

# Factors Related to ICU-Acquired Infections Incidence in Iran: Analysis of National Nosocomial Infections Registry Data

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## Research

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# Abstract

**Background:** Patients admitted to intensive care units (ICUs) are particularly susceptible to hospital-acquired infections (HAIs) and the HAIs are higher in the ICUs than other wards of the hospital. This study aimed at investigating factors associated with ICU-acquired infections incidence in Iran.

**Methods:** In this multi-center study, Iranian nosocomial infections surveillance (INIS) and hospital statistics and information system (AVAB) were used to collect data on patients with HAIs in 2018. The data was expanded based on 12 months of the year (13,632 records in terms of "hospital-ward-month") and then, the last observation carried forward method was used to replace the missing data. The generalized negative binomial regression with "patient-days" as an offset variable was used to identify the factors affecting ICU-acquired infections incidence.

**Results:** The median age of patients was 57.5 (IQR=55.09) years. Of the 22.92%, 5.76%, 13.62%, 43.41%, and 14.29% of patients were in NICU, PICU, internal ICU, general ICU, and surgical ICU, respectively. Only 13.73% of hospitals were in efficient zone (zone III). Based on multivariable regression, the number of death (IRR=1.02), the number of infections due to the device (catheters and ventilators) (IRR=1.1), ward type (PICU (IRR=1.58), internal ICU (IRR=1.63), general ICU (IRR=1.53) and surgical ICU (IRR=1.47)), hospital's expertise, hospital's accreditation, bed occupancy rate indicator (IRR=1.17 for moderate conditions) were associated with an increase of ICU-acquired infections incidence. Infection due to ventilator, infection due to catheter, and the number of surgery in hospitals reduced 5%, 7%, and 1% incidence of infections, respectively.

**Conclusions:** Based on the results, the most common ICU-acquired infections were VAE and UTI. Therefore due to the high sensitivity of intensive care units, full hygiene should be taught to the medical staff, especially the ICU wards. Ventilators and catheters should be used in special circumstances and minimum duration.

## Background

Hospital-acquired infections (HAIs) are a major health concern worldwide and are regarded as the most common complications in any health-care facility [1]. According to the European Center for Disease Prevention and Control estimates, more than 2.5 million cases of HAIs occur annually in Europe and the United States, HAIs account for 100,000 deaths annually [2].

Patients admitted to intensive care units (ICUs) are particularly susceptible to HAIs and the morbidity of HAIs is higher in the ICUs than other wards of the hospital, which are often severe [2, 3]. ICU-acquired infections affect patient's safety in developing and developed countries and are considered responsible for a substantial proportion of disability, increased length of stay (LOS) and mortality, delays in the recovery process, and impose additional costs and financial burden on the healthcare system of countries [4, 5].

Studies on infection in intensive care in Europe demonstrated the prevalence of ICU-acquired infections to be significantly higher (20.6%) [6]. The important ICU-acquired infections are ventilator-associated pneumonia (VAP), urinary catheter-related infection (UTI), central line-associated bloodstream infection (CLABSI), and surgical site infection (SSI) [6, 7]. In addition, a meta-analysis study by Ling et al. in Southeast Asia showed that the pooled incidence of HAI was 20 patient per 1000 ICU-days [8].

The majority of these infections are associated with the aging, severity of the disease, and healthcare factors including increase the use of invasive devices (endotracheal tubes, tracheostomy, central venous and urinary catheterization, and mechanical ventilation), type of providing health services, and inappropriate use of antimicrobial drugs [6, 7, 9].

Hence, HAIs prevention is now the most successful intervention and the recognition of the magnitude of related factors to the incidence of ICU-acquired infections has become essential for adopting proper infection control measures and reducing the incidence of infection in hospitals especially in ICU wards. Therefore, this study aimed at investigating factors associated with ICU-acquired infections incidence in Iran.

## Methods

### Data sources

In this multi-center study, Iranian nosocomial infections surveillance (INIS) and hospital statistics and information system (AVAB) were used to collect data on patients with HAIs from 662 hospitals in 2018. The national infectious control committee registers the HAIs including the following: bone and joint, central nervous system, chorionic villus sampling, eye, ear, nose, throat or mouth, urinary tract infections, ventilator-associated events, surgical site infections, central line-associated bloodstream infections, gastrointestinal system, reproductive tract infection, and skin and soft tissue infections. The data is collected to reduce mortality, morbidity, and complications of HAIs.

