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Incidence and trends of nosocomial infection in a tertiary general hospital in China from 2018 to 2021: a retrospective observational study

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Abstract. – OBJECTIVE: This study aimed to investigate the current status and changing trend of nosocomial infection in a tertiary general hospital in China, to provide a reference for the prevention and control of healthcare-associated/acquired infection (HAI).

PATIENTS AND METHODS: A retrospective investigation of the clinical data of HAI patients in Dongying People's Hospital in China from January 1, 2018, to December 31, 2021, was carried out. The incidence of HAI in different units and sites, distribution of pathogenic microorganisms, and antimicrobial use were investigated.

RESULTS: The incidence of HAI was 0.93%. It was on the rise from 2018 to 2020 but declined in 2021. The departments with the highest rate of HAI were the Intensive Care Unit (ICU), neurosurgery department, cardiothoracic surgery department, and hematology department. HAI often occurs in the lower respiratory tract, urinary tract, and in blood. The most common pathogenic microorganisms in cases of HAI were *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and *Staphylococcus aureus*. The rate of bacterial culture delivery for therapeutic drugs has increased from year to year.

CONCLUSIONS: This study shows that the incidence of HAI in the hospital is generally low. Gram-negative bacteria are still the main source of HAI. The rate of bacterial culture delivery for therapeutic use improved over the years and has gradually been standardized. It is necessary to focus on the management of HAI in the ICU, neurosurgery, cardiothoracic surgery, and hematology departments.

Key Words:
Nosocomial infection, Trend, Retrospective observational study.

Introduction

Nosocomial infection (NI), also known as healthcare-associated/acquired infection (HAI), is defined as an infection that occurs and is identified among patients and personnel in healthcare settings[1]. It is associated with invasive devices such as ventilators and catheters that are used in medical procedures[2]. It has been reported[3,4] that one in ten patients admitted to the hospital for more than 48 hours is likely to get infected. HAIs are associated with 2.5 times longer hospital stays and increased mortality of the affected patients. The prevalence of HAI ranges from 3.5% to 12% in high-income countries, and about 5.7% to 19.1% in low- and middle-income countries[5,6]. The impact of HAI is considerable as the infection may lead to sepsis, higher morbidity and mortality, mental stress, and substantial financial burden on patients and the healthcare system[7].

HAI surveillance is an essential and important way to monitor the occurrence and distribution of HAI in high-risk specialties and sites, and the obtained data on the occurrence of HAI may be then used for research, decision-making, and for keeping track of trends in HAI and clarifying the key points of HAI management.

Several studies[8-11] investigated HAI in hospitalized patients with a focus on the Intensive Care Unit (ICU). Moreover, in the context of the COVID-19 pandemic, the transmission mode of coronavirus disease 2019 (COVID-19) and its impact on HAI have also been extensively studied[12-14]. However, few studies have comprehensively examined the incidence of HAI in tertiary general hospitals. Although international data

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can be used as a reference for infection control, a case-by-case analysis of different hospitals is still needed as the profile of HAI varies across different countries, regions, hospitals, and units. Additionally, COVID-19 control policies vary from country to country. Therefore, in this study, we retrospectively reviewed the clinical data of HAI cases in our hospital from 2018 to 2021 and analyzed the incidence of HAI in different units and sites, distribution of pathogenic microorganisms, and antimicrobial use to provide a reference basis for hospital infection prevention and control in tertiary general hospitals.

Patients and Methods

Patients

This was a retrospective observational study conducted in Dongying People's Hospital (Shandong, China) from January 1, 2018, to December 31, 2021. Nosocomial infections occurred in 2,586 out of 260,509 patients, and the clinical data of these patients were collected. The nosocomial infection cases were reported by the clinicians of each department, and the infection management personnel made additional reports after checking the omissions.

The inclusion criteria were as follows: patients diagnosed with nosocomial infection based on the diagnostic criteria issued by the Centers for Disease Control and Prevention's National Healthcare Safety Network[15]; and patients with complete clinical data.

Exclusion criteria were as follows: community-acquired infection prior to the patient's original diagnosis on admission into the hospital; and patients hospitalized for less than four days[16,17].

The study was approved by the Dongying People's Hospital Ethics Committee (No. DYYX-2023-128), and it was conducted in accordance with the Declaration of Helsinki. Patient consent was waived as the study was retrospectively conducted on clinical data.

