ORIGINAL ARTICLE

Prevalence and risk factors of nosocomial infections in different wards and seasons in two hospitals in northeastern Iran

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ABSTRACT

The prevalence of nosocomial infections (NIs) is a significant health issue in developing countries, and the increased incidence rate of these infections results in longer hospital stays, more mental pressures, increased treatment costs, and higher antibiotic resistance. The present study aimed to evaluate the prevalence of NIs in two hospitals from 2011-2018. In total, 1123 patients with a history of NIs, as reported in the NIs surveillance systems of the hospitals, were included in the study. Data analysis was carried out by SPSS version 16 using Chi-square tests to evaluate the relationship between hospital wards, age, and gender. The prevalence of NIs was higher in the training hospital than in the social security hospital. Also, the prevalence of NIs decreased from 2011-2017 but has increased since 2018. The highest prevalence of NIs was related to E. coli (9.35%), with gram-negative bacteria having the highest frequency (36.2%). In addition, the most common location of NIs was the ICU (23.95%). In terms of the site of infection, postoperative infections had the highest prevalence (38.91%). The results were indicative of a significant relationship between mean age and various hospital wards. In addition, there was a significant relationship between the hospitalisation ward and gender. Meanwhile, no significant association was found between age and hospitalisation ward ($P<0.05$). There is a need for periodic training for all hospital-based agents to reduce NIs, especially in wards where invasive measures are used for treatment.

Key words: nosocomial infections, prevalence, epidemiology

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INTRODUCTION

Nosocomial infections (NIs) are one of the most critical health problems, as they affect hundreds of millions of people worldwide each year.[1-3] NIs are usually acquired after hospitalisation and manifest within 48-72 hours after hospital admission. In addition, NIs are caused by pathogens related to the infectious disease or its toxins that are typically not present or undergoing incubation at the time of admission [4]. The prevalence of NIs in high-income developed countries has been reported to be 6.3-12%. Meanwhile, the prevalence of the condition is 5.7-19.1% in developing countries with low-moderate income.[5,6] According to the results of a meta-analysis performed in Iran, the overall prevalence of NIs in Iran was 4.5%; *Klebsiella pneumoniae* was recognised as the most common cause of this type of infection.[7] Today, NIs are a major safety concern for the health system, patients, and their families. Due to the increased prevalence of NIs, patients stay in hospitals for longer and become more prone to pathogenic agents over time, which can result in antibiotic resistance in these individuals. On the other hand, NIs significantly contribute to morbidity and mortality while also imposing financial and socioeconomic burdens on patients, their families, and healthcare systems.[8,9]

Meanwhile, among pathogenic agents such as viruses, parasites, and bacteria, the latter are the most common pathogens responsible for Nis.[10] NIs are mainly caused by gram-negative bacilli; the most common infections included bloodstream infection (BSI), urinary tract infection (UTI), surgical site infection (SSI), and pneumonia (PNEU).[11] The agents that are usually involved in NIs included *Staphylococcusaureus*, *Pseudomo nas aeruginosa*, and *Escherichia coli*. According to reports, 22 patients per 1000 hospitalised patients are diagnosed with pneumonia and UTI.[12] The prevalence of NIs varies across the wards of a hospital, and up to 51% of NIs are reported in intensive care units (ICUs), compared to other hospital wards.[13] Surgical interventions are one of the most significant sources of NIs, with an incidence ranging from 1.2% to 23.6% of all surgical interventions.[14, 15]

Another variable that might affect NIs is the season. A previous study demonstrated that the incidence of NIs was higher in summer than in other seasons and increased as the temperature increased.[16] However, another study did not find a significant effect in this regard.[17] Determining the levels and types of NIs in various hospital wards, especially where invasive interventions are carried out, can help plan for strategies to control NIs and reduce the burden of complications that this factor causes for patients, their families, and community health systems. With this background in mind, the present study aimed to evaluate the prevalence and risk factors of NIs in various wards and seasons in two hospitals in north-eastern Iran from 2011-2018.

