

The pathogenic characteristics and influencing factors of health care-associated infection in elderly care center under the mode of integration of medical care and elderly care service

A cross-sectional study

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Abstract

The aim of this study was to analyze the distribution of pathogenic bacteria in hospitalized patients in elderly care centers under the mode of integration of medical care and elderly care service, and explore the influencing factors to reduce the health care-associated infection rate of hospitalized patients.

A total of 2597 inpatients admitted to elderly care centers from April 2018 to December 2019 were included in the study. The etiology characteristics of health care-associated infections (HCAI) was statistically analyzed, univariate analysis, and multivariate logistic regression analysis method were used to analyze the influencing factors of HCAI.

A total of 98 of 2597 inpatients in the elderly care centers had HCAI, and the infection rate was 3.77%. The infection sites were mainly in the lower respiratory tract and urinary tract, accounting for 53.92% and 18.63%, respectively. A total of 53 pathogenic bacteria were isolated, 43 of which (81.13%) were Gram-negative, mainly *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, which respectively accounted for 24.53, 16.98, and 13.21%. 9 (16.98%) strains were Gram-positive, mainly *Staphylococcus aureus* and *Enterococcus faecium*, respectively accounting for 7.55 and 5.66%. Only 1 patient (1.89%) had a fungal infection. Multivariate logistic regression analysis indicated that total hospitalization days, antibiotic agents used, days of central line catheter, use of urinary catheter and diabetes were independent risk factors of nosocomial infection in elderly care centers ($P < .05$).

Many factors can lead to nosocomial infections in elderly care centers. Medical staff should take effective intervention measures according to the influencing factors to reduce the risk of infection in elderly care facilities.

Abbreviations: CAUTI = catheter-associated urinary tract infection, HCAI = health care-associated infection, LRTI = Lower respiratory tract infections, SSTI = Skin and soft tissue infection, UTI = Urinary tract infection.

Keywords: bacterial infections, healthcare-associated infections, microbiology, risk factors

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1. Introduction

Under the background of healthy aging, the service mode that can effectively integrate medical and elderly care resources (integration of medical care and elderly care service mode) has become a new developed direction of elderly care services.^[1–3] Few studies have reported the pathogenic characteristics and influencing factors of healthcare-associated infection. Binzhou elderly care service center is a public welfare project of the Chinese government with a total investment of 280 million yuan, which is operated and managed by Binzhou people's hospital in a mode of combined medical and elderly care service. The service objects are mainly disabled, semi disabled, elderly, and disabled groups, all of which are high-risk groups for health care-associated infections (HCAI). The purpose of this study was to analyze the distribution and influencing factors of HCAI in the elderly care center, to provide a theoretical basis for the prevention and control of HCAI in elderly care facilities.

2. Materials and methods

2.1. Study participants

This study was approved by the medical ethics committee of Binzhou People's Hospital. The study was based on an in-patient population retrospective study and was conducted at a single center during the period from April 2018 to December 2019. A total of 2597 inpatients in the elderly care center were included in the study. The inclusion criteria were: all patients come from the elderly care center; confirmed infection in accordance with the diagnostic criteria of HCAI; the clinical data are completely; patients volunteered to participate in the study.

The exclusion criteria were: patients with community-acquired infection; incomplete clinical data; unwilling to join the study.

The HCAI was monitored using the real-time nosocomial infection surveillance system of Xinglin hospital (Xinglin Information Technology Co., Ltd., Hangzhou, China). The diagnostic standard was based on the "healthcare-associated infection diagnosis standard" issued by the ministry of health of People's Republic of China in 2001. The clinicians actively report the cases of HCAI, and the full-time staff of the infection control team supervise the cases of HCAI according to the early warning information of Xinglin nosocomial infection monitoring software and the results of microbiological examination, to avoid missing reports. In case of doubt, the full-time staff of the infection control group shall communicate with the clinical chief physician in time to ensure the accuracy of nosocomial infection monitoring.