Quality Control of the Clinical Data

The clinical data of nosocomial infection cases in this study were retrospectively obtained by professional infection control staff based on laboratory test results and by reviewing the medical records. Nosocomial infection cases reported by clinicians were reviewed by infection control specialists. Infection control specialists and clinicians regularly receive training on infection control knowledge to improve prevention and control skills and data management to ensure the accuracy and objectivity of the data entered. Furthermore, the Hospital Infection Monitoring and Management System can make logical corrections to the information entered and provide feedback on the pass rate of the information filled in, which can ensure the accuracy of the data.

Statistical Analysis

All data were analyzed by SPSS 21.0 (IBM Corp., Armonk, NY, USA). Counting data were presented as frequency and percentage (n, %), and χ^2 test was used to compare the difference between years. All tests were two-sided, and $p<0.05$ was considered statistically significant.

Results

Baseline Characteristics

A total of 2,586 patients (1,604 males and 982 females), admitted to our hospital, were diagnosed with HAI. The mean age and hospitalization time of the patients were (60.0718.18) years and (38.1970.56) days, respectively (Table I).

Table I. Characteristics of the patients that acquired HAI.

Year	N	Age, mean (SD), year	Sex, male, n (%)	Hospitalization time, mean (SD), day
2018	635	59.12 ± 17.10	392 (61.73)	34.50 ± 62.71
2019	732	59.57 ± 18.42	450 (61.48)	35.29 ± 45.43
2020	657	60.51 ± 18.18	400 (60.88)	39.43 ± 84.96
2021	562	61.28 ± 19.01	362 (64.41)	44.69 ± 85.43
F/χ^2		1.713	1.841	2.655
p		0.162	0.606	0.047

HAI, healthcare-associated/acquired infection.

Incidence of HAI

From 2018 to 2021, 2,586 out of 260,509 inpatients acquired HAI. The incidence rate of HAI was 0.93%, and the incidence rate of case times was 1.14%. The incidence of HAI rose from 2018 to 2020 but declined in 2021. There was a statistically significant difference in the incidence of nosocomial infection between different years (p<0.001) (Table II).

HAI in Different Clinical Departments

The departments with the highest HAI rate from 2018 to 2021 were ICU (11.48-15.04%) and neurosurgery department (5.91-8.37%), followed by the cardiothoracic surgery, hematology, cardiac ICU, and gastrointestinal surgery departments. In terms of development trends, most departments had a high infection rate in 2019 and then showed a downward trend (Table III).

HAI in Different Sites

From 2018 to 2021, HAI occurred frequently in the lower respiratory tract (41.33%), urinary tract (18.85%), blood (9.59%), upper respiratory tract (6.87%), and abdominal (pelvic) cavity (4.01%). The lower respiratory tract and blood infections showed a high level of fluctuation, the urinary tract infection showed an upward trend, the upper respiratory tract infection showed a downward trend, and the infection rate in the abdominal (pelvic) cavity was basically stable (Table IV).

Isolation of Pathogens From 2018 to 2021

From 2018 to 2021, 2,528 strains of pathogenic microorganisms were isolated from 2,971 HAI cases, with a detection rate of 85.09%. The most common pathogenic microorganisms each year included *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii,* and *Staphylococcus aureus*, and the detection rates of these five pathogenic microorganisms showed an upward trend since 2019 (Table V).

Antimicrobial Use From 2018 to 2021

From 2018 to 2021, there was no statistically significant difference in the rate of therapeutic drug use, and the combined use of antibacterial drugs (p>0.05). In contrast, the rate of bacterial culture and inspection of therapeutic drugs each year increased year by year, and the difference in the inspection rate was statistically significant (p<0.001) (Table VI).

Discussion

It is estimated that 3.8-4.0 million hospitalized patients in European countries and 1.7 million patients in the US contract HAIs annually, with 37,000 and 98,000 HAI-associated deaths, respectively[18-20]. In Africa, the data about the HAI prevalence is scarce, but it is estimated to be 3-15%[21]. In our study, the incidence rate of HAI from 2018 to 2021 was 0.93%, which was lower than the previous data. We believe that this difference may be due to several reasons: (1) the study was performed in a tertiary hospital with a good state of hygiene and adequate medical resources; (2) tertiary hospitals provide high-quality health care and have good HAI management techniques; (3) different methodology used may lead to different results; (4) since tertiary hospital provides a high medical level of care, many patients from other provinces who come to our hospital for surgery may choose to be treated at the local hospital after the discharge even if the infection occurs. As a result, fewer infected patients are diagnosed with HAI when they come to the hospital for follow-up; (5) COVID-19 control policies led to relatively

Table II. Comparison of incidence of HAI from 2018 to 2021.