Iranian nosocomial infections surveillance collects data from about 863 hospitals and records different types of information in different units of each hospital including age, gender, type of HAIs, number of hospitalizations, patient-day, number of deaths, number of surgeries, date of infection, province, university, affiliated organization, devices used, and outcome of infection. In addition, we extracted performance indicators including the average LOS, occupancy rate, and bed turnover from AVAB that is a web-based system for each hospital.

### Expanded data and missing data imputation

The data including 12,586 records in terms of "hospital-ward-month" for ICU-acquired infections was expanded based on 12 months of the year (13,632 records in terms of "hospital-ward-month") and then, the last observation carried forward (LOCF) method was used to replace the missing data. In LOCF

imputation, first, the data on each variable in each hospital ward was sorted in terms of months, and the last observation was replaced through the forward method; then, the data on the same variable was sorted in terms of the reversed order of months and the last observation was replaced for the missing values through the backward method. Finally, the average values obtained in the two steps of forward and backward methods were used as the value of the missing data. In addition, the hospitals with no data on the number of infections and hospitalizations (in none of the months under the study) were excluded. Final ICU-acquired infections were 10,836 records obtained from 579 hospitals.

## National standard for hospital performance indicators

Hospital performance indicators were categorized on the basis of the standards of Ministry of Health and Medical Education (MOHME) of Iran as follows:

**Average LOS (day):** <3.5 (desirable), 3.5-4 (moderate) and > 4 (undesirable)

**Bed occupancy rate (%):** >70 (desirable), 60–70 (moderate) and < 60 (undesirable)

**Bed turnover rate:** >24 (desirable), 17–24 (moderate) and < 17 (undesirable)

**Death to bedridden ratio (%):** <2 (desirable), 2–3 (moderate) and > 3 (undesirable)

In addition, the national average rate of bed turnover (134.24) and bed occupancy (62.73) was used to plot the Pabon Lasso graphical chart. The plotted Pabon Lasso graph indicates four zones, where zone I is the inefficient area, zone II, zone III are the efficient area of the model, and zone IV.

## Data Analysis

Mean (standard deviation), median (interquartile range) and count (percentage) were used to describe quantitative and qualitative variables, respectively.

To identify the factors affecting ICU-acquired infections incidence, we used generalized negative binomial regression with “patient-days” as an offset variable. All the variables with a p-value of less than 0.2 at the univariable model entered into the multivariable regression model. Data were analyzed by the Stata (version 12) and  $p < 0.05$  was considered statistically significant for all statistical tests.

## Results

The median age of patients was 57.5 (IQR = 55.09) years. The median hospitalization-infection length and hospital LOS in the patients were 8.28 (IQR = 12.8) days and 21 (IQR = 21.75) days, respectively. The highest median of the number of death was observed in internal ICU (7, IQR = 10). The distribution of different variables by type of ICU in Iran hospitals was shown in Table 1.

Table 1  
Distribution of different variables by type of ICU in Iran hospitals-2018

Variable	Hospitalization-infection length (day)	Hospital LOS (day)	Mean age	Bed occupancy rate	Bed turnover rate	Number of death	Number of surgery
<b>NICU</b>							
<b>N</b>	2484	2172	2484	2388	2388	2484	2484
<b>Mean</b>	10.55	21.83	15.44	69.59	171.05	12.03	1.98
<b>(SD)</b>	22.8	24	33.69	12.07	911.05	452.16	15.58
<b>Median</b>	6	17	0	70.9	98.63	1	0
<b>(IQR)</b>	10	19.66	1	16.52	41.33	4	0
<b>PICU</b>							
<b>N</b>	624	576	624	600	600	624	624
<b>Mean</b>	14.22	27.94	19.27	74.8	90.25	4.18	5.72
<b>(SD)</b>	17.1	24.76	28.97	10.68	25.63	4.18	14.82
<b>Median</b>	10	21.16	5	76.41	83.99	3	0
<b>(IQR)</b>	14	21.5	14.61	13.07	27.38	5	4
<b>Internal ICU</b>							
<b>N</b>	1476	1344	1476	1452	1452	1476	1476
<b>Mean</b>	13.33	29.96	61.68	70.98	88.52	9.36	8.22
<b>(SD)</b>	13.23	27.97	18.04	13.95	32.39	8.89	28.3
<b>Median</b>	10.33	25	65.6	73.1	82.45	7	0
<b>(IQR)</b>	13.5	22.2	18.25	17.44	29.8	10	6
<b>General ICU</b>							
<b>N</b>	4704	4368	4704	4584	4584	4704	4704
<b>Mean</b>	14.13	26.67	60.7	65.15	147.71	7.97	12.41
<b>(SD)</b>	25.17	29.52	18.99	16.12	736.67	7.74	33.29
<b>Median</b>	8.25	20.57	65.21	66.83	92.56	6	1
<b>(IQR)</b>	13.03	21.5	23.98	21.23	40.07	8	11
<b>Surgical ICU</b>							
<b>N</b>	1548	1416	1548	1524	1524	1548	1548

