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Prevalence of hospital-acquired infections in intensive care units in public hospitals in Tehran, Iran, in 2012-2014

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Original Article

Abstract

Infection control and hospital-acquired infection (HAI) prevalence have recently attracted much attention especially in developing countries. The aim of this study was to estimate the prevalence of HAI in public hospitals in Tehran, Iran, more specifically, to determine the epidemiological status of nosocomial infections in intensive care units (ICUs) of 3 public hospitals. The study was conducted in 3 governmental hospitals and all patients who had been in the hospital for at least 48 hours and had a primary diagnosis of HAI were included in the study. The study was performed on 1470 patients who were admitted to the ICU from 2012-2014; among them, 200 cases were affected by infectious diseases. The data collected using the questionnaire included demographic characteristics, length of admission, and cause of hospital infection which were all verified by the Infection Control Center (ICC). The clinical signs and symptoms of patients were also controlled. The effects of seasonal variation on HAI were also investigated by analyzing the data obtained in various seasons. Statistical analysis was performed using SPSS software. The chi-square (X^2) test was used to compare categorical variables and a 2-sided P-value of less than 0.05 was considered as significant. The effect of season on HAI prevalence was analyzed using Kruskal-Wallis Test. The prevalence of nosocomial infections was 13.65% in the study. Urinary tract (40.9%) and surgical wounds (26.1%) were the most common types of infections. Bacteriological analysis suggested that *Escherichia coli* (35.6%) and Staphylococcus aureus (26%) were the most prevalent microorganisms related to the incidence of HAI. The results obtained showed that HAIs were more prevalent during spring. The prevalence of nosocomial infection observed in the present study seems quite high. The results showed that the length of hospitalization was positively associated with HAI. Statistical analysis showed that long length of hospitalization, age, and season are risk factors for the development of HAI during hospitalization. Furthermore, like similar studies, gram-negative bacteria were found to be the most common cause of nosocomial infections.

KEYWORDS: Hospital Infections, Nosocomial infections, Prevalence Study, Gram-Negative Bacteria

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Introduction

Nosocomial infections are considered as complications of patient care in the hospital and were recognized for the first time in the fourteenth century.[1] A hospital-acquired infection (HAI) is usually one that first emerges 3 days after a patient is admitted to a hospital or other health-care facility. This

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type of infection is also called nosocomial infection.[2] Hospital infections that are transmitted directly from one person to another are called communicable or contagious diseases.[3] The term nosocomial infection is retained to refer only to infections acquired in hospitals. In its broad meaning, nosocomial infection is defined as any infection or disease that any individual suffers due to the invasion of pathogens in hospitals. In its narrow meaning, nosocomial infection refers to any infection or disease which does not exist or is not in incubation period when the patients are hospitalized, but is caused by the invasion of disease-producing microorganisms in hospitals with a wide range of symptoms during the hosts' hospitalization or after discharge from the hospital.[4] The nosocomial infection rate in patients in a health-care facility is an indicator of the quality and safety of care in that facility. The development of a surveillance process by itself is an effective process by which to decrease HAIs.[5] The rate of morbidity and mortality due to nosocomial infections is extremely high. Out of 100 hospitalized patients at any given time, about 7 in developed and 10 in developing countries will acquire at least one HAI. Moreover, the endemic burden of hospital acquired infectious diseases is also predominantly higher in low-income and middle-income communities compared with high-income communities, especially in patients admitted to intensive care units (ICUs).[6] It has been estimated that many patients die each year from catheter-related bloodstream infections in Iran, as an upper middle income country located in Western Asia.[7] Nosocomial infections increase the costs of neonatal intensive care, prolong hospitalization by several weeks, and are responsible for almost 50% of the deaths that occur beyond 2 weeks of age.[8] Prevalence survey conducted under the auspices of the World Health Organization (WHO) in 55 hospitals of 14 countries showed that four WHO regions (Europe, Eastern Mediterranean, South-East Asia, and Western Pacific) had an average of 8.7% nosocomial infections. At any time, over 1.4 million people worldwide suffer from infectious complications acquired in hospital.[4] Eastern Mediterranean and South-East Asia, with a prevalence of 11.8% and 10%, respectively, had the highest frequencies of nosocomial infection.[4] The most common nosocomial infections are infections of surgical wounds, urinary tract infections, and lower respiratory tract infections.[5] The highest prevalence of nosocomial infections have been observed in ICUs and in acute surgical and orthopedic wards. Infection rates are higher among patients with increased susceptibility because of old age, underlying disease, or chemotherapy.[8] Reports about the incidence, long-term outcomes, and predictive factors of HAIs in the Iranian population are scarce.[8] This study, therefore, was performed with the aim of assessing the importance of nosocomial infections in some public hospitals located in Tehran, the capital city of Iran.

