediatric ICU (PICU) ranges between 6.1% and 15.1%. Even though there are limited studies in PICU about NI, especially from developing countries, children hospitalized in PICU are a unique population concerning specific risk factors. Young children have increased susceptibility to infections because of the immaturity of their immune system.⁶ In a study done in Peru, PICU revealed an incidence of HAI of 19.5%, and bloodstream infection (BSI), nosocomial pneumonia (NP), and urinary tract infection (UTI) were the most common types of NI.⁷ As aforementioned, in Pakistan, the rate of HAI in PICUs was 4.7%,⁸ in Rwanda (15.1%), and in two PICUs, Egypt was 15.6%.^{9,10}

Significant identified risk factors for acquiring NI were young age, MV, re-intubation, sedation, NGT feeding, prolonged hospital stay, underlying illness, impaired consciousness, neuromuscular disease, and aspiration of gastric content.^{1,4,9,11,12} The current worldwide focus on improving the cost-effectiveness of health care, along with reports of successful nosocomial infection-control programs, stimulates hospital administrators, infection-control teams, and researchers to try to understand their own local situations in order to improve health-care programs and an essential prerequisite for developing effective infection control measures.^{2,13–15} Little is known about the prevalence of nosocomial infections and associated risk factors among children in Ethiopia. Additionally, the magnitude of HAI in pediatric ICU is not available in open access publications. This study aims to assess the prevalence, clinical profile, and risk factors for acquiring HAI in our setting for further planning.

Methodology

Ayder is one of the biggest institutions in the Tigray, established in 2008. The Department of Pediatrics and Child Health is one of the major specialties, with a total of 162 beds. Pediatric ICU is one of the main wards for critically ill patients and is staffed with 25 nurses, 3 residents, and two senior pediatricians. Moreover, it is equipped with mechanical ventilators, monitors, and perfusers.

A two-year retrospective chart review was done from 2019 to 2020. All pediatric patients admitted to the Pediatric Intensive Care Unit who stayed for more than 48 hours with complete data were included in the study. Incomplete chart documentation and patients who stayed in PICU for less than 48 hours were excluded from the study.

The sample size was calculated with a single proportional formula, and the minimum sample size required after adding 10% was 223. The systematic random sampling technique was used for a total of 630 patients who were admitted to pediatric ICU between 2018 and 2020. The total patients admitted during that period were divided into our sample size to assess equal patients in each month of the study period. For this, every third chart was recruited by excluding incomplete charts and those who stayed less than 48 hours in the pediatric intensive care unit.

Clinically investigated parameters included age, sex, underlying disease, patient feeding, duration of maintenance fluid, invasive procedures, hospital stays, mechanical ventilation, duration of mechanical ventilation, NGT feeding, and urinary catheterization.

A locally prepared structured questionnaire was used to collect data from patient's charts. The questionnaire was developed in English. Trained residents collected the data from the charts, and the principal investigator checked for completeness of the questionnaire daily.

Ethical clearance was obtained from the Institutional Review Board (IRB) of the College of Health Sciences, Mekelle University, with an IRB number of 1853/2021. The permission letter was also obtained from the ACSH Chief Clinical director's office before the commencement of the study. Consent was taken from the care givers after they were told about the objective and purpose of the study. They were also told about their right to refuse to participate in the study at any time.

The collected data were checked for completeness. Descriptive and analytical statistics, including univariate, frequency distribution, percentage, ratios, and the measure of dispersion, were used for univariate analysis. Visual (histogram) and analytical methods (Kolmogorov–Smirnov test) were used to determine whether variables exhibited normal distribution. Variables with normal distribution were expressed as mean plus/minus standard deviation, while not normally distributed data were expressed as median (minimum–maximum) values. Categorical data were compared using Pearson's Chi-square test or Fisher's exact test. Correlations were determined using Pearson's or Spearman correlation analyses. Binary logistic regression analysis was performed to assess the predictors of hospital-acquired infection (HAI).

The odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. P-values <0.05 were considered significant for all tests. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS-IBM) for Windows version 26.

Results

Socio-Demographic Profile

From a total of 680 admitted patients to PICU over two years, 223 patients were selected by systematic random sampling after exclusion was done for incomplete data records. Among 223 enrolled patients, 45 (20.2%) acquired Nosocomial infection. The median age of the children who participated in this study was 4 years, with a 25–50th IQR of (0.6–9). Male patients accounted for 138 (61.9%) of study participants making an M:F ratio of 1.6:1. The main source of admission was emergency department 151 (67.7%), followed by pediatric ward 49 (22%). The most common organ/system affected was neurology (25.6%), followed by infectious (19.3%) and respiratory (13.5%). Severe and moderate malnutrition was reported in 25.6% and 19.3% of them, respectively. Fifty-seven percent (57.0%) of children had an additional diagnosis and the main reason for their ICU admission (Table 1).