<b>Mean</b>	13.78	29.26	55.78	71.33	182.31	5.62	38.86
<b>(SD)</b>	15.33	23.06	17.5	11	988.42	6.1	84.34
<b>Median</b>	10.28	25.12	59.28	71.74	92.11	4	18
<b>(IQR)</b>	12.25	22.65	22.36	16.08	36.11	7	53
<b>Total</b>							
<b>N</b>	10836	9876	10836	10548	10548	10836	10836
<b>Mean</b>	13.15	26.5	47.37	68.4	146.58	8.54	12.84
<b>(SD)</b>	21.69	27.17	30.78	14.35	752.26	216.56	42.47
<b>Median</b>	8.28	21	57.5	69.97	91.75	4	0
<b>(IQR)</b>	12.8	21.75	55.09	18.26	38.3	8	9

Of the 22.92%, 5.76%, 13.62%, 43.41%, and 14.29% of patients were in NICU, PICU, internal ICU, general ICU, and surgical ICU, respectively. Concerning patient-days, the rate of ICU-acquired infections was 24.6, 21.3, 20.9, 10.1, and 7.6 per 1,000 patient-days for internal ICU, general ICU, surgical ICU, PICU, and NICU, respectively. The most common ICU-AIs were VAE (6.49 per 1,000 patient-days) and UTI (3.32 per 1,000 patient-days). Based on hospital expertise and hospital type 90.53% and 63.87% of hospitals were general hospitals and medium hospitals (bed size = 100–320). In addition, based on the Pabon Lasso model, only 13.73% of hospitals were in efficient zone (zone III) (Table 2). Considering performance indicators including average LOS, bed occupancy and bed turnover, the frequency of desirable conditions was higher in hospitals (Fig. 1).

Table 2  
The frequency of hospital variables in ICU of Iran hospitals-2018

<b>Variables</b>		<b>N</b>	<b>%</b>
<b>Ward type</b>	<b>NICU</b>	2484	22.92
	<b>PICU</b>	624	5.76
	<b>Internal ICU</b>	1476	13.62
	<b>General ICU</b>	4704	43.41
	<b>Surgical ICU</b>	1548	14.29
	<b>Total</b>	10836	100
<b>Hospital type</b>	<b>Educational-therapy</b>	3168	31.92
	<b>Therapy</b>	6132	61.79
	<b>Educational-therapy- research</b>	624	6.29
	<b>Total</b>	9924	100
<b>Hospital expertise</b>	<b>General</b>	8952	90.53
	<b>Pediatrics</b>	300	3.03
	<b>Gynecology</b>	276	2.79
	<b>Psychiatric</b>	36	0.36
	<b>Accident</b>	48	0.49
	<b>Heart</b>	156	1.58
	<b>Ortopedi</b>	24	0.24
	<b>Cancer</b>	84	0.85
	<b>Surgery</b>	12	0.12
	<b>Total</b>	9888	100
<b>Accreditation</b>	<b>Excellent</b>	456	4.61
	<b>1</b>	8628	87.26
	<b>2</b>	804	8.13
	<b>Total</b>	9888	100
<b>Affiliation</b>	<b>Government</b>	7572	71.46
	<b>Semi- government</b>	528	4.98
	<b>Profit</b>	1992	18.8

Variables		N	%
	Non-Profit/other	504	4.76
	Total	10596	100
Hospital based on bed size	Small (< 100 bed)	1860	17.55
	Medium (100–320)	6768	63.87
	Large (320–600)	1464	13.82
	X.Large (600–1000)	456	4.3
	Hospital complex (> 1000)	48	0.45
	Total	10596	100
Pabon Lasso	Zone I (not efficient)	2964	27.35
	Zone II	276	2.55
	Zone III (efficient)	1788	13.73
	Zone IV	6108	56.37
	Total	10836	100