Materials and Methods

This was a cross-sectional study. A total of 1470 individuals who were hospitalized (in 3 public hospitals) and followed up in ICU during 2012-2014 (From 1st January 2012 until 31st December 2014) were included in the primary selection. All subjects had been in the hospital for at least 48 hours.

The following criteria were used for diagnosis and confirmation of nosocomial infections: fever, urinary culture, chest X-ray radiography, and physical examination by pulmonologist, phlegm culture, blood culture, detection of leukocytosis, and testing of other bodily discharges. The dates of the microbiological information of the patients were collected and checked for the date of admission to ICU, the date of specimen culture, and the results of the cultures from the central sterilization room (CSR) database. All these procedures were conducted by the hospitals' Infection Control Center (ICC). The results of the cultures were then collected using a checklist of points to look for any sign of infection. The data collected using the checklist included administrative data, additional information describing demographic risk factors (e.g., age, gender, severity of underlying illness which was ranked by clinicians as mild (1), moderate (2), severe (3), or extremely severe (4) applying a modified Horn's index,[9] primary diagnosis, and immunological status using immune assessment tests to detect various activation states by applying sequential analysis rates), and interventions for infected patients (e.g., device exposure, surgical procedure, and treatments), date of onset, site of infection, microorganisms isolated, and antimicrobial susceptibility. To confirm the HAI diseases among positive samples, the infected patients were visited by an infectious diseases specialist and all clinical manifestations were listed.

Statistical analysis was performed using SPSS software (version 15.0, SPSS Inc., Chicago, IL, USA). Quantitative variables were expressed as mean ± standard deviation (SD), while frequencies were calculated for categorical variables. The chi-square test was used to compare categorical variables. Prevalence rate was thereafter calculated by dividing the number of occurrences of HAI during the specified time period (2012-2014) by the size of the population (1470) who were admitted to the hospitals. The result is expressed as a percentage. Prevalence of HAI (number of infected subjects per 100 admitted patients) and its 95% confidence intervals (CIs) were estimated. A 2-sided P-value of less than 0.05 was considered as significant. The odds ratio (OR) was used to identify a variable as a risk factor.

Results and Discussion

Total number of hospital and active ICU beds were as follows: 132 and 31 beds in hospital 1, 143 and 21 in hospital 2, and 114 and 18 in hospital 3, respectively. During the 2-year period of the survey, 1800 patients occupied a bed in the ICU (bed occupancy rate of 80%) and 1470 (81.6%) patients were hospitalized for over 48 hours.

Table 1 illustrates the patients' characteristics.

