ORIGINAL ARTICLE

Epidemiology of nosocomial infections and related factors in patients admitted to the intensive care unit of selected hospitals in Tehran

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ABSTRACT

Background: Getting a nosocomial infection (NI) equals higher hospitalization costs, higher mortality and morbidity rates, and a tremendous financial burden both to the patients and the health care system. Therefore, the aim of this study was the epidemiology of nosocomial infections and its related factors in patients admitted to the intensive care unit of selected hospitals in Tehran.

Method and Materials: This study was conducted on all patients admitted from 2015 to 2017 to the intensive care unit (ICU) of selected hospitals in Tehran, Iran. The inclusion criteria for the study was having a confirmed NI. Confirmed NI was defined as a positive culture result during the first 48 hours of admission to intensive care unit. Demographic variables, hospitalization days before admitting to ICU, reason of admission, pathogen, site of infection, medical history and list of invasive were interventions used for patient. Confirmed cases were evaluated more to specify the underlying pathogen and the route of infection. Data were analyzed using R software version 4.0.2.

Result: In the beginning, 2055 patients were enrolled in the study and 307 patients (14.9%) were positive for nosocomial infections. The mean age in the patients with NIs was 66.9 and 52.9 in patients without NIs, which was significantly different between groups (p=0.00). We also found that days of hospitalization before ICU admission was significantly correlated with getting NIs (p=0.00). We organized them in five groups: Respiratory disorders, non-respiratory internal disorders, Trauma patients, neurosurgical disorders and other surgical complaints. As can be seen, patients with respiratory disorders were at significantly higher risk of getting a NI (OR=4.85, p=0.00). The risk of getting NI was lower for other patients, and it was at its lowest point for trauma patients (OR=0.17, p=0.00). Based on data, patients with CKD were at the highest risk of getting a NI, compared to other complications (OR=3.94, p=0.00). Also having a prior history of diabetes mellitus, myocardial infection, lymphoma, and any form of immunosuppression were significantly associated with a higher risk of getting a NI.

Conclusion: Lowering hospitalization by doing appropriate interventions as fast as possible, may decrease the risk of getting NIs. Also taking a complete and appropriate history from patients and perfect documentation is necessary for predicting NIs in them.

Key word: Epidemiology, Nosocomial Infections, Intensive Care Unit, Patients.

INTRODUCTION

Nowadays, it is recognized worldwide that healthcare-associated infections are responsible for an increase in patient morbidity, mortality, and higher costs related to prolonged hospital stays. Nosocomial infections (NIs), a serious healthcare-related problem, are believed to affect 4% to 12% of hospitalized patients annually (1, 2). According to a study, the additional cost per hospital-acquired bloodstream infection was 4900 Euros (3). It also showed that the extra length of stay in ICUs was between 9.1 and 9.5 days. Besides, reports have indicated that NIs result in 17500-70000 deaths annually in the US (4). The most common NIs include bloodstream infections, ventilator-associated pneumonia, urinary tract infections, and surgical site infections, with pneumonia being the most common (2). The high financial and individual costs associated with NIs make it a serious condition worthy of more precise study. According to a study, demographic factors, comorbidities and invasive interventions may increase risk of NIs in hospitalized patients (5). As we know, one of the most important types of hospital acquired infections are ventilator associated. According to a study, 36% of patients with traumatic brain injuries got ventilator associated NI (6). For example, a study in 2018 shows that diabetic patients are more likely to get NI (7). As shown in another study, diabetes mellitus and intubation were identified as predictors for increased mortality in patients who had NI (8). According to a study, The odds of developing hospital-acquired infection among immune deficient patients were 2.34 times higher (9). As we know, NIs are usually hard to cure and many of causing pathogens are resistant to Antibiotics (10). In this retrospective cohort, we evaluated 2055 patients admitted to the intensive care unit (ICU) of selected hospitals of Tehran for any form of NIs. We collected their laboratory

test results, their comorbidities, and their interventions in ICU, to help identify some of the factors correlated to NIs. Also we collected data about pathogens responsible for NI. Our goal is finding risk factors for NI to prevent this complication in ICU admitted patients.

MATERIAL AND METHODS

This study was conducted on all patients admitted from 2015 to 2017 to the intensive care unit (ICU) of selected hospitals in Tehran, Iran. The study was approved by the Army University of Medical Sciences ethics committee. All the data were collected from files with no direct contact with patients. We also used IDs (instead of their actual names) for patients to keep their identity secure.