## The risk of ICU-acquired infections incidence

In investigating the relationship between ICU-acquired infections incidence and hospital variables and indicators, the number of death (death in HAIs patients) was associated with an increase of ICU-acquired infections incidence (IRR = 1.02; 95% CI: 1.01–1.02). Based on multivariable generalized negative binomial regression, the number of infections due to the device (catheters and ventilators) was associated with a 10% increase in ICU-acquired infections incidence rate (IRR = 1.1; 95% CI: 1.08–1.13). Also, PICU, internal ICU, general ICU, and surgical ICU were associated with a 58%, 63%, 53%, and 47% increase in ICU-acquired infections incidence rate compared to the NICU, respectively. Considering the hospital's expertise, the largest increase in the incidence of ICU-acquired infections was related to the heart hospitals (IRR = 2.91; 95% CI: 2.37–3.57), accidents (IRR = 2.08; 95% CI: 1.6–2.71), and pediatric hospitals (IRR = 1.95; 95% CI: 1.67–2.27). In addition, the risk of an increase in the incidence of the ICU-acquired infections was 23% (IRR = 1.23; 95% CI: 1.12–1.35) and 73% (IRR = 1.73; 95% CI: 1.52–1.97) higher in hospitals with accreditation 1 and 2, respectively. In hospitals with moderate conditions in terms of bed occupancy rate indicator, the incidence of ICU-acquired infections was 1.17 times higher than the desirable conditions (IRR = 1.17; 95% CI: 1.09–1.25) (Table 3).

Table 3

The univariable and multivariable generalized negative binomial regression between ICU-acquired infections incidence and hospital variables and indicators in Iran hospitals

Variables	Univariable			Multivariable		
	IRR	95% CI	P-Value	IRR	95% CI	P-Value
<b>Ward type</b>						
NICU	1	-	-	1	-	-
PICU	1.88	1.72–2.05	< 0.001	1.58	1.42–1.78	< 0.001
Internal ICU	2.47	2.33–2.62	< 0.001	1.63	1.49–1.79	< 0.001
General ICU	2.33	2.22–2.44	< 0.001	1.53	1.41–1.66	< 0.001
Surgical ICU	2.03	1.91–2.15	< 0.001	1.47	1.34–1.6	< 0.001
<b>Hospital type</b>						
Educational-therapy	1.03	0.99–1.07	0.14	1.06	1.007–1.13	0.02
Therapy	1	-	-	1	-	-
Educational-therapy- research	1.15	1.07–1.24	< 0.001	1.06	0.96–1.16	0.2
<b>Hospital expertise</b>						
General	2.5	2.22–2.8	< 0.001	1.82	1.6–2.07	< 0.001
Pediatrics	1.7	1.46–1.98	< 0.001	1.95	1.67–2.27	< 0.001
Gynecology	1	-	-	1	-	-
Psychiatric	1.8	1.26–2.59	0.001	1.88	0.72–4.88	0.19
Accident	2.78	2.11–3.65	< 0.001	2.08	1.6–2.71	< 0.001
Heart	7.24	5.99–8.75	< 0.001	2.91	2.37–3.57	< 0.001
Ortopedi	1.54	0.95–2.5	0.07	0.71	0.42–1.2	0.2

IRR = Incidence Rate Ratio; CI = Confidence Interval

Variables	Univariable			Multivariable		
	IRR	95% CI	P-Value	IRR	95% CI	P-Value
<b>Cancer</b>	1.87	1.48–2.36	< 0.001	1.76	1.37–2.27	< 0.001
<b>Surgery</b>	1.61	0.92–2.83	0.09	1.3	0.67–2.52	0.42
<b>Accreditation</b>						
<b>Excellent</b>	1	-	-	1	-	-
<b>1</b>	1.21	1.12–1.32	< 0.001	1.23	1.12–1.35	< 0.001
<b>2</b>	1.66	1.49–1.85	< 0.001	1.73	1.52–1.97	< 0.001
<b>Affiliation</b>						
<b>Government</b>	1	-	-	-	-	-
<b>Semi- government</b>	0.98	0.89–1.06	0.64	-	-	-
<b>Profit</b>	0.91	0.86–0.95	< 0.001	-	-	-
<b>Non-Profit/other</b>	1.04	0.95–1.14	0.28	-	-	-
<b>Hospital based on bed size</b>						
<b>Small (&lt; 100 bed)</b>	1	-	-	1	-	-
<b>Medium (100–320)</b>	0.94	0.89–0.99	0.04	1.005	0.92–1.08	0.9
<b>Large (320–600)</b>	1.03	0.97–1.1	0.27	1.03	0.92–1.15	0.53
<b>X.Large (600–1000)</b>	1.13	1.03–1.24	0.005	1.02	0.88–1.19	0.73
<b>Hospital complex (&gt; 1000)</b>	2.4	1.93–2.99	< 0.001	0.92	0.69–1.22	0.57
<b>Referral number</b>	1	1–1	0.05	0.99	0.99–1.001	0.53
<b>Bed occupancy rate</b>	0.99	0.99–0.99	< 0.001	1.007	1.004–1.01	< 0.001
<b>Bed turnover rate</b>	0.99	0.99-1	0.09	0.99	0.99-1	0.86