METHODS

Study Design, Population, and Location

This cross-sectional study is designed based on the STROBE protocol.[18] This study was conducted from January 2011 to December 2018 for a period of 8 years, using 1123 patients screened after more than 48 hours of admission, from various wards of 9-Dey and Razi hospitals, which are the largest hospitals in Torbat Heydariyeh county (with an area of 6,175 km^2 is located in Khorasan Razavi province in the Northeast of Iran (59° 12’ 58.12” E and 35° 16’ 47.43” N, (Figure 1)). These hospitals had 287 tertiary care beds in different health wards (CCU, ICU, NICU, Orthopedic, Pediatric, Surgery, Neurosurgery, Internal, Obstetrics and Gynecology and Infectious Diseases). The

9-Dey hospital is a 182-bed teaching hospital with 12 wards.

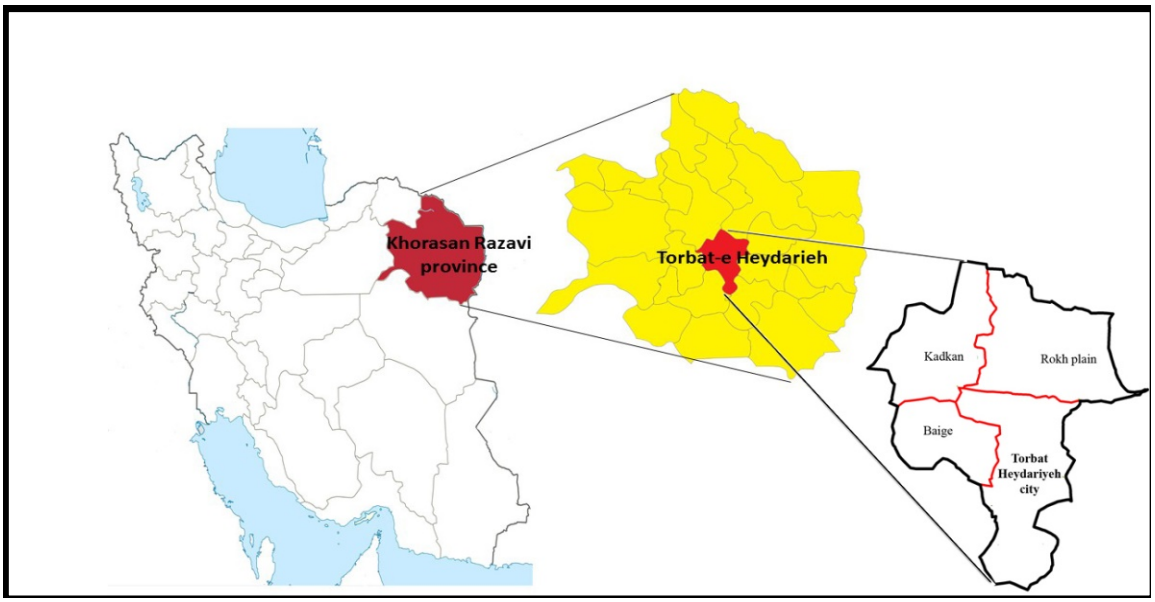

Figure 1 Study location of Torbat Heydariyeh County

Data collection and inclusion and exclusion criteria

NIs or healthcare-associated infections were diagnosed according to the Diagnostic Criteria for Nosocomial Infection issued by the original Ministry of Health of Iran and the Centers for Disease Control (CDC)[19]. A nosocomial infection was defined as at least one positive infection in patients hospitalised for more than 48 hours with signs or symptoms of infection. We collected secondary data on NI patients recorded by hospitals. Data collected included patients' demographic characteristics (age and gender); hospital length of stay (LOS); date of admission (day, month, and season); hospitalisation ward; cause of admission; gastrointestinal surgery; central venous catheter (CVC) use; and type of organism. Patients with incomplete data for each variable were excluded or considered as missing data. Patients infected <48 hours after admission and patients in emergency, dialysis and maternity wards were also excluded. In addition to outpatients, monitored patients and patients with clear signs of infections at admission were excluded. The inclusion criteria were hospitalisation for more than 48 hours in one of the two investigated hospitals (9-Dey and Razi); no obvious signs of infection at admission; detection of criteria related to NIs 48 hours after admission; and the presence of symptoms and criteria related to BSI, laboratory-confirmed bloodstream infection (LCBI), UTI, and PNEU in admitted patients. NI-related data were obtained, and patients with UTI, PNEU, BSI, SSI and device-associated infections (DAIs), which are a subset of the four main infection groups, were included. Pathogens responsible for NIs were mentioned in previous studies.[10]