Table 1. The characteristics of the 200 inpatients included in the prevalence survey

	Number of patients	Percentage	OR	(95% CI)	P
Age (year)					
< 30	22	10	1.16	1.01-2.4	< 0.001
30-50	54	27	1.35	1.13-3.12	
51-70	80	40	1.66	1.55-2.65	
> 70	44	22	1.23	1.02-1.66	
Gender					
Female	67	33.5	1.11	1.03-1.67	0.17
Male	133	66.5	1.74	1.55-2.02	
Length of hospitalization (days)					
< 5	12	6	1.02	1.02-1.43	< 0.001
5-8	29	14.5	1.32	1.24-1.77	
1.02 > 8	159	79.5	1.80	1.66-2.4	
Immune deficiency					
Yes	45	22.5	1.34	0.93-1.56	< 0.001
No	151	77.5			
Surgery					
Yes	156	78	1.56	0.8-1.9	< 0.001
No	44	22			
Intravascular catheter					
Yes	172	86	1.95	1.6-2.12	< 0.001
No	28	14			
Urinary catheter					
Yes	125	62.5	1.30	1.1-1.75	< 0.001
No	75	37.5			

OR: Odds Ratio; CI: Confidence intervals

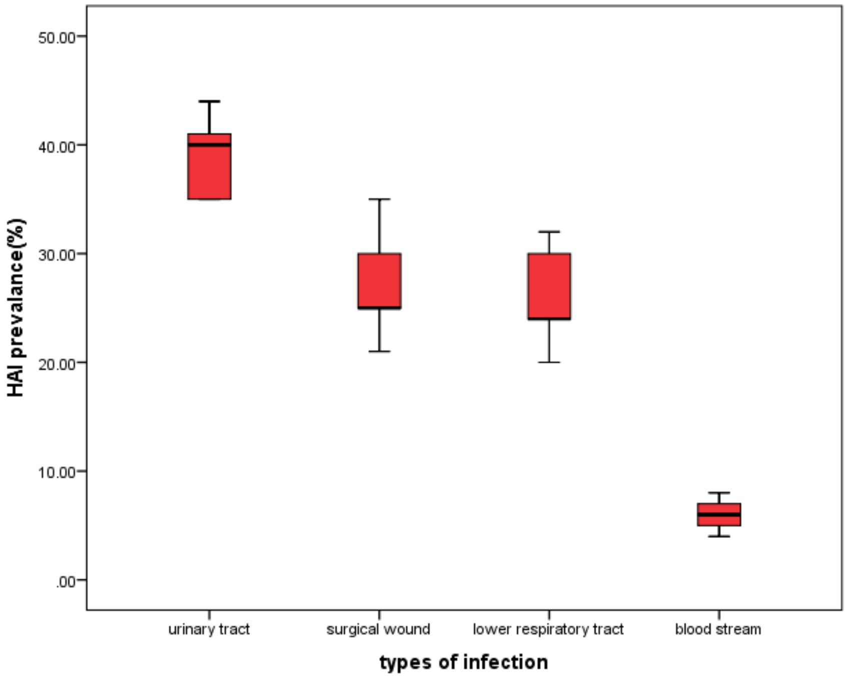

Figure 1. Box plot graph depicting hospital-acquired infection (HAI) prevalence (%) according to the type of infection

Among the 200 (13.6%) affected subjects surveyed in the study, 133 patients (66.5%) were men and 67 patients (33.5%) were women, and their ages ranged from 27 to 91 years with a mean ± SD age of 65 ± 10. In addition, 10% of patients were less than 30 years of age, whereas 22% were older than 70 years of age. The mean length of hospital stay from admission to the beginning of the study was 8 ± 0.7 days. Immune deficiency which was analyzed by taking blood samples from admitted patients and applying sequential analysis rates was reported in 22.5% (48 out of 200) of patients.

Overall, the prevalence of HAI was 13.7% (95% CIs: 13.5% to 13.8%). Figure 1 illustrates the prevalence of HAI as a function of infection type. The error bars obtained from the standard error analysis of HAI tests are also presented in this figure. The error bars of HAI prevalence rate for the points illustrated in the graph were ± 7.95% to ± 40.9%. Furthermore, in the case of blood stream infection, the bar overlapped with the corresponding point. As depicted in this figure, urinary tract infections showed the highest rate of frequency (40.9%), followed by surgical wound infection (26.1%), lower respiratory tract infection (25%), and bloodstream infection (7.95%), respectively.