IRR = Incidence Rate Ratio; CI = Confidence Interval

Variables	Univariable			Multivariable		
	IRR	95% CI	P-Value	IRR	95% CI	P-Value
Bed surgery turnover	0.99	0.99–0.99	< 0.001	0.99	0.99–0.99	< 0.001
Personnel-to-bed ratio	0.98	0.97–1.005	0.18	1.02	0.99–1.05	0.12
Doctor-to-bed ratio	1.001	0.95–1.04	0.94	-		
Nurse-to-bed ratio	1.04	0.99–1.09	0.06	0.97	0.89–1.05	0.49
Number of death	1	0.99-1	0.87	-		
Number of surgery	1.0005	1.00007–1.001	0.02	0.99	0.99-1.0001	0.33
Device-day	1.00006	1.00003-1.00009	< 0.001	0.99	0.99-1.0001	0.39
Catheter-day	1.00004	1.00001-1.00008	0.006	0.99	0.99-1.0001	0.31
Ventilator-day	1.0007	1.0005–1.0008	< 0.001	-		
Mean age	1.007	1.006–1.008	< 0.001	1.0007	0.99–1.001	0.16
Hospitalization-infection length	1.0008	0.99–1.001	0.86	-		
Hospital LOS	1.0001	0.99-1	0.69	-		
Male-to-patients ratio	0.99	0.99–0.99	0.04	0.99	0.99-1.0006	0.86
Number of death (in HAIs patients)	1.09	1.08–1.09	< 0.001	1.02	1.01–1.02	< 0.001
Infection due to ventilator	1.09	1.09–1.1	< 0.001	0.99	0.99–1.001	0.37
Infection due to catheter	1.09	1.08–1.1	< 0.001	0.99	0.99-1.0001	0.24
Infection due to device	1.05	1.05–1.06	< 0.001	1.1	1.08–1.13	< 0.001
<b>Pabon Lasso</b>						
Zone I (not efficient)	1.03	0.97–1.1	0.25	-		
<b>IRR = Incidence Rate Ratio; CI = Confidence Interval</b>						

Variables	Univariable			Multivariable		
	IRR	95% CI	P-Value	IRR	95% CI	P-Value
<b>Zone II</b>	0.96	0.84–1.1	0.61			
<b>Zone III (efficient)</b>	1	-	-			
<b>Zone IV</b>	1.03	0.97–1.09	0.21			
<b>Average LOS indicator</b>						
<b>Desirable</b>	1	-	-	1	-	-
<b>Moderate</b>	1.09	1.03–1.16	0.002	0.85	0.79–0.91	< 0.001
<b>Undesirable</b>	1.02	0.97–1.08	0.31	0.79	0.57–1.005	0.052
<b>Bed occupancy rate indicator</b>						
<b>Desirable</b>	1	-	-	1	-	-
<b>Moderate</b>	1.03	0.98–1.07	0.17	1.17	1.09–1.25	< 0.001
<b>Undesirable</b>	1.03	0.98–1.08	0.14	1.07	0.96–1.19	0.16
<b>Bed turnover rate indicator</b>						
<b>Desirable</b>	1	-	-	-		
<b>Moderate</b>	1.005	0.62–1.62	0.98			
<b>Undesirable</b>	0.9	0.53–1.54	0.72			
<b>Death-to-bedridden ratio</b>						
<b>Desirable</b>	1	-	-	-		
<b>Moderate</b>	0.95	0.85–1.07	0.48			
<b>Undesirable</b>	1.48	1.4–1.56	< 0.001			
<b>IRR = Incidence Rate Ratio; CI = Confidence Interval</b>						

Based on univariable regression, infection due to the ventilator, infection due to catheter, and the number of surgery in hospitals were associated with an increase in ICU-acquired infections incidence, but in multivariable regression, these variables were not statistically significant. As the hospital bed surgery

turnover increases, the incidence rate of infections decreases by one percent (IRR = 0.99; 95% CI: 0.99–0.99) (Table 3).

