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Point prevalence and risk factors of hospital acquired infections in a cluster of university-affiliated hospitals in Shiraz, Iran

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Summary
Background: Hospital-acquired infections (HAIs) are critical and mostly preventable complications that occur in hospitalized patients and lead to major health and economic burdens. Most of the information on HAI risk factors and the recommended preventive measures is based on data acquired from only a few countries. The aim of this point prevalence HAI study conducted in Shiraz, Iran, was to study the local epidemiology of HAIs and the major risk factors for acquiring HAIs in a Middle-Eastern region.
Methods: The study employed four identical point prevalence surveys in eight university hospitals, each consisting of 60—700 beds. The study was conducted during all four season of 2008—2009. All of the patients admitted for ≥48 h were studied, although the patients admitted to emergency wards were excluded. A standardized data collection form that included name, age, gender, presence or absence of HAI, administration of any antibiotics, insertion of a central line, use of an endotracheal tube, mechanical ventilation, and use of an urinary catheter was completed for each patient. The HAI definitions used in this study were based on the US National Nosocomial Infection Surveillance (NNIS) guidelines.
Results: Data from 3450 patients were prospectively collected and analyzed. The overall HAI prevalence was 9.4%. The most common HAIs were blood stream infections (2.5%), surgical site infections (2.4%), urinary tract infections (1.4%), and pneumonia (1.3%). A logistic regression analysis showed that the odds ratio OR for males rather than females acquiring infections was 1.56 (95% confidence interval [CI] 1.21—2.02). Other HAI risk factors included using a central intravascular catheter, adjusted OR of 3.86 (95% CI 2.38—6.26), and using an urinary catheter, adjusted OR

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of 3.06 (95% CI 2.19—4.28). Being admitted to an ICU was not an independent HAI risk factor. For all HAIs, the OR of acquiring infection was 3.24 (95% CI 2.34—4.47) in the patients with hospital stays longer than eight days. A high discrepancy between HAIs and antibiotic use was observed. Antibiotics were administered to 71% of the patients, but only 9.4% of the patients also had at least one documented infection.
Conclusion: This point prevalence study showed that HAIs are frequent in Shiraz university hospitals, and that the proportion of patients receiving antibiotics is high. The results imply that more primary prevention efforts are necessary to address HAIs associated with using indwelling devices and to prevent surgical site infections.

Introduction

Hospital acquired infections (HAIs) are one of the most critical complications in hospitalized patients and are responsible for major health and economic burdens [1]. HAIs double the medical care costs of infected patients [2], and it is estimated that 80% of all hospital deaths are directly or indirectly related to HAIs [3]. Recent studies conducted at multiple locations worldwide have reported HAI prevalences ranging from 4% to 47% [4—15].

Epidemiological data support the position that HAI risk is associated with multiple variables (e.g., patient's age, pre-existing underlying disease, length of hospital stay, an immune-compromised state, and the presence of invasive medical devices, such as urinary catheters, central lines, and ventilation) and that HAIs can be prevented through adequate preventative measures [3]. A point prevalence study of HAIs in Saudi Arabia demonstrated a 12.7-fold increased risk associated with a hospital stay exceeding eight days [10]. A prospective study conducted in Slovenia identified the presence of central and peripheral vascular catheters, urinary catheters and admission to intensive care units as significant risk factors [16].

Surveillance has been accepted as a primary element of preventing and controlling HAIs. Although continuous prospective surveillance for HAIs is the gold standard, this approach requires comprehensive resources. Therefore, point prevalence surveys are preferred for determining the magnitude of HAIs in countries with limited resources. Such studies are inexpensive and do not require extensive resources [3].

Most of the information on HAI risk factors and the recommended preventive measures is based on data from a small number of countries, mainly from North America and Europe. Therefore, the aim of this point prevalence HAI study conducted in Shiraz, Iran, was to study the local epidemiology of HAIs and the major related risk factors for acquiring HAIs in a Middle-Eastern region. This study used the criteria of the Centers for Disease Control and Prevention's (CDC's) National Healthcare Safety Network (NHSN) [17] to define HAIs in a cluster of university-affiliated hospitals associated with the Shiraz University of Medical Sciences, Iran.