Year	Number of in patients	HAI cases	HAI rate (%)	HAI times	HAI times rate (%)	χ^2	p
2018	67,347	635	0.94	702	1.04	29.416	< 0.001
2019	69,797	732	1.05	848	1.21		
2020	57,619	657	1.14	780	1.35		
2021	65,746	562	0.85	641	0.97		
Total	260,509	2,586	0.93	2,971	1.14		

HAI, healthcare-associated/acquired infection.

fewer patients that visited other departments during 2020-2021, except for the critical care unit, which may reduce the HAI rate in other departments.

Our study supported the previous observation that 20-50% of HAIs are contracted in ICUs[22,23]. Patients in ICUs generally have severe underlying conditions and undergo more invasive procedures than patients in other units, making it a place with a high incidence of HAI. We also found a relatively high incidence of HAI in departments of neurosurgery, cardiothoracic surgery, and hematology. The invasive and complicated procedures in surgical departments may cause long hospital stays, postoperative indwelling catheters, and extensive use of antibiotics, which consequently increases the chance of postoperative HAI[3,24-26]. In the division of hematology, patients often exhibit impaired immune function that declines after high-dose chemotherapy treatment and immunosuppressant use. This makes the patients in this department more susceptible to endogenous and exogenous infections[27]. In most departments, the incidence of HAI showed a downward trend from 2019 to 2021. We speculate that this decrease is associated with COVID-19 control policies.

Table III. The top 15 departments of HAI from 2018 to 2021 [n (%)].

No.	2018		2019		2020		2021	
	Department	HAI case	Department	HAI case	Department	HAI case	Department	HAI case
1	ICU	43 (12.80)	ICU	63 (15.04)	ICU	44 (14.06)	ICU	130 (11.48)
2	Neurosurgery	116 (8.37)	Neurosurgery	110 (7.09)	Neurosurgery	103 (7.16)	Neurosurgery	87 (5.91)
3	Cardiothoracic	35 (4.13)	Cardiothoracic	50 (5.57)	Hematology	45 (5.81)	Hematology	34 (4.66)
4	Hematology	26 (4.05)	Hematology	37 (5.47)	Cardiothoracic	41 (4.89)	Rehabilitation	25 (3.36)
5	Gastrointestinal surgery	42 (3.09)	Cardiac ICU	4 (4.08)	Cardiac ICU	3 (3.8)	Cardiothoracic	29 (2.92)
6	Nephrology	20 (2.38)	Brain Injury Rehabilitation	4 (3.28)	Rehabilitation	25 (3.53)	Emergency	37 (1.90)
7	Traumatology	21 (2.14)	Rehabilitation	29 (3.02)	Gastrointestinal surgery	41 (3.18)	Cardiac ICU	3 (1.88)
8	Rheumatology and immunology	7 (2.09)	Neurology	23 (2.75)	Neurology	21 (2.62)	Neurology	14 (1.48)
9	Hepatobiliary surgery	13 (1.46)	Interventional oncology	17 (2.66)	Interventional oncology	4 (1.59)	Dermatologic Venereology	9 (1.45)
10	Oncology	50 (1.38)	Rheumatology and immunology	12 (2.63)	Oncology	71 (1.49)	Neonatal Care Unit	10 (1.30)
11	Neurology	17 (1.35)	Gastrointestinal surgery	33 (2.31)	Emergency	15 (1.45)	Oncology	62 (1.20)
12	Hand and Foot	21 (1.34)	Hepatobiliary surgery	19 (1.9)	Health care	9 (1.44)	Hepatobiliary surgery	15 (1.18)
13	Vascular surgery	7 (1.33)	Traumatology	15 (1.55)	Spine surgery	16 (1.42)	Cerebrovascular diseases	8 (1.15)
14	Rehabilitation	12 (1.30)	Articular Surgery	19 (1.54)	Urological surgery	20 (1.32)	Neurology	27 (1.13)
15	Interventional oncology	10 (1.22)	Neonatal Care Unit	9 (1.53)	Infectious diseases	2 (1.29)	Health care	7 (1.07)

HAI, healthcare-associated/acquired infection.