2.2. Methods

2.2.1. Operation mode of the combined medical and elderly care service. When the condition of the patient in the elderly care center changes and the person needs to be hospitalized after evaluation, the evaluating doctor will give the inpatient order and transfer the basic information of the patient to the "general medical ward" in the medical path. When the patient's condition is stable and no hospitalization is needed according to the physician's assessment, the assessing doctor will give an order to discharge the patient, and transfer the patient's information to the elderly care center in the elderly care path.

2.2.2. Pathogen culture and identification. The samples sent for examination were collected strictly in accordance with the

guidelines, and the isolation of pathogenic bacteria was in strict accordance with the "National Clinical Test Regulation of Operation". The Phoenix-100 identification system (Becton, Dickinson and Company, NJ) was used for strain identification. The culture medium and antimicrobial article were provided by Antibio (Henan, China) and Oxoid (Thermo Fisher Scientific, MA), respectively. The quality control strains of *Escherichia coli* (ATCC25922), *Pseudomonas aeruginosa* (ATCC27853) and *Staphylococcus aureus* (ATCC25923) were purchased from the clinical testing center of the Health Ministry of China.

2.2.3. Clinical data collection. The age, sex, average days of hospitalization, and other general data of the patients were recorded in detail, including the presence of basic diseases such as diabetes, hypertension, chronic lung disease, and whether antibiotics, ventilators, catheters, central venous catheter, or surgical procedure were used. The infection rate, infection site, and distribution of pathogenic bacteria were counted, and the risk factors of HCAI were analyzed. All authors had full access to the data.

2.3. Statistical analysis

SPSS 20.0 statistical software (IBM Corp., USA) was used to analyze the data. The counting data was expressed as the numbers of cases or percentages. The sample rate was compared using the χ^2 test. Univariate analysis and multivariate logistic regression analysis were used to analyze the influencing factors of nosocomial infection in inpatients. Differences with $P < .05$ were considered statistically significant.

3. Results

3.1. The frequency of HCAI and distribution of infection sites among inpatients in the elderly care center

A total of 98 of 2597 patients developed HCAI, corresponding to an infection rate of 3.77%. The number of HCAI cases was 102, and the rate of HCAI episodes was 3.93%. There were a total of 28,604 hospitalization-days, and the rate of hospitalization-days per patient was 3.43%. Among them, there were 55 (53.92%) cases of lower respiratory tract infections, with the highest infection rate, followed by 19 cases (18.63%) of catheter-associated urinary tract infections, as shown in Table 1.

3.2. Distribution of pathogens causing nosocomial infections in inpatients of the elderly care center

A total of 53 strains of pathogenic bacteria were detected in 98 hospital-infected patients in the elderly care center, including 43 (81.13%) strains of Gram-negative bacteria, 9 strains of Gram-positive bacteria, and 1 (1.89%) strain of fungus. The distribution of pathogenic bacteria is shown in Table 2.

3.3. Distribution of pathogenic bacteria among hospitalized patients in the elderly care center

Gram-negative bacteria were mainly distributed in the lower respiratory tract (22 cases) and catheter-associated urinary tract infection (CAUTI) (11 cases), accounting for 51.16 and 25.58%, respectively. Gram-positive bacteria were mainly distributed in the lower respiratory tract (5 cases), accounting for 55.56%. The distribution of pathogenic bacteria is shown in Table 3.

Table 1
Distribution of 98 HCAIs.

Type of infection	No. of infections	% Of all HCAIs
Low respiratory tract infections	55	53.92
Catheter-associated urinary tract infection	19	18.63
Skin and soft-tissue infection	8	7.84
Other types of the UTI	7	6.86
Upper respiratory tract infection	5	4.90
Intraabdominal infections	4	3.92
Bacteremia	3	2.94

HCAI = health care-associated infection, other types of the UTI = urinary tract infections caused by nonurinary catheters, UTI = urinary tract infection.