Participants were all adult patients admitted from 2015 to 2017 to the intensive care unit (ICU) of selected hospitals of Tehran. The inclusion criteria for the study was having a confirmed NI. Confirmed NI was defined as a positive culture result during the first 48 hours of admission to intensive care unit. During this timeline we had 2055 patients admitted to the ICU setting. Scanning the for the eligibility criteria, at the end we left with 307 patients who experienced at least one NI.

Demographic variables, hospitalization days before admitting to ICU, reason of admission, pathogen, site of infection, medical history (history of diabetes mellitus, chronic kidney disease, myocardial infarction, cirrhosis, chronic obstructive pulmonary disease, HIV infection, leukemia, lymphoma and immunosuppression) and list of invasive interventions used for patient (Intubation, nasogastric tube, Central venous catheter, trans parental nutrition, tracheostomy, using anesthetic and packed cell infusion) were collected from files coded with IDs, to keep patients' privacy. All the patients underwent normal care by their doctors, and we just collected the data from coded files with each code representing an unknown patient.

All patients were evaluated by laboratory measures for any sign on NI. Confirmed cases were evaluated more to specify the underlying pathogen and the route of infection.

Data were analyzed using R software version 4.0.2. Ultimately to evaluate the parameters which could be associated with NIs incidence, we used binary logistic regressions. We also present in here the odds ratio (OR) with 95% confidence interval (95% CI) and Hosmer and Lemeshow's measure (R^2_L) for our logistic models.

RESULTS

Demographic data and days of hospitalization before ICU admission: In the beginning, 2055 patients from the intensive care units of selected hospitals in Tehran were enrolled in the study. We screened their files, and 307 patients (14.9%) were positive for nosocomial infections. 141 of 307 patients (45.9%) were female and the rest were males. The mean age in the patients with NIs was 66.9, with a range of 26-90, and 52.9 with a range of 18-91 in patients without NIs, which was significantly different between groups (p=0.00). We also found that days of hospitalization before ICU admission was significantly correlated with getting NIs (p=0.00). Patients with more days of hospitalization have a greater chance of getting NIs. Our sample demographic data are presented in Table 1.

Reason for admission: We evaluated the reason for admission in our patients. We organized them in five groups: Respiratory disorders, non-respiratory internal disorders, Trauma patients, neurosurgical disorders and other surgical complaints. We compared the chance of NI between patients with different complaints. Data are provided in Table 2. As can be seen, patients with respiratory disorders were at significantly higher risk of getting a NI (OR=4.85, p=0.00). The risk of getting NI was lower for other patients, and it was at its lowest point for trauma patients (OR=0.17, p=0.00).

Site of infection and Pathogen: We collected the site of infection in patients. Our categories included positive tracheal aspiration, urine culture, wound culture, and blood culture. Data are provided in Table 3.

We also collect the pathogen identified in their specimens. Our pathogens were klebsiella, pneumoniae, pseudomonas aeruginosa, Acinetobacter, Candida albicans, Eshershia coli and Staphylococcus aureus. All the data are provided in Table 4.

Comorbidities: We evaluated patients for their prior chronic diseases and compared the rate of NI among patients with different complications. In this section, we included diabetes mellitus (DM), chronic kidney disease (CKD), cirrhosis, myocardial infarction, chronic obstructive pulmonary disease (COPD), HIV infection, lymphoma, leukemia, and any form of immunosuppression. Based on our data, patients with CKD were at the highest risk of getting a NI, compared to other complications (OR=3.94, p=0.00). Also having a prior history of diabetes mellitus, myocardial infection, lymphoma, and any form of immunosuppression were significantly associated with a higher risk of getting a NI. Extended data are provided in Table 5.

Invasive interventions: We took into account all the invasive interventions that were performed for patients, including orotracheal intubation, placement of a central venous catheter (CV Line), tracheostomy, nasogastric tube placement (NG tube), packed cell infusion, receiving a dose of anesthesia for any reason, and receiving total parental nutrition (TPN). Comparing NI rate among people who received these interventions, had shown to significantly increase NI rate, except for getting a dose of anesthetics which p-value was not significant (p=0.13). Giving patients a dose of packed cell infusion was the intervention that resulted in getting a NI the most (OR=3.29, p=0.00). All the data related to invasive interventions and their correlation with getting NIs are provided in Table 6.