Materials and methods

The study was designed as a prospective point prevalence survey measured at four points, using an identical design and repeating the study design at identical settings. The data collection period for the survey was randomly determined by using a random number table to select 3-month intervals corresponding to the seasons, including the spring of 2008, summer of 2008, autumn of 2008, and winter of 2008/2009. The study was conducted during May—June 2008/August—September 2008/December 2008/February 2009 at eight university affiliated hospitals in Shiraz, Iran. The participating hospitals had 60—700 beds. These eight hospitals serve as referral hospitals for the southern region of Iran. All of the patients admitted for $\geq$48 h were studied, although patients admitted to the emergency rooms were excluded. All of the patients were visited at least once a day. A history and physical examination were conducted for each patient, and all of the laboratory results and medical charts were reviewed carefully. If necessary, interviews with the treating physicians were conducted. If the laboratory data or medical records were not available, the ward and patients were visited again and the data collection form was completed. The data collection form included name, age, gender, chart number, name of the hospital, name of the ward, date of admission, medical diagnosis of the patient, administration of antibiotics, presence of a fever, use of a central or peripheral intravascular line, use of an endotracheal tube, mechanical ventilation, and the use of a Foley or any other urinary catheter.

The patients that had a blood-stream infection, ventilator-associated pneumonia, a surgical site infection, an urinary tract infection or any other hospital acquired infection were investigated in further detail. An infection was defined to be hospital-acquired using the NHSN definitions [17]. All HAIs were considered when calculating prevalence and ranking, even if one patient had two or more infections. When calculating risk factors, however, only the first HAI occurring in a patient was considered. When calculating odds ratios (ORs) to assess the associated risk factors, the patients with HAIs were compared to matched (age, gender, admission date, ward, and underlying disease) patients without HAIs who were identified on the same day and at the same facility.

Statistical analysis

The data were analyzed by SPSS for windows version 11.5. Percentages were compared using the Chi-square test and means were compared using Student's *T*-test. The variables with *P*-values $\leq$0.05 in the univariate tests were further analyzed in a multivariate analysis using a multiple logistic regression model. Maximum likelihood estimates of odds ratios with their 95% confidence intervals were calculated. A *P*-value of <0.05 was regarded as a statistically significant difference.

Results

General patient characteristics

During the 4 point prevalence survey periods, a total of 323 HAIs were identified among 3450 patients (9.4%). A total of 1701 male and 1742 (50.6%) female patients were investigated for the presence of HAIs. The ages of the patients ranged from less than 1 month to 90 years (median = 32 years). The mean age was 35.3 ± 23.7 years among the males and 33.2 ± 20.4 years among the females. No statistically significant seasonal differences in prevalence were observed between the four investigated seasons (chi = 4.93, 3 df, *P* = 0.177; Table 1).

The most frequent HAIs were blood stream infections (BSI, 2.5%), surgical-site infections (SSI, 2.4%), urinary tract infections (UTI; 1.4%), and pneumonia (PNEU; 1.3%). A high prevalence of HAIs was observed in medical (non-surgical) ICUs (28.9%, 22/76 patients diagnosed with HAIs) and burn units (37.5%, 38/63 patients diagnosed with HAI). The absolute numbers and prevalence rates of all HAIs among the patients, stratified by medical specialty and level of care are shown in Table 2.

Risk factors

The distribution of the main HAI subgroup (BSI, SSI, UTI and PNEU) was significantly different between the male and female patients (Table 3). The HAI prevalence was higher in the male than in the female patients (males = 11.8%, females = 7%). Hospital-acquired UTIs were found in 5.4% (31/544) of the patients with a urinary catheter. Hospital-acquired pneumonia was reported in 9.8% (24/222) of the intubated patients, and 14.2% (36/218) of patients with a central vascular line had hospital-acquired BSIs.

The multiple logistic regression model for HAIs showed that the presence of an urinary catheter, an intubation tube, an intra-vascular line and a hospital stay of more than 8 days were significantly associated with HAI incidence ($P \leq 0.05$). After correcting for confounders in the multiple logistic analysis model, the most important risk factors for hospital-acquired UTIs were the presence of an urinary catheter and an extended hospital stay ($P \leq 0.001$). For pneumonia, the most relevant factors were intubation and ventilators

Table 1 Prevalence of HAIs during the four study seasons.