The box plot graph of HAI prevalence rate as a function of the infectious microorganism type is given in figure 2. As depicted, 7 microorganisms were isolated in microbiological cultures. It clearly shows that Escherichia coli (35.6%) and Staphylococcus aureus (26%) were the predominant species responsible for HAI, followed by Klebsiella pneumoniae (15%), Proteus mirabilis (12.3%), Acinetobacter baumannii (5.47%), Candida utilis (2.73%), and Pseudomonas aeruginosa (2.68%).

Previous studies have shown that the prevalence of HAI differs markedly between communities.[6] Our investigation revealed a nosocomial infection prevalence of 13.65%. This rate is much higher than the mean HAI prevalence rate (approximately 8 %) observed in almost all other studies related to developed countries.[10,11] This result is, however, in a good agreement with those obtained by studies in other developing countries.[12-14]

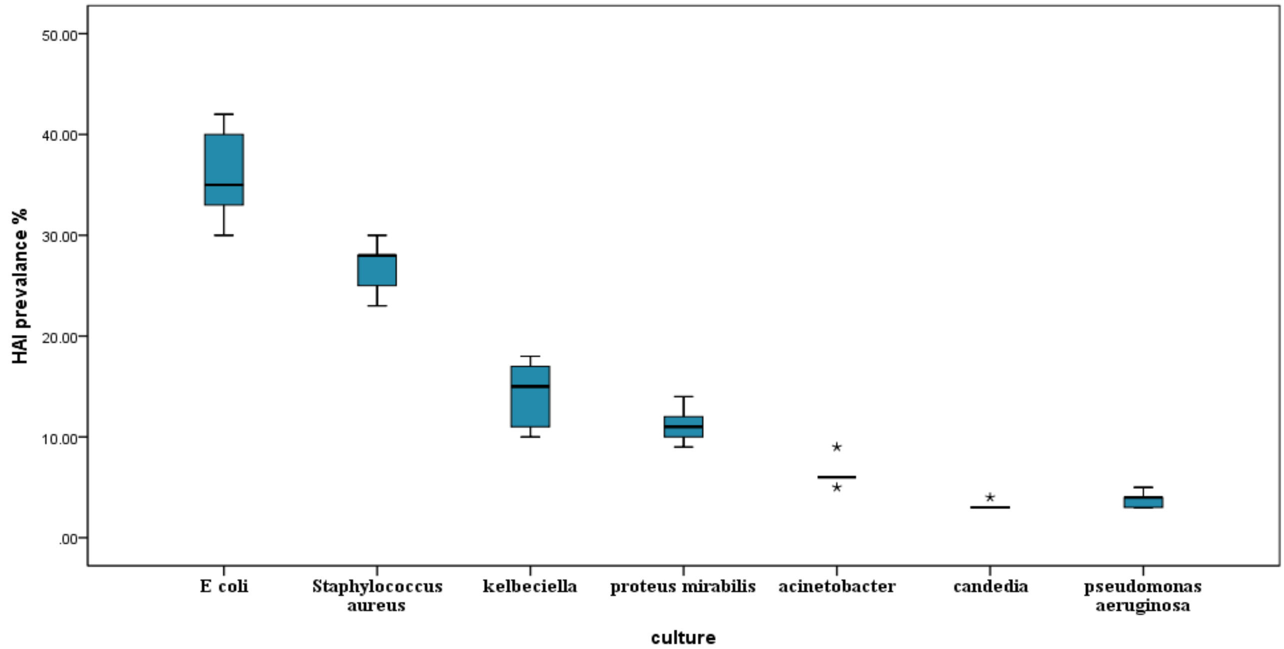

Figure 2. Box plot graph depicting hospital-acquired infection (HAI) prevalence based on the type of organisms