Table 1: Demographic data of patients

Variable	NI positive			NI negative			p
	N (%)	Mean (±SD)	Range	N (%)	Mean (±SD)	Range	
Gender							0.51
Female	141 (45.9%)	-	-	842 (48.2%)	-	-	
Male	166 (54.1%)	-	-	906 (51.8%)	-	-	
Age (years)	307	66.9 (±12.7)	26-90	1748	52.9 (±15.1)	18-91	0.00
Hospitalization before ICU admission (days)	307	4.41 (±2.89)	0-23	1748	2.04 (±2.80)	0-26	0.00

Table 2: Reason of admission and its relationship with getting a nosocomial infection

Variable	N (%)		Logistic regression					
	NI +	NI -	Intercept	β	Wald's χ^2 (df)	R^2_L	OR (95% CI)	p
Neurosurgical disorders	24 (9.0%)	243 (91.0%)	-1.82	-0.64	9.57 (1)	0.006	0.53 (0.33-0.80)	0.00
Trauma	15 (3.5%)	414 (96.5%)	-1.17	-.180	72.01 (1)	0.034	0.17 (0.09-0.27)	0.00
Other surgical disorders	47 (10.8%)	389 (89.2%)	-1.25	-0.46	8.03 (1)	0.004	0.63 (0.45-0.87)	0.01
Respiratory disorders	137 (35.5%)	249 (64.5%)	-1.80	1.58	132.17 (1)	0.067	4.85 (3.73-6.30)	0.00
Other internal disorders	84 (15.6%)	453 (84.4%)	-1.05	0.07	0.28 (1)	0.000	1.08 (0.82-1.41)	0.59

Table 3: Site of infection among patients with NIs

Tracheal aspiration	166(54.0%)
Urine culture	105(34.2%)
Wound culture	16(5.2%)
Blood culture	20(6.5%)

Table 4: Pathogen and its relationship with mortality among patients with NIs

Klebsiella	75 (24.4%)
Pseudomonas aeruginosa	17 (5.5%)
Staphylococcus aureus	64 (20.8%)
Acinetobacter	74 (24.1%)
E.coli	71 (23.1%)
Candida albicans	6 (1.9%)

Table 5: Comorbidities and its relationship with getting a nosocomial infection

Variable	N (%)		Logistic regression					
	NI +	NI -	Intercept	β	Wald's χ^2 (df)	R^2_L	OR (95% CI)	p
DM	111 (17.6%)	520 (82.4%)	-0.86	0.29	4.92 (1)	0.002	1.34 (1.03-1.72)	0.03
CKD	53 (37.6%)	88 (62.4%)	-2.94	1.37	47.64 (1)	0.047	3.94 (2.72-5.65)	0.00
Cirrhosis	2 (4.1%)	37 (95.9%)	-3.59	-1.44	6.21 (1)	0.013	0.24 (0.04-0.77)	0.05
Myocardial infarction	84 (21.5%)	307 (78.5%)	-1.55	0.57	15.07 (1)	0.008	1.77 (1.33-2.33)	0.00
COPD	52 (18.4%)	230 (81.6%)	-1.89	0.30	3.00 (1)	0.002	1.35 (0.96-1.86)	0.08
HIV infection	0 (0.0%)	5 (100.0%)	-5.85	-15.71	1.62 (1)	0.023	1.500731e-07	0.99
Lymphoma	14 (35.9%)	25 (64.1%)	-4.23	1.19	10.67 (1)	0.028	3.29 (1.65-6.32)	0.00
Leukemia	0 (0.0%)	6 (100.0%)	-5.67	-15.90	1.94 (1)	0.024	1.249892e-07	0.99
Immunosuppression	68 (23.1%)	227 (76.9%)	-1.90	0.65	16.11	0.010	1.91 (1.40-2.57)	0.00

Table 6: Invasive interventions and its relationship with getting a nosocomial infection

Variable	N (%)		Logistic regression					
	NI +	NI -	Intercept	β	Wald's χ^2 (df)	R^2_L	OR (95% CI)	p
Intubation	172 (19.3%)	721 (80.7%)	-0.35	0.60	23.00 (1)	0.008	1.81 (1.42-2.32)	0.00
CV Line	193 (16.8%)	953 (83.2%)	0.18	0.35	7.47 (1)	0.003	1.41 (1.10-1.82)	0.01
Tracheostomy	39 (20.4%)	152 (79.6%)	-2.35	0.42	4.60 (1)	0.004	1.53 (1.04-2.20)	0.03
NG Tube	296 (15.5%)	1613 (84.5%)	2.48	0.81	7.95 (1)	0.008	2.25 (1.26-4.47)	0.01
Packed cell infusion	149 (27.7%)	389 (72.3%)	-1.25	1.19	84.40 (1)	0.036	3.29 (2.56-4.23)	0.00
Anesthesia	253 (15.6%)	1373 (84.4%)	1.30	0.25	2.44 (1)	0.001	1.28 (0.94-1.77)	0.13
TPN	53 (20.1%)	211 (79.9%)	-1.99	0.42	5.86 (1)	0.003	1.52 (1.09-2.10)	0.01