Date	Total number of patients	No infection No (%)	UTI No (%)	SSI No (%)	PNEU No (%)	BSI No (%)	Other HAIs No (%)
Spring	956	869 (90.9)	10 (1.0)	25 (2.6)	12 (1.3)	21 (2.2)	19 (2.0)
Summer	909	813 (89.4)	14 (1.5)	22 (2.4)	13 (1.4)	28 (3.1)	19 (2.1)
Autumn	853	768 (90.0)	17 (2.0)	22 (2.6)	14 (1.6)	19 (2.2)	13 (1.5)
Winter	732	677 (92.5)	7 (1.0)	14 (1.9)	7 (1.0)	18 (2.5)	9 (1.2)
Total	3450	3127 (90.6)	48 (1.4)	83 (2.4)	46 (1.3)	86 (2.5)	60 (1.7)

UTI, urinary tract infection; BSI, bloodstream infection; SSI, surgical site infection; PNEU, pneumonia; HAI, hospital acquired infection; Chi-square (χ^2) = 4.93, 3 df, (*P* = 0.177).

Table 2 Prevalence of HAIs stratified by medical specialty.

Clinical unit	Total infections No (%)	UTI No (%)	SSI No (%)	PNEU No (%)	BSI No (%)	Other HAIs No (%)
Surgical	479 (93.9)	9 (1.8)	13 (2.5)	3 (0.6)	5 (1)	1 (0.2)
Internal medicine	458 (92.7)	8 (1.6)	4 (0.8)	4 (0.3)	19 (3.8)	1 (0.2)
Surgical ICU	236 (82.8)	6 (2.1)	11 (3.9)	12 (4.2)	15 (5.3)	5 (1.8)
Medical ICU	54 (71.1)	4 (5.3)	2 (2.6)	10 (13.2)	6 (7.9)	0 (0.0)
Pediatric	249 (96.1)	1 (0.4)	3 (1.2)	0 (0)	5 (1.9)	1 (0.4)
Pediatric ICU	30 (93.8)	1 (3.1)	0	0	1 (3.1)	0
CCU	98 (89.9)	6 (5.5)	0	2 (1.8)	2 (1.8)	1 (0.9)
N ICU	172 (81.5)	1 (0.5)	1 (0.5)	8 (3.8)	16 (7.6)	13 (6.2)
Pediatric surgery	61 (88.4)	2 (2.9)	4 (5.8)	0	1 (1.4)	1 (1.4)
Transplant	85 (97.7)	0	0	0	2 (2.3)	0
Dermatology	35 (97.7)	0	0	0	0	1 (2.8)
OB & GYN	401 (96.4)	0	6 (1.4)	0	7 (1.7)	2 (0.5)
Orthopedic	345 (89.4)	4 (1)	31 (8)	1 (3)	2 (0.5)	3 (0.8)
Neurosurgical	113 (90.4)	1 (0.8)	6 (4.8)	3 (24)	1 (0.8)	1 (0.8)
Rehabilitation	28 (93.3)	0	0	2 (6.7)	0	0
Ophthalmology	51 (96.2)	0	1 (1.9)	0	0	1 (1.9)
ENT	61 (98.4)	0	0	0	0	1 (1.6)
Psychiatric	108 (100)	0	0	0	0	0
Burns	63 (62.4)	5 (5)	1 (1)	0	4 (4)	28 (27.7)
Total	3127 (90.6)	48 (1.4)	83 (2.4)	46 (1.3)	86 (2.5)	60 (1.7)

UTI, urinary tract infection; BSI, bloodstream infection; SSI, surgical site infection; PNEU, pneumonia; HAI, healthcare associated infection; ICU, intensive care unit; OB, obstetrics; GYN, gynecology; ENT, Ear-, Nose-, Throat. Chi-square (χ^2) 0 342.39; 72 df, ($P \leq 0.001$).

Table 3 Prevalence of HAIs stratified by gender.

Gender	No infection No (%)	All infections No (%)	UT I No (%)	SSI No (%)	PNEU No (%)	BSI No (%)	Other HAIs No (%)
Female	1620 (93)	122 (7)	16 (0.9)	33 (1.9)	16 (0.9)	33 (1.9)	24 (1.4)
Male	1500 (88.2)	201 (11.8)	32 (1.9)	50 (2.9)	30 (1.8)	53 (3.1)	36 (2.1)
Total	3120 (90.6)	323 (9.4)	48 (1.4)	83 (2.4)	46 (1.3)	86 (2.5)	60 (1.7)
P-value		≤0.0001	0.016	0.046	0 0.031	0.022	0.098

UTI, urinary tract infection; BSI, bloodstream infection; SSI, surgical site infection; PNEU, pneumonia; HAI, hospital acquired infection. $\chi^2 = 24.25$, 5 df, ($P \leq 0.001$).

and an extended hospital stay. The presence of an intra-vascular line and intubation were associated with hospital acquired BSIs. The associations between different HAI risk factors and HAI incidence observed in the multiple logistic regression analyses are shown in Table 4.