ICU Care and Invasive Procedures Done

Regarding patient feeding, 98 (43.9%) patients were on maintenance fluid, with the majority (50%) of them put for 24–72 hours. About invasive procedures done, the most common was nasogastric tube (57%), followed by mechanical ventilation (17.9%) and urinary catheter (13.9%). The culture was done for a total of 110 (49.3%) patients, of which

Table 1 Socio-Demographic and Admission-Related Characteristics of Pediatric ICU Patients of ACSH, Mekelle, Tigray (N = 223)

Variable	Category	Frequency	Percent
Age	Median – 4 Years (25–75th IQR: 0.6–9)		
Gender	Female	85	38.1
	Male	138	61.9
Residence	Rural	142	63.7
	Urban	81	36.3
Source of admission	Emergency	151	67.7
	Ward	49	22.0
	Operation theatre	22	9.9
	Burn unit	1	0.4
Organ/system	Neurology	57	25.6
	Respiratory	30	13.5
	Cardiac	20	9.0
	Renal	15	6.7
	Gastro-intestinal	20	9.0
	Infectious	43	19.3
	Haemato-oncology	20	9.0
	Other	18	8.1
Nutritional status	Normal	114	51.1
	Moderate malnutrition	43	19.3
	Severe malnutrition	57	25.6
	Not recorded	9	4.0
Comorbidity	Yes	127	57.0
	No	96	43.0

39.1% (43) were patients who developed HAI. The majority (62.8%) of ICU patients were improved and transferred to the ward, but 20.6% of them died (Table 2)

Hospital-acquired infection (HAI) was diagnosed in 45. The main clinical indicators of nosocomial infection were heterogeneous, with the most dominant feature of Fever (39%) followed by urinary complaint (5%). The main focus of infection for NI was chest (53.3%), followed by BSI (22%) and GI (9%) (Figure 1).

A total of 127 samples were taken for culture, of which 38.6% (49/127) were from patients with NI. The culture was positive, and etiologic diagnosis was made in 27.3% (30/110 pts), with the majority (56.7%, 17/30 pts) of them with hospital-acquired infection.

In the culture growth, a total of 37 bacteria were isolated. The most common bacteria isolated in PICU were *Klebsiella pneumonia* (27%, 10/37), followed by *Staphylococcus aureus* and *E. coli*, accounting for 13.5% (5/37) for each. Concerning the dominant etiology for those with and without HAI, there was no difference (in both *Klebsiella pneumonia* commonest bacteria), but *Staphylococcus* is more common in those ICU patients without HAI than with HAI (8.2% vs 5.4%). *Acinetobacter* and *E. Coli* were isolated more in those patients with NI than those without (8.2% vs 5.4%) (Figure 2).

Predictors of Hospital-Acquired Infection (HAI)

In the binary logistic regression model, different factors have been identified that increase the risk of hospital-acquired infection. The mean length of PICU stays in those patients with NI and without NI were 24.33 days and 2.36 days, respectively (AOR: 4.1, 95% CI: 2.0, 8.6, $p < 0.001$). The mean duration of mechanical ventilation in those patients with and without NI was 1.65 days and 13.96 days, respectively (AOR = 3.46, 95% CI = 1.44–9.81, $p = 0.02$). The longer the mechanical ventilation and hospital stay duration, the higher the risk of developing HAI, which was statistically significant. The younger age (<5 years), those patients who started antibiotics at admission, and patients who were on

Table 2 Pediatric ICU Care and Different Procedures, Ayder, Mekelle, Tigray (N = 223)

Variable	Category	Frequency	Percent
Patient feeding	Oral feeding	48	21.5
	NGT feeding	77	34.5
	Maintenance fluid	98	43.9
Duration of maintenance fluid (n = 98)	<24 hours	15	15.3
	24–72 hours	48	50
	>72 hours	35	35.7
Mechanical ventilator	Yes	40	17.9
	No	183	82.1
Urinary catheter	Yes	31	13.9
	No	192	86.1
Central line	Yes	3	1.3
	No	220	98.7
NG tube	Yes	127	57.0
	No	96	43.0
Chest tube	Yes	8	3.6
	No	215	96.4
Hospital-acquired infection (HAI)	Yes	45	20.2
	No	178	79.8
Final outcome	Discharged	11	4.9
	Transferred	140	62.8
	Died	46	20.6
	Left against advice	26	11.7