A possible explanation for these results may be the lack of adequate infection control programs and high occupancy rate (90%). The most frequently infected sites were the urinary tract (40.9%) and surgical wounds (26.1%). These results are consistent with those of other studies and suggest the importance of the strong association between urinary tract infection and urinary catheter. The rate of bloodstream infection was much lower than other HAIs (7.95%). The Iranian health system includes comprehensive instructions and guidelines for the prevention of nosocomial infections. Thus, a possible explanation for the high prevalence of HAI in our study may be the failure in execution of those guidelines. Another possible explanation for this is that the examined hospitals are teaching institutions to which complex surgical cases are referred.[15] Based on the results released by the National Nosocomial Infections Surveillance on 100 hospitals with more than 200 beds each and6,616,520 studied patients between 2007 and 2010, urinary tract infections (28.9%), pneumonia (28%), surgical site infections (26.8%), and bloodstream infections (16.4%) were the main cause of HAI in Iran. HAIs were the most prevalent in burn wards, followed by ICUs, and hematology/oncology wards.[16,17] The overall mortality rate among patients with HAIs was 14.8%. The majority of these mortality cases (41.66 %) occurred in the age group of more than 50 years, followed by the age group of 30 to 50 years (27%) and less than 30 years (10%). It seems possible that these results are due to the role of the immunity system in the control over or development of infections. According to a literature review of national or multicenter studies published from 1995 to 2008, the overall prevalence of HAI in developed countries varies between 5.1% and 11.6%. However, based on studies conducted in health-care settings in developing countries, HAI rates were noticeably higher than those in developed communities.[18-20]

In developing countries, prevalence rates in hospitals fluctuate between 5% to 19%, but most studies report values higher than 10%.[21] In a survey conducted by Zahraei et al., urinary tract infection was the most prevalent type of infection (32.2%) and bloodstream infection was the least prevalent (16.3%).[22]

Regarding gender, this study found that men (66.5%) were infected more than women (33.5%); however, the statistical analysis showed no significant differences between men and women. As supported by the data in table 1, the length of hospital stay is positively associated with HAI. Infection rate was at its minimum (6%) when preoperative hospital stay was less than 5 days and maximum (94%) when preoperative hospital stay was longer. A possible explanation for this might be that longer hospitalization increases colonization in patients with nosocomial strains of bacteria which are most resistant to antibiotics, and also it indirectly increases infection rate by lowering patients' resistance. With the increasing of the preoperative hospital stay to more than 8 days, HIA prevalence increased significantly. The observed correlation between the long length of hospitalization, surgery, and invasive devices and increased risk of HAI shows the importance of infection control measures. According to the results of the present study, the most common pathogenic agents were Escherichia coli (35.6%) and Staphylococcus aureus (26%). This finding is in agreement with the results of the studies which reported Staphilococcus aurues, Klebsiella, and E. Coli as the main organisms causing HAIs.[23,24] These commensal bacteria may cause infection if the natural host is compromised. Cutaneous Staphylococci result in intravascular line infection and intestinal Escherichia coli is the most common cause of urinary infection.[6]

The Kruskal-Wallis test results concerning the effects of seasonal variation on infection incidence in the studied hospitals during 2012-2014 are presented in table 2 and figure 3. Error analysis for the results of HAIs presented in figure 3 was performed on the basis of the standard error of the infection tests and season analysis. The error is also presented in figure 3 in the form of an error bar. As can be seen, during spring, a very high prevalence of HAI was observed (mean prevalence: 24%), while the infection prevalence declined sharply from spring to winter. Evidently, HAI occurrence is very common during spring.