## Discussion

The incidence of HAIs depends on many factors, including medical interventions, hospital factors, and personal characteristics. In addition, it varies in hospital wards and shows that although the intensive care units have increased the recovery rate and reduced mortality, on the other hand, the length of hospital stay of these patients and the use of invasive devices and catheters have increased HAIs in these wards [10].

Based on the results, the number of death (death in HAIs patients), type of ICU, hospital's expertise, and bed occupancy rate indicator were associated with an increase in ICU-acquired infections incidence rate. Knowing the causes, type, and frequency of HAIs can be very effective in optimal management and improving the quality of services. Therefore, organizing the nosocomial infection control committee, designing and implementing educational programs, paying attention to the basic design of the physical structure of hospital wards, creating motivational and attitudinal mechanisms in infection control are important factors that can reduce HAIs [11].

Device-related infections are a leading cause of HAIs, particularly in ICUs. Also, catheter-related infections are the most frequent cause of hospital-acquired bacteremia and mechanical complications and are mostly accessible to prevention if establishing standard disinfection and sterilization mechanisms and rigorous policies are implemented [12, 13]. Furthermore, mechanical ventilation is a commonly used mode of support in the ICU [11, 14]. In this study, the number of infections due to the device (catheters and ventilators) was associated with a 10% increase in ICU-acquired infections incidence rate. In addition, the most common ICU-acquired infections were VAE (38.6%) and UTI (19.76%), which are mostly related to the device used. Other studies show that the important infections in the ICU include UTI, pneumonia, bloodstream infections [7, 15, 16]. In Ohannessian et al.'s study, the HAIs incidence rate was 14.9 per 1,000 patients-days. Furthermore, pneumonia and UTI rates were 9.7 and 6.1 per 1,000 patients-days [5]. Furthermore, in Choudhuri et al.'s study, pneumonia accounted for more than a third of HAIs observed in ICUs. The duration of mechanical ventilation, duration of endotracheal intubation, duration of urinary catheterization, and ICU length of stay were significantly related to ICU-acquired infections [17].

Present findings imply that device-related infections are associated with increased complications and costs. Therefore, the specific preventive strategies of device-related infections, establishing a system of reporting and follow-up, healthcare workers' education and training about the use of invasive devices are necessary to reduce the ICU-acquired infections.

However, our study had some limitations. One, this study was a retrospective study, so there is a possibility of some biases. Second, the impact of pathogens, antimicrobial resistance, and other factors on ICU-acquired infections incidence rate was not considered in our study and may limit our interpretation. But, this study was a multicenter study and conducted using registered data, so it can be

claimed that the results are generalizable. In addition, this study was the first large sample size, comprehensive and national study that was conducted the investigating factors associated with ICU-acquired infections incidence and will be better clarify the factors affecting the occurrence of infections.

## Conclusions

Based on the results, internal ICU had the largest increase in ICU-acquired infections incidence compared to the NICU and the most common ICU-acquired infections were VAE and UTI. The occurrence of HAIs in medical centers is inevitable and its control is one of the most important health goals of medical centers. Therefore due to the high sensitivity of intensive care units, full hygiene should be taught to the medical staff, especially the ICU wards. Ventilators and catheters should be used in special circumstances and minimum duration. Regular hand washing, the use of antimicrobial gels, and the use of disposable gloves and masks in the face of patients are very reasonable and necessary.