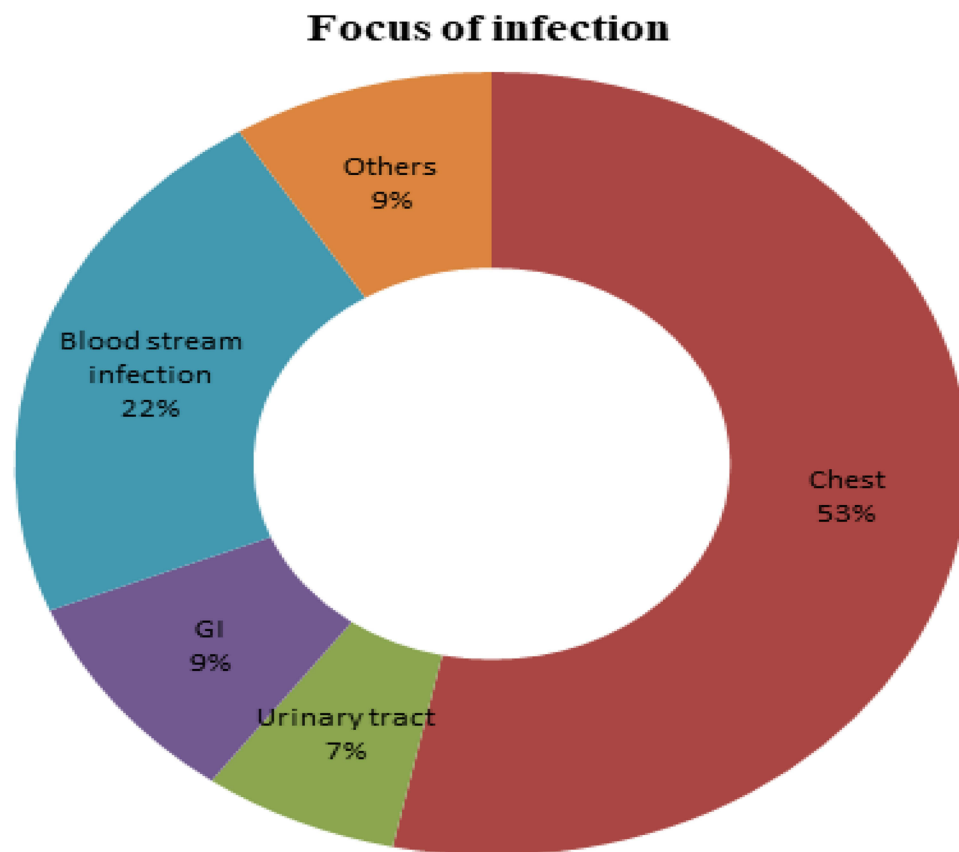


Figure 1 Focus of infection for nosocomial infection in pediatric ICU, Ayder, Mekelle (n=45).

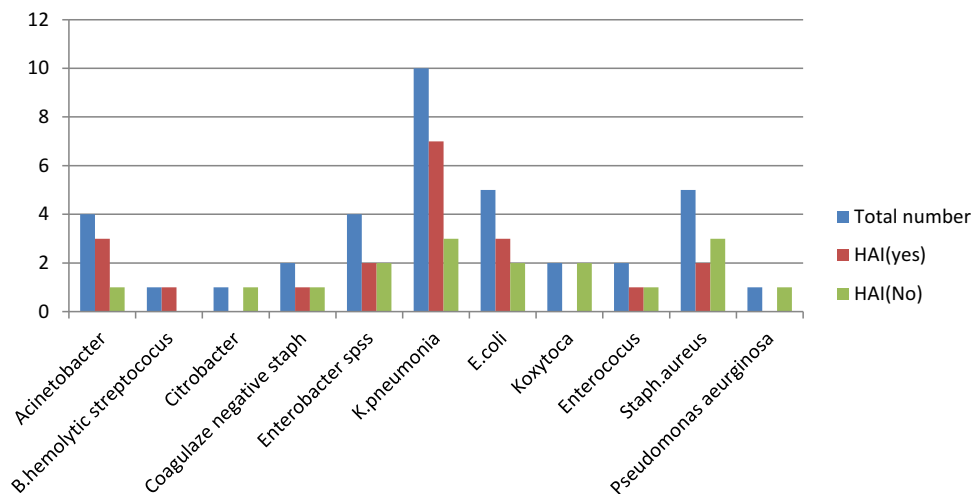


Figure 2 Identified bacterial etiologies from different samples in patients admitted to PICU (n=37).