Table 2. Kruskal-Wallis test of HAI in various seasons

	Number of seasons	Mean ± SD	Minimum	Maximum	P
HAI prevalence (%)	12	25.75 ± 16.44	4	54	0.016

SD: Standard deviation

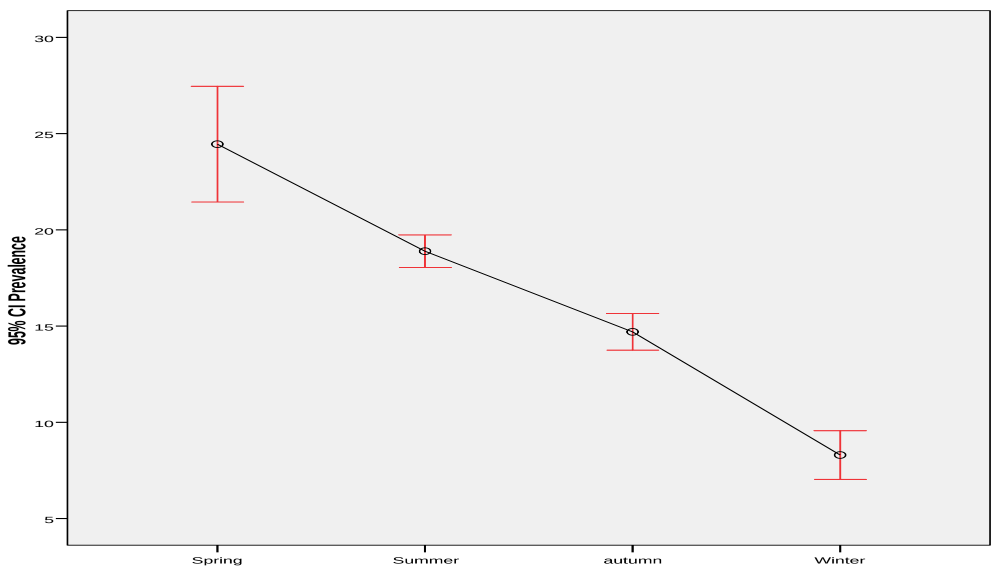

Figure 3. Hospital-acquired infection (HAI) prevalence (%) in each season

The rate of infection was greatly influenced by patient characteristics of age and immunodeficiency, as specified by univariate analysis, and patients of more than 50 years of age experienced an increased rate of infection. However, gender had no effect on the rate of infection (Table 1). Moreover, extrinsic factors associated with HAI were long duration of hospitalization (> 8 days), undergoing surgery, and exposure to intravascular and urinary catheter.

Seasonal variation in the incidence of infectious diseases is of great importance for epidemiologists and clinicians who deal with these diseases.[25] In our study, the peak of HAI was observed in spring. Summer and autumn also showed higher rates of total HAI. Table 2 shows that the seasonal differences were statistically significant. From these results, it can be concluded that contrary to common belief, winter with low temperature is not the main cause of HAI. We do not have a convincing explanation for the peak in HAI prevalence in spring in spite of the higher number of patients hospitalized in the ICU during winter. This result matches those observed in the study by Kim et al.[26]

Conclusion

In summary, the prevalence of HAI was high in some governmental hospitals in Tehran. In our study, HAI was more prevalent in spring; however, more research needs to be undertaken on this topic before the association between the seasons and HAI can be more clearly understood. In this study, ORs were used to compare the relative odds of the occurrence of HAI, given the variables of general interest (age, gender, and length of hospitalization). With regards to age, the odds of HAI in 51-70 year-olds was higher (OR 1.66, 95% CI: 1.5–2.6) and was statistically significant ($P < 0.001$). Furthermore, the length of hospitalization was another contributor to HAI, as an OR of 1.8 (95% CI: 1.6–2.4) was attributed to longer hospitalizations. Overall, in order to avoid HAI, the length of hospitalization should be shortened when possible and comprehensive surveillance and prevention measures must be undertaken by the Infection Control Committee like a practical HAI prevention guide provided by the WHO.

Limitations

Our prevalence survey was conducted in 3 public hospitals with the focus on ICUs; hence, its findings are not transferable to other wards or hospitals. Moreover, due to the rules of hospitals, their names were omitted from the paper. The prevalence of HAI can also be largely affected if there happens to be an outbreak of infection at the time of the survey, and this has to be considered when interpreting the data.

Conflict of Interests

Authors have no conflict of interests.

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