Statistical Analysis

Statistical analyses were performed using SPSS 18.0 (IBM Corp., Armonk, NY, United States). The frequency and

percentage (%) were used for qualitative data analysis and the mean and mean ± SD ($\bar{x}$ ± SD) or medians for quantitative data analysis. Qualitative and categorical variables were compared using χ^2 or Fisher's exact test or continuity correction, as appropriate. Two-sided p-values less than 0.05 were considered statistically significant.

RESULTS

In total, the data of 1123 patients hospitalised in the hospitals of Torbat Heydariyeh with confirmed NIs were recorded from 2011-2018. Among them, 806 were in the 9-Dey Hospital and 317 were in Razi Healthcare Center (social security) (Table 1). According to the results, 60.3% and 62.8% of admitted patients in both 9-Dey Hospital and Razi Healthcare Center were males and females, respectively. The reported infection ages for male and female patients were 46.86±28.1 and 42.73±27.0, respectively. The results were indicative of a higher NI prevalence in 9-Dey Hospital (1.05%) than at Razi Healthcare Center (0.73%) (Figure 2).

Table 1 The frequency of NIs based on the year and hospitalization ward

Hospitalization Ward	Years/Percent							
	2011	2012	2013	2014	2015	2016	2017	2018
CCU	1 (2.1)	1 (2.1)	3 (6.4)	6 (12.8)	3 (6.4)	10(21.3)	11(23.4)	12 (25.0)
ICU	21(6.7)	10 (3.2)	20 (6.4)	17 (5.4)	18 (5.8)	23 (7.4)	70(22.4)	115(36.9)
NICU	3 (2.6)	4 (3.5)	12(10.4)	16(13.9)	20(17.4)	12(10.4)	29(25.2)	11(9.6)
Orthopedic	4(5.4)	12(16.2)	18(24.3)	11(14.9)	7(9.5)	6(8.1)	6(8.1)	8(10.8)
Pediatric	0(0)	0(0)	0(0)	2 (15.4)	2 (15.4)	1 (7.7)	6 (46.2)	2 (15.4)
Surgery	0(0)	1 (6.0)	9 (5.5)	14 (8.5)	32(19.4)	31(18.8)	33(20.0)	35(21.2)
Neurosurgery	1(3.0)	0(0)	1(3.0)	1(3.0)	2(6.1)	3(9.1)	10(30.3)	14 (42.4)
Internal	3(2.2)	4(2.9)	2(1.4)	9(6.5)	9(6.5)	16(11.6)	35(25.4)	47(34.1)
Obstetrics and Gynecology	2(1.3)	0(0)	11(7.0)	17(10.8)	21(13.3)	24(15.2)	21(13.3)	58(36.7)
Infectious Diseases	5(7.4)	10(14.7)	2(2.9)	3(4.4)	8(11.8)	5(7.4)	14(20.2)	17(25.0)

ICU: Intensive Care Unit, CCU: Critical Care Unit, NICU: Neonatal Intensive Care Unit