nasogastric tube feeding were also statistically significant risk factors for developing NI (AOR: 3.3, 95% CI: 1.4, 8.0, $p < 0.008$; AOR = 2.67, 95% CI = 1.37–9.64, $p = 0.02$; AOR = 2.45, 95% CI = 1.64–6.53, $p = 0.03$). Other risk factors which increase the risk of developing HAI were sedated than conscious patients (33.3% Vs 21.1%), on maintenance than oral feeding (25.5% vs 8.3%), those who were on maintenance Fluid for greater than 72 hours than less than 24 hours (35.3% vs 13.3%), but they were not statistically significant ($p > 0.05$) (Table 3).

Table 3 Predictors of HAI Among Pediatric ICU Patients, Ayder, Tigray (N = 223)

Variable	With HAI (N, %)	Without HAI (N, %)	P-value	Total (N)
Age category (years) (N = 223)			0.006	
<5 years	34 (26)	97 (74)		131
≥5 years	11 (8.4)	81 (91.6)		92
Gender (N = 223)			0.186	
Male	24 (17.4)	114 (82.6)		138
Female	21 (24.7)	64 (75.3)		85
Source of admission (N = 223)			0.12	
Emergency	24 (15.1)	127 (84.9)		159
Ward	18 (36.7)	31 (63.3)		49
Operation theatre	3 (13.6)	19 (86.4)		22
Burn unit	0	1(100)		1
GCS (N = 223)			0.5	
15	24 (21.1)	88 (78.9)		114
9–14	14 (32.6)	56 (67.4)		43
<9	4 (7)	28 (93)		57
Sedated	3(33.3)	6 (66.7)		9
Nutritional status (N = 223)			0.64	
Normal	22 (19.3)	92 (80.7)		114
Moderate acute malnutrition	10 (23.3)	33 (76.7)		43
Severe acute malnutrition	12 (21.1)	48 (78.9)		57
Not recorded	1 (11.1)	8 (88.9)		9
Patient feeding (N = 223)			0.220	
Oral feeding	4 (8.3)	44 (91.7)		48
Nasogastric feeding	16 (21)	61 (79)		77
Maintenance fluid	25 (25.5)	73 (74.5)		98
Duration of maintenance			0.22	
<24 hours	2 (13.3)	13 (86.7)		15
24–72 hours	11 (22.9)	37 (77.9)		48
>72 hours	12 (35.3)	22 (64.7)		34
Mechanical ventilator (N = 223)			0.29	
Yes	11 (27.5)	29 (72.5)		40
No	34 (18.6)	149 (81.4)		183
Duration of MV (n = 40)			0.03	
<72 hours	2 (10)	18 (90)		20
4–6 days	3 (37.5)	5 (63.5)		8
≥7 days	6 (50)	6 (50)		12
Urinary catheter (N = 223)			0.186	
Yes	9 (29)	22 (71)		31
No	36 (18.7)	156 (81.3)		192
NG tube (N = 223)			0.013	
Yes	33 (26)	94(74)		127
No	12 (12.5)	84 (87.5)		96
Duration of hospital stay (N = 223)			0.0005	
≤14 days	18 (12.3)	128 (87.7)		146
>14 days	27 (18.5)	52 (81.5%)		79

(Continued)

Table 3 (Continued).

Variable	With HAI (N, %)	Without HAI (N, %)	P-value	Total (N)
Residence (N = 223)			0.82	
Rural	28 (19.7)	114 (80.1)		142
Urban	17 (17.3)	64 (82.7)		81
Comorbidity (N = 223)			0.64	
Yes	27 (21.3)	100 (78.7)		127
No	18 (18.7)	78 (81.3)		96
Antibiotics started immediately after admission			0.002	
Yes	45 (23.7%)	145 (76.3%)		190
No	0	33 (100%)		33