Antibiotic use

Administration of antibiotics was noted in 70.9% (2446/3450) of the surveyed patients. However, only 9.4% (323/3450) of the surveyed patients also had at least one documented infection. The treating physicians were asked about their reasons for administering antibiotics in 2123 of the remaining patients and they either stated that the patients were given antibiotics for prophylactic reasons or no clinical justification for administering antibiotics could be given. Furthermore, in those patients that were given antibiotics for prophylactic reasons, the classes of antibiotic and the durations of therapy were appropriate for treatment rather than infection prophylaxis regimens.

Antibiotic use was high among most of the medical services and most frequent in the ICUs (88.7% of the patients [522/588]).

Discussion

To our knowledge, the results presented in this manuscript represent the largest prospectively collected point prevalence study of HAIs conducted in Iran to date. Data from a total of 3450 patients were

Table 4 Multiple logistic regression results for HAI incidence and various risk factors.

Risk factor	No (%)	Odds ratio	*P*-value (95% CI)
All infections	323		0.001
Male	201 (11.8)	1.562	(1.21–2.017)
Female	122 (7)	1	
Urinary catheter			
All infections			≤0.001
Yes	133 (23.1)	3.059	(2.185–4.282)
No	190 (6.6)	1	
UTI			≤0.001
Yes	31 (5.4)	12.17	(6.009–24.6)
No	17 (0.06)	1	
Intubation			
All infections			0.016
Yes	74 (30.1)	1.742	(1.107–2.741)
No	249 (7.8)	1	
PNEU			0.017
Yes	24 (9.8)	3.014	(1.215–7.477)
No	22 (0.07)	1	
BSI			0.006
Yes	29 (11.8)	2.755	(1.335–5.683)
No	57 (1.8)	1	
Length of hospital stay			
All infections			≤0.001
<8 days	125 (5.3)	1	
8–13 days	75 (16.1)	3.4	
>13 days	123 (20.8)	4.40	(3.350–5.950)
UTI			≤0.001
<8 days	20 (0.8)	1	
8–13 days	11 (2.4)	3.004	(1.397–6.459)
>13 days	17 (2.9)	3.628	(1.815–7.252)
BSI			≤0.001
<8 days	26 (1.1)	1	
8–13 days	22 (4.7)	3.597	(1.977–6.545)
>13 days	38 (6.4)	4.548	(2.663–7.766)
Intra vascular line			
All infections			
No	46 (3.9)	1	
Peripheral	203 (10.1)	1.989	≤0.001 (1.403–2.820)
Central	73 (28.7)	3.861	≤0.001 (2.380–6.264)
BSI			
No	6 (0.5)	1	
Peripheral	44 (2.2)	3.075	0.012 (1.286–7.353)
Central	36 (14.2)	17.119	≤0.001 (6.423–45.624)
Age group			
All infections			≤0.001
≤18 years	42 (16.5)	1	
19–49 years	179 (7.8)	0.356	(0.217–0.584)
≥50 years	102 (11.6)	0.393	(0.231–0.669)

UTI, urinary tract infection; BSI, bloodstream infection; SSI, surgical site infection; PNEU, pneumonia. The maximum likelihood estimates for the odds ratios and their 95% confidence intervals (95% CI) and likelihood ratio tests for significant associations (*P*-values) were computed using logistic regression.

included in this study. Only a few systematic studies on HAI frequency have been conducted in Iran. Most of those studies used different methodologies, conducted incidence vs. prevalence studies, investigated different patient populations, and used different case definitions for the HAIs in question, which makes comparing the results difficult.

A study similar to the current study was conducted in Iran in 2004 (the first time that such a study was conducted in Iran). The prevalence reported in that study [15] was moderately higher than the 9.4% prevalence reported here. However, the 2004 study considered only three HAIs (UTI, SSI, and BSI) and did not study the associated risk factors [15].

The 9.4% HAI prevalence reported in this study is high compared to the published results from other recently conducted national HAI surveys from other countries, which have ranged between 4% and 8% [5—8]. Furthermore, our study showed a high number of young patients diagnosed with HAIs. These differences can be explained by the mean age of the Iranian population being low (28 years) [18].