Table 2 The frequency of patients stratified by pathogen category in valid data

Type of pathogens	Season frequency (percent)			
	Winter	Spring	Summer	Autumn
Klebsiella	22(7.46)	21(7.47)	12(4.56)	23(8.1)
Citrobacter	8(2.71)	8(2.85)	8(3.04)	5(1.76)
Pseudomonas aeruginosa	23(7.8)	22(7.83)	17(6.46)	18(6.34)
Acinetobacter	8(2.71)	4(1.42)	1(0.38)	5(1.76)
Enterobacter	12(4.07)	10(3.56)	17(6.46)	14(4.93)
E. coli	33(11.19)	18(6.41)	23(8.75)	31(10.92)
Staphylococcus aureus	13(4.41)	2(0.71)	6(2.28)	8(2.82)
Staphylococcus epidermidis	18(6.1)	13(4.63)	14(5.32)	12(4.23)
Other [a]	158(53.56)	183(65.12)	165(62.74)	168(59.15)
Total	295(100)	281(100)	263(100)	284(100)

[a]: Other, this item includes up to 24 species of pathogens such as Klebsiella pneumoniae, Candida albicans, Serratia marcescens, Proteus, Bacillus cereus, Enterococcus and so on.

According to the results, the most common causes of NIs in 9-Dey Hospital and Razi Healthcare Center were E. coli (17%) and Acinetobacter (15%), respectively. Overall, the highest NI prevalence was reported in the age range of 21-30 (15%), whereas the lowest NI prevalence rate was related to the age range of 61-70 (12%). In the mentioned hospitals, 36.2% and 12.6% of infections were caused by gram-negative and gram-positive bacteria, respectively, and the remaining cases had unknown causes. Furthermore, the most common causes of NIs were E. coli (9.35%), Pseudomonasaeruginosa (7.12%), Klebsiella (6.95%), and Staphylococcus epidermidis (5.08%). According to the results of the present study, E.coli (9.6%), Klebsiella (8.11%) and Pseudomonas aeruginosa (7.8%) had the highest frequencies in male subjects, while women were mostly infected by E. coli (9.05%), Pseudomonasaeruginosa (6.36%), and Klebsiella (5.6%).

In terms of the ward, most NIs occurred in ICUs (23.95%), internal wards (10.24%), and NICUs (6.3%) (Table 3). In this regard, most pathogenic agents in ICUs were Pseudomonasaeruginosa (18.21%) and Klebsiella (14.5%). In internal, NICU, and infectious diseases wards, the main bacteria causing Nis were E.coli (26.72%), Staphylococcus epidermidis (22.53%), and E. coli (31.70%). Regarding the site of infection, the most common infections were postoperative infections (38.91%), respiratory tract infection (PNEU) (30.28%), UTI (18.25%), septicemia (8.20%), and diseases of other organs (4.36%), respectively. The results regarding the frequencies of NIs in 9-Dey Hospital and Razi Healthcare Center from 2011-2018 are presented in Figure 2. Both hospitals show increasing trends from 2017-2018.