DISCUSSION

Getting a nosocomial infection (NI) equals higher hospitalization costs, higher mortality and morbidity rates, and a tremendous financial burden both to the patients and the health care system. Finding the predictors in this regard could lead to lowering NIs in hospitals. In this retrospective cohort, we tried to evaluate some of the factors that might affect NIs rates. Our first finding was the relationship between age and NIs. Immunosenescence is a well-known fact nowadays. It includes a range from poorer responses to vaccination, lower capacity to mediate anti-cancer responses, more inflammation, and tissue damage, along with autoimmunity and loss of control of persistent infections (11-14). So, it was no surprise to find the same finding in our study. We also found that patients who got an NI had an extra length of stay in ICUs for about 2 days on average. This is in concordant with similar studies (3, 15), which reported an increase of €431 on average in the costs of hospitalization for patients. Thus, as a cost-lowering strategy, lowering the NIs rate could be considered as a considerable option.

When comparing the reason of admission among patients with the NIs rate, we found that patients with respiratory disorders are at the greatest risk of getting NI compared to other internals and surgical patients. Different reports acknowledge that getting an NI could lead to significantly higher mortality rates in most respiratory disorders, including COPD (16), asthma (17), and bronchiectasis (18, 19). Combining these data with our data that showed the risk of getting a NI is significantly higher for a patient with respiratory disorders, indicate the utmost importance of preventive health protocols to be taken in to account for these patients. A multicenter study shows that even a simple intervention like frequent hand washing could lead to a significant decrease of NIs for these patients (20). Base on a study in China, the severity of illness, length of stay at the ICU, receiving immunosuppressive therapies, and ventilator use are the most predictive factors for getting NI in patients with respiratory disorders (21). The importance of the length of stay at the ICU for getting a NI is indicated in other studies too (22, 23), showing the significance of early discharge for these patients .We found that respiratory infections to be the most common form of NI, confirming the results of different studies in China (24-26) which were in discordant with 2015 CDC report claiming urinary tract infections as the most common NI (27). When comparing the risk of getting an NI based on the patients' comorbidities, we found that CKD patients were the ones most likely to get an NI, with lymphoma patients as the second most common comorbidity associated with NIs. CKD is reported to both result in poor outcome following a NI like C. difficile and also to be a risk factor for it (28, 29). We also found that lymphoma will increase the risk of NIs. Patients that were under impression of any form of immunosuppressive therapy had a greater risk of getting NIs. Myocardial infarction was another factor that increased the risk of NIs. Diabetic patients and patients with COPD also had higher chance for NIs. These patients have longer duration of hospitalization in most cases and these results may be predictable. These data indicate the importance of obeying preventive measures when dealing with these patients in ICUs. Finally, when comparing the relationship between invasive interventions that patients received with the risk of getting NIs, we observed that invasive interventions may cause higher risk of getting NIs, just like a previous systematic review study that showed Age, sex, and comorbidities were non-modifiable risk factors and critical care interventions were modifiable factors and suggest that effective management of critical care interventions may play a key role in decreasing the development of sepsis in patients admitted to the ICUs (5). Getting a packed RBC infusion to have the highest risk. Although we believe that this should not be interpreted that getting packed RBC infusions result in getting more NIs, but we hypothesized that patients who received packed RBC infusions were patients with higher complications and more severe disorders. Placement of NG tube, CV line and orothracheal intubation, trans parental nutrition and using anesthetic will increase risk of NIs.

CONCLUSION

In this study, we analyzed relationship between different factors and getting NIs. We found significant relationships between NIs and age of ICU admitted patients. Also we found that patients with longer hospitalization had greater chance for NIs. Comorbidities and invasive interventions in those patients were cause higher risk of NIs. These

findings show that lowering hospitalization by doing appropriate interventions as fast as possible, may decrease risk of getting NIs. Also taking a complete and appropriate history from patients and perfect documentation is necessary predicting NIs in them.

We suggest proper isolation, close observation and routine screening for patients with higher risks for NIs. We also suggest doing appropriate researches on patients with each comorbidity named in our study with proper number of patients.

We also suggest limiting unnecessary interventions for ICU admitted patients and disconnecting unnecessary catheters as soon as possible. Routine sterilization of wards, proper hand washing from patient to patient, and obeying protocols are essential for prevention of NIs. As soon as sighting a positive culture for NIs, proper quarantine should take place for patients. All of these protocols must consider even more in patients with comorbidities, invasive interventions, longer hospitalizations and older patients. We suggest organizing a protective guideline for patients with higher risk of NIs.

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