Point prevalence studies are performed by investigating a defined population over one day or other short time period. Therefore, the results obtained from studies using identical hospitals and similar designs can differ by the season of the year and the number of patients admitted to each ward (the ''patient load'') [10]. To avoid this problem, we conducted our survey using an identical study design at each of the four different seasons so that we could evaluate the effects of the four different weather conditions and of different patient loads. Although we carefully controlled for possible seasonal influences in the HAI frequency, our final analysis showed no significant differences between the four seasons. Seasonality certainly plays a role in the frequency of certain infection, such as influenza [19], malaria [20,21], or rotavirus gastroenteritis [22]. Although few studies have investigated the association of seasonal climate effects, some have been able to show an influence on the frequency of SSIs [23] or device related infections, such as central venous catheter related BSIs [24].

The most common HAI observed in our survey was BSI. This finding is consistent with the results from a study conducted in Saudi Arabia [13], but is inconsistent with the results of the prevalence study conducted in Shiraz in 2004 [15]. The high BSI frequency found in the present study may be explained by the presence of multiple risk factors related to BSI, such as the high prevalence of intravascular lines in the investigated wards (surgical, medical and pediatrics) and the length of stay of the patients at the university hospitals in Shiraz.

Admission to an ICU was not an independent HAI risk factor in the multiple logistic regression analysis. This finding may have been due to not measuring independent risk factors in the patients who were not in ICUs or to the relatively high exposures of non-ICU patients to invasive procedures, such as central lines, Foley catheters and endotracheal intubation. Situations where non-ICU patients are subjected to more invasive medical procedures than ICU patients are unusual and are in contrast to most of the published literature [10,15,16,25].

Similar to the results reported by other studies [10,16], however, we also found significant differences by sex. The odds of experiencing an HAI were higher in male patients than in female patients, particularly for UTI and pneumonia, but no gender difference was observed in the results of the prevalence study conducted in Shiraz in 2004. Simple regression analyses were first employed to identify the possible risk factors for acquiring infection, and these factors were then analyzed in a stepwise logistic regression analysis to eliminate confounding. This approach allowed us to show an association between a prolonged hospital stay (longer than eight days) and HAI incidence (mostly BSI or UTI). This association has been demonstrated in other published studies [8,13]. Moreover, the presence of intubation was a major risk factor for acquiring BSIs, along with pneumonia itself. Similar to other studies [13,25], the results of our study showed that invasive medical devices (urinary catheters, endotracheal tubes and intra-vascular lines) increase the risk of HAIs and require strict preventive measures to prevent and control infection.

Our study had some additional findings that were interesting in light of previously published work. A high HAI incidence was observed in medical ICUs; however, the observed HAI incidence among ICU patients (18%) was lower than the reported range of HAI rates in ICUs from other countries [5,10,16]. One explanation for this observation may be that most patients requiring intensive care are not admitted to ICUs but are cared for at medical wards because of limited ICU beds.

The most prominent result of this study was the high rate of antibiotic use (71%), which was among highest reported among studies with a similar design [5,26]. Most of the antibiotics were intended to treat or prevent HAIs. If a single NHSN HAI criterion, antibiotic use, were sufficient to identify an HAI, the HAI prevalence in our study would have been 71%. However, the high rate of antibiotic use we found was lower than the results reported from other Iranian studies conducted in the surgical wards of Shiraz hospitals in 2004 [27,28]. The highest rate antibiotic use was observed for the neonatal ICUs (94% of the patients [198/211]), and the lowest rates were observed for the cardiac care units [50% of the patients (47/94)] and the pediatric wards [63.5% of the patients (165/259)].

Our study has some limitations. First, the study was performed in multiple hospitals, but only university hospitals were included. Our results do not allow conclusions about the possible HAI incidences at private facilities. Second, although the data were prospectively collected, the study was not conducted longitudinally, and the cross sectional study design did not allow establishing causality between different factors; in particular, it was not possible to interpret which factor came first. Furthermore, one-day point prevalence studies tend to overestimate persistent infections and underestimate infections with shorter durations. Third, our study did not investigate the different risk factors leading to HAIs, such as underling disease, previous hospitalizations, surgical procedures, frequency of days before surgery, admission to the emergency ward and the need to perform invasive procedures under emergency conditions.

In conclusion, several results of this prevalence study are noteworthy. The prevalence of HAIs is high. Because HAIs represent an important public health problem in Iran, a crude baseline prevalence rate has been established, implying the urgent need for a nationwide HAI surveillance system. The high rate of BSIs and SSIs requires further investigation to identify their associated risk factors and the possible measures for preventing them. Finally, the prevalent misuse of antibiotics in the investigated facilities will lead to the development and spread of multi-resistant pathogens if the use of antibiotics is not controlled soon.

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Competing interests

None declared.

Ethical approval

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