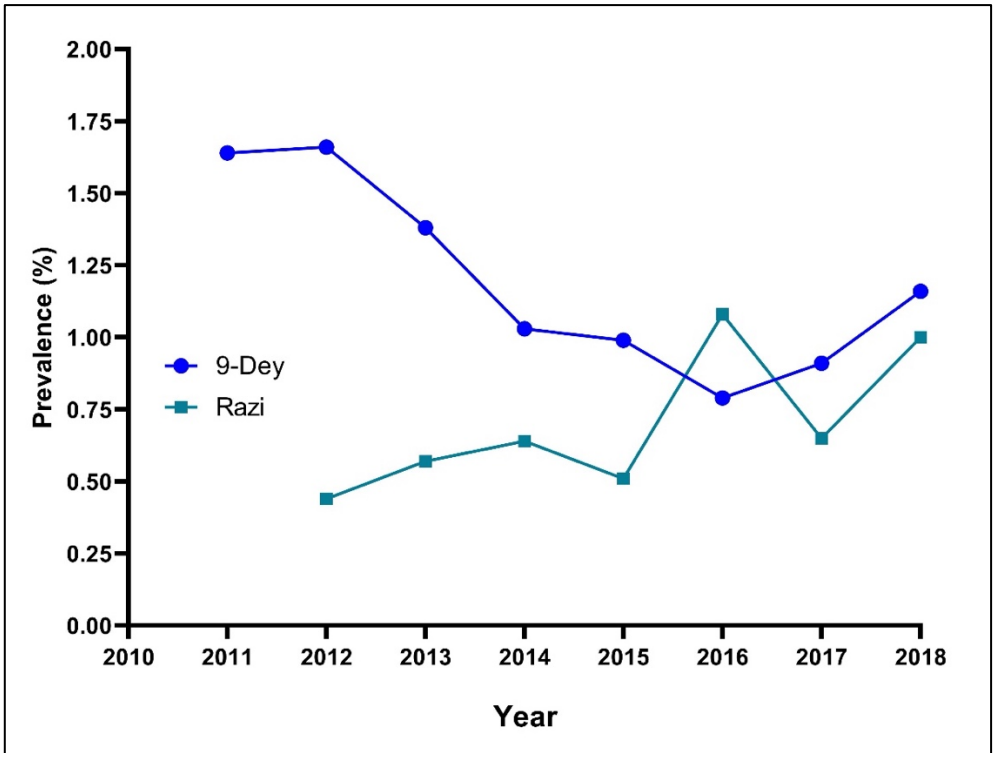

Figure 2 The Prevalence of NIs in 9-Dey and Razi hospitals during 2011-2018

According to the results of the frequency of NIs based on the season of the year, the majority of NIs occurred in winter (Figure 3). In addition, the frequency of NIs based on the year and hospitalisation ward are shown in Table 1. According to the statistical analysis results, there was no significant relationship between hospitalisation ward and age (categorised) ($P>0.05$). We also found a nonsignificant association between mean age and various hospital wards ($P>0.05$). Meanwhile, the Chi-square results showed a significant gender difference among patients admitted to various wards ($P<0.01$) (Table 3). The frequency of NIs based on seasons is shown in Table 4.

Table 3 The frequency of patients stratified by gender and hospitalization ward

Hospitalization Ward	Gender frequency (percent)		Chi-square test
	Male	Female	
CCU	29 (61.7)	18 (38.3)	P<0.01
ICU	208(66.7)	104 (33.3)	
NICU	58 (50.4)	57 (49.6)	
Orthopedic	58 (78.4)	16 (21.6)	
Pediatric	7 (53.8)	6 (46.2)	
Surgery	102 (61.8)	63 (38.2)	
Neurosurgery	18 (54.5)	15 (45.5)	
Internal	71 (51.4)	67 (48.6)	
Obstetrics and Gynecology	0	158 (97)	
Infectious Diseases	48 (70.6)	20 (29.4)	

Table 4 The frequency of patients stratified by gram category

Season	frequency (percent)		Gram-/ gram+
	gram – (%)	gram+ (%)	
Winter	115(70.12)	49(29.88)	2.35
Spring	105(77.21)	31(22.79)	3.39
Summer	84(73.04)	31(26.96)	2.71
Autumn	102(77.27)	30(22.73)	3.40