3.4. Univariate and multivariate Logistic Regression analysis of HCAI in inpatients in the elderly care center

The univariate analysis results showed that the incidence of HCAI is related to age, total hospitalization-days, antibiotic agents used, days of antibiotics, surgery procedure, combined antibacterial drugs, combined antibiotics duration, use of ventilator, days of ventilator, frequency of ventilator, use of central line catheter, days of central line catheter, frequency of indwelling central line catheter, use of urinary catheter, days of urinary catheter, frequency of indwelling urinary catheter, diabetes, cerebral infarction, chronic lung disease, or urological disease ($P < .05$). Multivariate logistic regression analysis was carried out on the results with statistical significance according to univariate analysis. The results showed that the total hospitalization-days, antibiotic agents used, days of central line catheter, use of urinary catheter and diabetes were independent factors affecting HCAI in inpatients in the elderly care center ($P < .05$), as shown in Table 4.

4. Discussion

In this study, we retrospectively analyzed the 2597 inpatients admitted to elderly care centers from April 2018 to December 2019, and explored the distribution of pathogenic bacteria and influencing factors of HCAI in hospitalized patients in elderly

Table 2
Distribution of HCAIs pathogens in elderly care center.

Pathogen	No. of strains	(%)
Gram negative bacteria	43	81.13
<i>Escherichia coli</i>	13	24.53
<i>Pseudomonas aeruginosa</i>	9	16.98
<i>Klebsiella pneumoniae</i>	7	13.21
<i>Proteus mirabilis</i>	5	9.43
<i>Acinetobacter baumannii</i>	3	5.66
<i>Enterobacter aerogenes</i>	1	1.89
Acid-producing <i>Klebsiella</i>	1	1.89
<i>Citrobacter freundii</i>	1	1.89
<i>Haemophilus influenzae</i>	1	1.89
<i>Serratia marcescens</i>	1	1.89
<i>Enterobacter cloacae</i>	1	1.89
Gram positive bacteria	9	16.98
<i>Staphylococcus aureus</i>	4	7.55
<i>Enterococcus faecium</i>	3	5.66
<i>Staphylococcus Kochi subsp</i>	1	1.89
<i>Streptococcus pneumoniae</i>	1	1.89
Fungus	1	1.89

HCAI = health care-associated infection.

care centers under the mode of integration of medical care and elderly care service. Our study found that 98 of 2597 inpatients in the elderly care centers had HCAI, and the infection rate was 3.77%. The infection sites were mainly in the lower respiratory tract and urinary tract, accounting for 53.92% and 18.63%, respectively. A total of 53 pathogenic bacteria were isolated, 43 of which (81.13%) were Gram-negative, mainly *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, which respectively accounted for 24.53, 16.98, and 13.21%. Nine (16.98%) strains were Gram-positive, mainly *Staphylococcus aureus* and *Enterococcus faecium*, respectively accounting for 7.55 and 5.66%. Only 1 patient (1.89%) had a fungal infection. Multivariate logistic regression analysis indicated that total hospitalization days, antibiotic agents used, days of central line catheter, use of urinary catheter, and diabetes were independent

Table 3
Distribution site of HCAIs pathogens in elderly care center.

Pathogen	No. of strains	LRTI	CAUTI	UTI	Bacteremia	Ascites	SSTI
Gram negative bacteria	43	22	11	6	3	0	1
<i>Escherichia coli</i>	13	4	4	3	2	0	0
<i>Pseudomonas aeruginosa</i>	9	8	1	0	0	0	0
<i>Klebsiella pneumoniae</i>	7	4	1	1	1	0	0
<i>Proteus mirabilis</i>	5	0	3	2	0	0	0
<i>Acinetobacter baumannii</i>	3	3	0	0	0	0	0
<i>Enterobacter aerogenes</i>	1	1	0	0	0	0	0
Acid-producing <i>Klebsiella</i>	1	0	1	0	0	0	0
<i>Citrobacter freundii</i>	1	0	0	0	0	0	1
<i>Haemophilus influenzae</i>	1	1	0	0	0	0	0
<i>Serratia marcescens</i>	1	0	1	0	0	0	0
<i>Enterobacter cloacae</i>	1	1	0	0	0	0	0
Gram positive bacteria	9	5	0	1	1	2	0
<i>Staphylococcus aureus</i>	4	4	0	0	0	0	0
<i>Enterococcus faecium</i>	3	0	0	1	0	2	0
<i>Staphylococcus kochi subsp</i>	1	0	0	0	1	0	0
<i>Streptococcus pneumoniae</i>	1	1	0	0	0	0	0
Fungus	1	0	1	0	0	0	0
<i>Candida tropicalis</i>	1	0	1	0	0	0	0