Discussion

Developing and developed countries are suffering from a high burden of hospital-acquired infection. According to a WHO study in 55 hospitals in 14 countries, about 8.7% of admitted patients had NI.¹¹ As NI is more rampant and its prevention is the critical step in improving healthcare quality, surveillance is crucial for further interventional plans.^{6,7} In this study, 20.2% of admitted patients develop HAI, with the main focus of infection being the chest. Our study differs as we only assessed the focus, and it does not differentiate the type of infection, including whether it was ventilator-associated or not, and causative etiology. Even though the prevalence of HAI in our study (20.2%) was higher than in studies done in Pakistan (4.7%), Lithuania (13.6%), Egypt (15.6%), American study (11.9%), Rwanda (12.1%) and Peru (20%),^{6-8,16,17} but it was lower than studies done in India (27.3–30.5%), Egypt (27.7%), Serbia (32.7%), Nigeria (45%).^{1,3,10,11,18} The differences in the prevalence of HAI in developing countries may be due to the disparities in quality of care, strong infection prevention mechanism implementation, the study design we used, and the study area (we used only PICU, but in others, adult ICU and General ICU were included) and the type of patients where NI was assessed. According to our findings, the main focus of infection was the chest which was consistent with a study done in Lithuania (58.8%)⁶ and Egypt, but in other studies, BSI was more prevalent than respiratory infection like in Peru⁷ and Nigeria.³

Despite the differences between studies with regard to causative organisms, Gram-Negatives showed the most common pathogens identified in this study, which is consistent with other studies.^{1,3,18,19} Among body fluid analysis, 36 isolates of organisms were found, of which Gram-Negatives accounted 75% and the rest were Gram-Positives.

Klebsiella pneumonia was the leading bacterial etiology of HAI, followed by *Escherichia coli* and *Acinetobacter baumannii*. This is parallel to the study reported in the literature.^{6,7,12} This may be due to differences in the site of infection (chest vs BSI), sampling site, demographic differences, and the degree of infection prevention implementations.

According to our findings, statistically significant predictors which increase the risk of nosocomial infection were younger age (under five years), prolonged duration of mechanical ventilation (more than 7 days), presence of nasogastric tube, patients started antimicrobial at admission and long duration of hospital stay (more than two weeks). Some of these findings were compatible with that of previous studies like duration of hospital stay,⁶ mechanical ventilation, presence of NGT,¹¹ preceding use of antibiotics,³ and using the medical device.²⁰ The new finding of our study is the younger the age, the more they are at risk of developing HAI. This could be attributed to young age groups' immature immune systems^{3,11,19,20}.

Despite the fact that we failed to evaluate reintubation rate, other studies have consistently demonstrated as a strong predictor of NI. And others we did not assess as risk factors were prophylactic use for stress ulcers, beta-blocker medication, neuromuscular block, and the severity of illness at admission. As in our study, knowing risk factors is crucial, and efforts can be made to prevent subsequent infections. All necessary precautions, including timely removal of medical devices like NGT and urinary catheters, must be taken to minimize HAI.

This study has certain limitations, including, first, it is a retrospective study challenging to examine other lab-related investigations to correlate the clinical profile. Second, the study did not provide data regarding re-intubation. Third, the sample was also not taken from the trachea and/or respiratory samples. Besides these limitations, our study is one of the few studies done in PICU on the prevalence and risk factors for HAI, which may further help us to strategize our infection prevention plans.

Conclusion

Our study revealed that the prevalence of NI in PICU was 20.2% which was higher compared to some developing countries, and K. pneumonia was the leading etiology. Young age (<5 years), hospital stay for more than 14 days, mechanical ventilation >7 days, NGT, and initiation of antibiotics at admission were significantly associated with HAI. Further studies are needed to implement and evaluate adequate infection prevention plans. Therefore, priority should be given to implementing an effective infection control team. Hospital management and the Ministry of Health should give precedence to this high rate of nosocomial infection and implement infection prevention control programs.

Abbreviations

NI, Nosocomial Infection; WHO, World Health Organization; HAI, Hospital Acquired Infection; PICU, Pediatric Intensive Care Unit; ACSH, Ayder Comprehensive Specialized hospital; NGT, Naso Gastric tube; MV, Mechanical Ventilation; BSI, Blood Stream Infection.

Data Sharing Statement

The data included in the manuscript.

Ethical Consideration

Ethical clearance was obtained from the Institutional Review Board (IRB) of the College of Health Sciences, Mekelle University, with an IRB number of 1853/2021. The permission letter was also obtained from the ACSH Chief Clinical director's office before the commencement of the study. Moreover, it confirms that this study compiles all the requirements of the latest 2013 version of the Declaration of Helsinki.

Informed Consent

Consent was taken from the care givers after they were told about the objective and purpose of the study. They were also told about their right to refuse to participate in the study at any time.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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