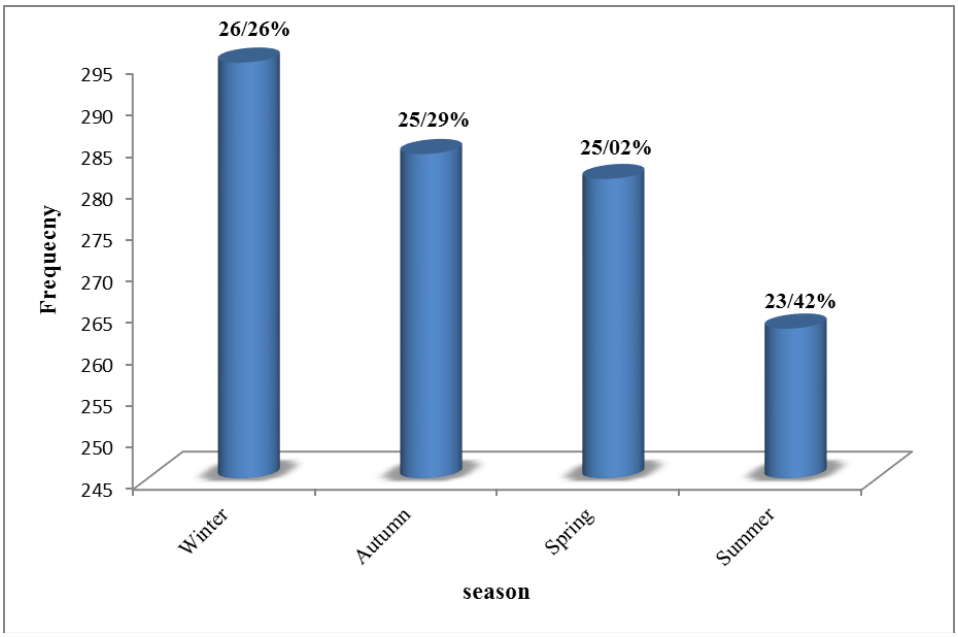

Figure 3 The Frequency of NIs based on the season of the year

DISCUSSION

NIs are among the most serious health problems worldwide, especially in developing countries. According to a World Health Organization (WHO) report, about 15% of all hospitalised patients experience NIs caused by the environment, ward, other infected patients, and healthcare providers.[10] According to previous studies, a person who is susceptible and exposed to various infections plays a crucial role in NI development.[20] Irrespective of their mortality rates, hospital-acquired infections are common and affect recovery time. In addition, NIs impose a major problem for patient safety and can increase the financial and non-financial burdens of healthcare systems in various countries.[21-23] These factors should be considered by medical and nursing teams, medical science researchers, and health managers.

Based on this perspective, we carried out the present research to determine the prevalence of NIs in hospitals and their risk factors. Moreover, NI prevalence decreased from 2011-2018 but then increased from 2018-2019.

In a previous study, Mohammadi et al. (2019) reported a prevalence of NIs in hospitals of Iran as 4.6%, signifying a decrease in this type of infection compared to previous studies (30.4%).[24] According to Behnke et al. (2017), the prevalence of NIs in Europe decreased from 5.1% in 2011 to 4.6% in 2016.[25] In this regard, the cause of the decreased prevalence of NIs is the increase in knowledge among medical staff about the causes of NIs, the spread of infections, and ways to prevent them.[26] On the other hand, infection control centres have been established in hospitals due to the importance of the issue and to decrease NI prevalence through specific plans.[27]

Age can be considered an important risk factor for the spread of NIs. The results of our study showed that the prevalence of NIs in the age range of 21-30 years is higher than in the age range of 61-70 years, which is consistent with the study of Tomczyk-Warunek et al. (2021).[28] However, Bochicchio et al. (2001) showed that the rate of NIs was directly related to age.[29]

This may be because health care workers are more responsible than older people and are more sensitive to complications in this age group.

The prevalence of NIs was highest in winter, which is consistent with the results obtained by Chen et al. (2020). They reported that the number of pathogenic agents in the air of the ward of cerebrovascular patients was significantly higher in winter than in spring and summer.[17] Moreover, Schwab et al. (2020) concluded that respiratory tract infections caused by Streptococcus pneumoniae were highest in winter, whereas BSI caused by gram-positive bacteria was most prevalent in summer due to increased bacterial activity caused by increased temperature.[30] In winter, the number of patients admitted to infectious wards increases because of the health problems associated with cold weather and the prevalence of respiratory diseases, which results in a higher spread of NIs in this season when compared to other seasons. On the other hand, pathogenic agents have various impacts depending on temperature, weather, and season. In other words, seasonality drives fluctuations in the probability of pathogen emergence.[31]