AUTI = catheter-associated urinary tract infection, LRTI = lower respiratory tract infections, SSTI = skin and soft tissue infection, UTI = urinary tract infection.

Table 4
Univariate and multivariate Logistic Regression analysis of HCAs in elderly care center.

Characteristics	Infection n=98 (3.77%)	Noninfection n=2499 (96.23%)	Univariate			Multivariate		
			OR	95% CI	P	OR	95% CI	P
Age >70 y	72 (73.47%)	1352 (54.10%)	2.349	1.490–3.704	<0.01			
Sex, male	70 (71.43%)	1567 (62.71%)	0.673	0.431–1.050	0.079			
The total hospitalization-days	26.77 ± 12.116	11.79 ± 9.382			<0.01	1.077	1.049–1.107	0.000
Antibiotic agents used	86 (87.76%)	744 (29.77%)	16.905	9.185–31.114	<0.01	7.210	3.183–16.329	0.000
Days of antibiotics	11.57 ± 9.695	2.78 ± 5.398			<0.01			
Surgery procedure	27 (27.55%)	284 (11.36%)	2.966	1.872–4.698	<0.01			
Combined antibacterial drugs	43 (43.88%)	322 (12.89%)	5.286	3.488–8.011	<0.01			
Combined antibiotics duration	3.79 ± 5.978	1.01 ± 3.190			<0.01			
Use of ventilator	9 (9.18%)	38 (1.52%)	6.549	3.073–13.958	<0.01			
Days of ventilator	1.40 ± 6.283	0.16 ± 1.755			<0.01			
Frequency of ventilator	0.17 ± 0.658	0.02 ± 0.174			<0.01			
Use of central line catheter	20 (20.41%)	63 (2.52%)	9.915	5.713–17.206	<0.01			
Days of central line catheter	4.30 ± 9.233	0.38 ± 2.806			<0.01	1.095	1.007–1.190	0.035
Frequency of indwelling central line catheter	0.29 ± 0.658	0.03 ± 0.201			<0.01			
Use of urinary catheter	64 (65.31%)	311 (12.44%)	13.243	8.593–20.410	<0.01	2.943	1.113–7.782	0.030
Days of urinary catheter	12.79 ± 14.250	1.93 ± 6.419			<0.01			
Frequency of indwelling urinary catheter	0.99 ± 0.902	0.16 ± 0.479			<0.01			
Diabetes	45 (45.92%)	562 (22.49%)	2.926	1.945–4.402	<0.01	2.350	1.437–3.843	0.001
High blood pressure	68 (69.39%)	1605 (64.23%)	1.263	0.815–1.955	0.295			
Coronary heart disease	60 (61.22%)	1335 (53.42%)	1.377	0.910–2.082	0.129			
Cerebral infarction	71 (72.45%)	1543 (61.74%)	1.629	1.038–2.556	0.032			
Chronic lung disease	55 (56.12%)	899 (35.97%)	2.276	1.515–3.421	<0.01			
Tumor	15 (15.31%)	270 (10.80%)	1.492	0.849–2.623	0.162			
Urological disease	40 (40.82%)	524 (20.97%)	2.599	1.718–3.933	<0.01			

CI = confidence interval; HCAI = health care-associated infection; OR = odds ratio.

risk factors of nosocomial infection in elderly care centers ($P < .05$).

The operation mode combining medical and elderly care services effectively solves the problems of medical and general care services for elderly patients. The sick elderly did not have to go back and forth to their families, hospital and elderly care institutions frequently, which ensures their timely and effective medical treatment, professional rehabilitation guidance and life care. This study also provides a reference for the prevention and control of nosocomial infections in elderly care centers.