Table IV. Composition ratio of nosocomial infection sites from 2018 to 2021 [n (%)].

HAI site	2018	2019	2020	2021	Total
Lower respiratory tract	303 (43.16)	336 (39.62)	320 (41.03)	269 (41.97)	1,228 (41.33)
Urinary tract	124 (17.66)	138 (16.27)	162 (20.77)	136 (21.22)	560 (18.85)
Bloodstream	69 (9.83)	71 (8.37)	84 (10.77)	61 (9.52)	285 (9.59)
Intra-abdominal (pelvic) tissue	26 (3.7)	31 (3.66)	36 (4.62)	26 (4.06)	119 (4.01)
Superficial incision	31 (4.42)	31 (3.66)	23 (2.95)	7 (1.09)	92 (3.10)
Deep incision	17 (2.42)	7 (0.83)	6 (0.77)	6 (0.94)	36 (1.21)
Vascular related	12 (1.71)	30 (3.54)	18 (2.31)	10 (1.56)	70 (2.36)
Oral cavity	4 (0.57)	3 (0.35)	5 (0.64)	5 (0.78)	17 (0.57)
Genital tract	4 (0.57)	9 (1.06)	4 (0.51)	2 (0.31)	19 (0.64)
Central nervous system	9 (1.28)	16 (1.89)	8 (1.03)	18 (2.81)	51 (1.72)
Skin soft tissue	15 (2.14)	16 (1.89)	15 (1.92)	25 (3.9)	71 (2.39)
Organ cavity	12 (1.71)	23 (2.71)	13 (1.67)	7 (1.09)	55 (1.85)
Upper respiratory tract	48 (6.84)	75 (8.84)	48 (6.15)	33 (5.15)	204 (6.87)
Gastrointestinal tract	17 (2.42)	41 (4.83)	19 (2.44)	15 (2.34)	92 (3.10)
Other sites	11 (1.57)	21 (2.48)	19 (2.44)	21 (3.28)	72 (2.42)
Total	702 (100.00)	848 (100.00)	780 (100.00)	641 (100.00)	2,971 (100.00)

HAI, healthcare-associated/acquired infection.

Table V. Top 10 pathogenic microorganisms for HAI, 2018-2021 (No. of isolates, %).

No.	2018		2019		2020		2021	
	Pathogenic microorganisms	Isolates	Pathogenic microorganisms	Isolates	Pathogenic microorganisms	Isolates	Pathogenic microorganisms	Isolates
1	*Escherichia coli*	79 (16.42)	*Escherichia coli*	97 (11.98)	*Escherichia coli*	92 (12.99)	*Escherichia coli*	78 (14.74)
2	*Klebsiella pneumoniae*	66 (13.72)	*Klebsiella pneumoniae*	78 (9.63)	*Klebsiella pneumoniae*	77 (10.88)	*Klebsiella pneumoniae*	63 (11.91)
3	*Pseudomonas aeruginosa*	48 (9.98)	*Pseudomonas aeruginosa*	68 (8.4)	*Pseudomonas aeruginosa*	52 (7.34)	*Pseudomonas aeruginosa*	55 (10.4)
4	*Acinetobacter baumannii*	37 (7.69)	*Staphylococcus aureus*	40 (4.94)	*Staphylococcus aureus*	45 (6.36)	*Acinetobacter baumannii*	39 (7.37)
5	*Staphylococcus aureus*	32 (6.65)	*Acinetobacter baumannii*	31 (3.83)	*Acinetobacter baumannii*	39 (5.51)	*Staphylococcus aureus*	34 (6.43)
6	*Enterobacter cloacae*	22 (4.57)	*Gram-negative diplococci*	31 (3.83)	*Enterobacter cloacae*	32 (4.52)	*Enterobacter cloacae*	26 (4.91)
7	*Gram-negative diplococci*	13 (2.7)	*Fungal spores resembling Candida*	31 (3.83)	*Stenotrophomon-as maltophilia*	29 (4.1)	*Enterococcus faecalis*	18 (3.4)
8	*Stenotrophomon-as maltophilia*	11 (2.29)	*Stenotrophomon-as maltophilia*	29 (3.58)	*Pseudomonas albicans*	28 (3.95)	*Stenotrophomon-as maltophilia*	17 (3.21)
9	*Pseudomonas albicans*	9 (1.87)	*Enterobacter cloacae*	27 (3.33)	*Enterococcus faecalis*	26 (3.67)	*Pseudofilamen-tous yeast*	16 (3.02)
10	*Streptococcus straw green alpha-hemolytic*	7 (1.46)	*Pseudomonas albicans*	24 (2.96)	*Fungal spores esembling Candida*	16 (2.26)	*Fungal spores resembling Candida*	15 (2.84)

HAI, healthcare-associated/acquired infection.