## Abbreviations

AVAB= Hospital statistics and information system

CAUTI= Catheter-related urinary tract infection

CLABSI= Central line-associated blood stream infections / septicemia

HAIs= Hospital-acquired infections

ICU-AIs= ICU-acquired infections

ICUs= Intensive care units

INIS= Iranian Nosocomial Infections Surveillance

IQR= Interquartile range

LOCF= Last observation carried forward

LOS= Length of stay

MOHME= Ministry of Health and Medical Education

NICU= Neonatal Intensive care units

PICU= Pediatric Intensive care units

SSI= Surgical Site Infection

VAE/VAP= Ventilator-associated events / respiratory infections / pneumonia

# Declarations

## **Ethics approval and consent to participate**

All procedures performed in the study were in accordance with the ethical standards of the School of Public Health & Neuroscience Research Center- Shahid Beheshti University of Medical Sciences research committee (approval ID= IR.SBMU.PHNS.REC.1398.167) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

## **Consent to publish**

Not applicable. The manuscript does not contain patient identifiable data.

## **Availability of data and materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## **Competing interests**

The authors declare that they have no competing interests.

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## **Authors' Contributions**

N. I: Contribution to study concept and design, acquisition, analysis and interpretation of data, drafting of manuscript

B. E: Contribution to study concept and design, acquisition, analysis and interpretation of data

Y. M: Contribution to analysis and interpretation of data

K. E: Contribution to drafting of manuscript

SS. HN: Contribution to study concept and design, acquisition, analysis and interpretation of data, drafting of manuscript

All authors have read and approved the manuscript

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## Figures

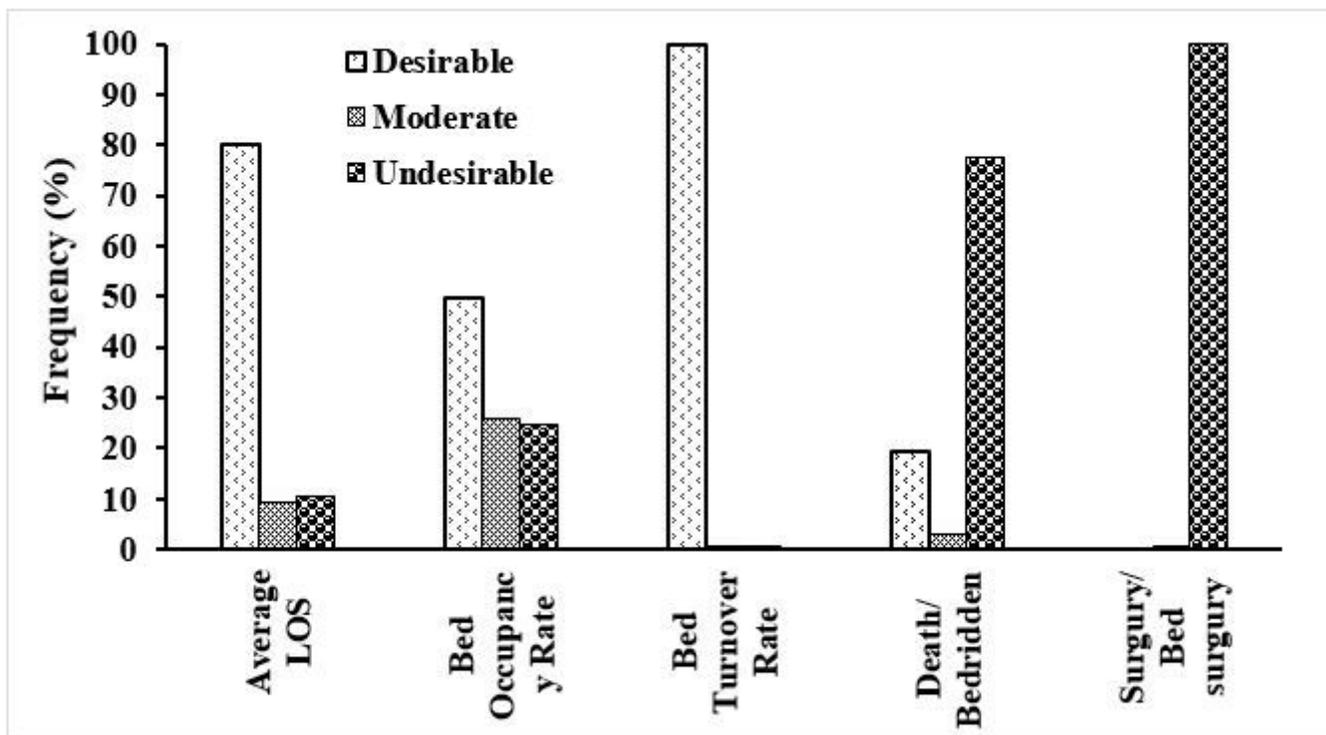


Figure 1