In our study, most NIs were caused by gram-negative bacteria, which is in line with other studies.[30, 32] The difference in the ratio of gram-positive to gram-negative bacteria could be attributed to the increased drug resistance of gram-negative bacteria.[33] In the current research, *E. coli* was reported as the most common pathogenic agent, which is congruent with the results obtained by Sang et al. (2017) and Mohammadi et al. (2019).[25,34] On the other hand, Staphylococcusaureus *and* Klebsiellapneu moniae have been cited as the most common cause of Nis.[7,30,35] Furthermore, Dhaliwal et al. (2000) identified Enterococcus, Staphylococcus, and Klebsiella as the microorganisms responsible for infections in women undergoing obstetric surgery.[36] Meanwhile, Nashibi et al. (2020) stated that the Escherichia coli was the most common pathogen, followed by coagulation-negative staphylococci, which could be due to differences in study populations and study locations.[37]

According to other results, the most common infection sites were SSI, PNEU, UTI, and septicemia. In addition, about half of all NIs were related to lung infection.[38, 39] In a study by Khan et al. (2017), the most prevalent infections were central and peripheral venous lines-related bloodstream infection, catheter-related bloodstream infection (CRBSI), SSI, and ventilator-associated pneumonia (VAP). Since these infections occur during patients' hospital stays, they can increase the hospitalisation period and lead to disability and heavy economic burden.[10] A comprehensive study showed that the most important NI sites in Iran were UTI, PNEU, BSI, and SSI.[7] According to another previous study, the most common NIs were SSI, UTI, and PNEU.[39]

In a study based on the data of the national NIs surveillance in Iran, the most commonly reported NIs were UTI (26.83%), VAP (20.28%), SSI (19.73%), and BSI (13.51%).[40] A study conducted in Ghana reported an overall prevalence of NIs of 8.2%. The most prevalent NIs were SSIs (32.6%), BSIs (19.5%), UTIs (18.5%) and VAP (16.3%).[23] In China, the most commonly reported NIs were lower respiratory tract infections (47.2%).[41] In a meta-analysis conducted in Iran, the highest prevalence of NIs was associated with BSIs (9%), pneumonia (7.1%), SSIs (4.4%), and UTIs (3.1%).[7] Another study stated that prolonged operation time was linked to an increased risk of organ infection.[42]

Given that the most prevalent NIs in the current research occurred in wards that carried out invasive treatments on patients, it appears that a lack of adherence to hygienic principles in these wards resulted in the transmission of infections from the environment and personnel to patients, thereby increasing the level of NIs,

especially secondary infections.[43] In a previously mentioned study, the most prevalent infection site was the ICU, and the most important pathogenic agent in this ward was Pseudomonas aeruginosa. The prevalence of NIs is two to five times higher in ICUs than in other wards.[44] Meanwhile, Vincent et al. (2009) reported that the highest NI prevalence was in surgical and orthopaedic care wards.[39]

The high prevalence of NIs in ICUs is due to issues such as nutrition disorders, instability in the level of consciousness, increased length of hospital stays, and a decrease in immune system function. Another reason is that the studied hospitals were mainly training centres, and the presence of students and residents in various wards could affect the increase of NIs in these centres. Therefore, the growing frequency of NIs and pathogenic agents in hospitals necessitates the need of paying more attention to this issue. In addition, since the causes of infection could be the environment, the ward, healthcare providers, or other patients,[10] conditions must be provided to prevent the spread of NIs through training and the use of specialists.

One of the main limitations of the present study was that the data were obtained from the national health system, which largely depends on the sensitivity and implementation of the NIs surveillance system in each hospital. Therefore, the information gathered cannot show all infections in various hospital wards. Other limitations were the small number of reports of infections and the lack of proper identification of NIs that occurred after discharge. Therefore, it is recommended that more accurate studies be carried out to identify more accurately different types of NIs.

RECOMMENDATIONS

Training teaching hospital staff by infection control specialists and experts should be considered in the prevention and control of NIs. In addition, planning and implementing knowledge improvement programs for physicians and nurses in infection control departments can significantly improve hospital reporting. It is also crucial to carry out preventive interventions in sensitive hospital wards with high NI rates.

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CONFLICTS OF INTEREST

This study had no influence on designing the study, conducting the study and analysing the data. Conflicts of interest are not declared

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