Because of the particularity of the service object, the inpatients in the elderly care center are more likely to have HCAI. In this study, the main infection sites were the lower respiratory tract and the urinary tract. It may be associated with the fact that many elderly patients have chronic bronchitis, chronic obstructive pulmonary disease, prostatic hypertrophy, or renal dysfunction, whereas some patients also had tracheal intubation, the use of ventilator use, catheter placement, and other invasive procedures. The most common infecting pathogens were Gram-negative bacteria, mainly *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, which was consistent with previous studies.^[4–6]

The total hospitalization-days were an independent risk factor for HCAI in the elderly care center, which was in agree with published findings.^[7–9] Long-term hospitalization increases the contact between patients and medical staff, resulting in increased probability of cross-infection and hospital infection. Moreover, once the infection worsens, the length of stay is extended.^[10]

Most studies on the relationship between hospitalization days and HCAI in elderly patients are based on a stay of 1 month. Researchers suggested that the total hospitalization-days of elderly patients should be shortened to 15 days.^[11] In this study, the average total number of hospitalization-days in the infected

group was 26.77 ± 12.116 days, which was significantly higher than in the non-infected group at 11.79 ± 9.384 days. Therefore, the total hospitalization-days should be minimized to prevent and control the occurrence of HCAI in elderly patients, and the patients should be discharged as soon as possible after their condition stabilizes.

Multiple logistic regression analysis showed that antibiotic agents used was an important factor of HCAI in the elderly care center. Antibiotics are an important means to treat patients with infection, but unreasonable use can cause flora imbalance and increase the incidence of opportunistic pathogens and drug-resistant bacteria infection.^[12–14] Therefore, according to the results of pathogenic examination and drug sensitivity test, grasp the time of drug use correctly, and abide by the indications of combined drug use strictly. Scientific and rational use of antibiotics is an important means to prevent and control hospital infection in elderly care centers.

This study shows that 73.08% of urinary tract infections are related to the use of urinary catheter. It is reported that indwelling catheter will destroy the body barrier and create opportunities for pathogenic microorganism invasion.^[15,16] Invasive procedures break the first line of defense of human body and increases the infection of opportunistic pathogens. However, there are many basic diseases in the elderly, the immune system deteriorates, and the tolerance to invasive operation is poor. Therefore, invasive procedures are a high-risk factor for HCAI in elderly patients and are still the key point of prevention and control of HCAI in elderly inpatients. To reduce the incidence of HCAI, clinical staff should strictly grasp the indication of catheterization, minimize the number of catheterizations, evaluate the necessity of indwelling catheterization every day, and pull out the catheter in time.

This study also found that elderly patients with diabetes were more likely to develop HCAI. This is similarly to the results of other studies.^[17–19] The hyperglycemia environment will not only increase plasma osmotic pressure and reduce immune cell activity, but also promote the propagation of pathogenic bacteria.^[20] Clinically, patients with diabetes should be given high priority to prevent the occurrence of HCAI.

Our research has several limitations. First, it is a single-center study with relatively few patients. Second, this is a retrospective study, using real-time nosocomial infection surveillance system of Xinglin hospital to collect data, there may be have the potential of information bias. In addition, sample collection is performed by different personnel, and the results may be biased. Therefore, a multicenter, prospective randomized controlled study is needed.

5. Conclusions

In summary, there are many risk factors for HCAI in inpatients in elderly care center. Clinical medical staff should predict the risks, early intervention, and prevent nosocomial infections according to the characteristics and influencing factors of HCAI. More attention should be given to patients with long hospital stays, the use of antimicrobials, the presence of invasive procedures, surgery, and patients with diabetes or chronic lung disease.

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Author contributions

LZ and PPJ conceived and designed the study. LZ, PPJ, and JHJ collected the clinical data. YFJ and PPJ performed the statistical analysis and wrote the manuscript. LZ contributed to the writing and critical reading of the paper. All authors read and approved the final manuscript.

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