Table VI. Antimicrobial use from 2018 to 2021 [n (%)].

Year	HAI patients on antibiotics	Therapeutic medication	Bacterial culture and inspection of therapeutic drugs	Combination of antibiotics		
				Alone	Dual	Triplet and above
2018	624	351 (56.25)	312 (88.89)	212 (33.97)	188 (30.13)	224 (35.90)
2019	722	435 (60.25)	387 (88.97)	282 (39.06)	186 (25.76)	254 (35.18)
2020	642	369 (57.48)	344 (93.22)	214 (33.33)	182 (28.35)	246 (38.32)
2021	549	329 (59.93)	318 (96.66)	172 (31.33)	164 (29.87)	213 (38.80)
χ^2			3.11	19.69	12.945	
p			0.375	< 0.001	0.165	

HAI, healthcare-associated/acquired infection.

In our study, we also found that the respiratory tract and urinary tract are the top two sites with a high incidence of HAI, which is consistent with the previous reports[28,29]. Studies[30] showed that hospital-acquired pneumonia (HAP) is the most common HAI leading to death and affecting 0.5-1.0% of inpatients. Respiratory tract infections are largely associated with the use of ventilator support, so-called ventilator-associated pneumonia (VAP)[31]. Urinary tract infection (UTI) accounts for 20-40% of all HAI, and catheter-associated urinary tract infections (CAUTIs) contribute to more than 75% of UTIs[32-34]. Limiting inappropriate usage of ventilators and urinary catheters may help to reduce the incidence of VAP and CAUTIs[35,36]. A study by Scherbaum et al[37] demonstrated a higher rate of bloodstream HAI. This observation is further confirmed by results that show a high incidence of HAI in the hematology department.

Our study reinforced previous observations[16,38-41] that *Escherichia coli, Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Staphylococcus aureus* are the most frequently isolated bacteria in HAIs. Gram-negative bacteria are conditional pathogens that may lead to infection in patients who are already weakened by serious underlying diseases, malignant tumors, or chronic inflammation. Therefore, there is a great need for adequate control measures to prevent HAI associated with these strains. Furthermore, increasing the detection rate of infected specimens can provide a timely basis for the rational use of antibiotics in clinical practice. In this study, we found that the rate of bacterial culture delivery for therapeutic use increased year by year, indicating that the awareness of the need for rational use of antibiotics by clinicians in the hospital has gradually improved.

WHO[42] has recently reported that most HAIs are preventable through effective infection prevention and control measures that may reduce HAI by 70%. Therefore, it is important to strengthen the HAI-related training of clinicians, ensure the appropriate use of antibiotic medications, improve awareness of HAI prevention measures, and to further improve the surveillance system.

Limitations

Our study has several limitations. The retrospective nature of the study may limit the generalization of the results. Additionally, risk factors for nosocomial infections were not studied in this paper. Finally, this study did not analyze the antimicrobial use and resistance rates of pathogenic bacteria to antimicrobial drugs, which is also an important part of HAI control.

Conclusions

The incidence of HAI in the hospital is generally low. Gram-negative bacteria are still the main pathogens of HAI, and the bacterial culture and inspection work of therapeutic drugs has gradually been standardized. It is necessary to focus on the management of HAI in the ICU, neurosurgery, cardiothoracic surgery, and hematology departments.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Ethics Approval

The study was approved by the Ethics Committee of Dongying People's Hospital (No. DYYX-2023-128).

Informed Consent

Patient consent was waived as the study was retrospectively conducted on clinical data.

Authors' Contribution

Conception and design: ZJ and NZ. Administrative support: YM and WM. Provision of study materials or patients: ZJ, NZ and YM. Collection and assembly of data: ZJ, NZ and WM. Data analysis and interpretation: YM and WM. Manuscript writing: ZJ and NZ. Final approval of manuscript: All authors.

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Data Availability

The Authors declare that they have no conflict of interests.Data will be provided upon request to the corresponding author.

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