Universal Journal of Public Health 11(6): 792-799, 2023 http://www.hrpub.org
DOI: 10.13189/ujph.2023.110602

Association Between Length of Stay and Healthcare-Associated Infections among Inpatients in a Secondary Health Care Hospital

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Received July 11, 2023; Revised October 17, 2023; Accepted November 14, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Songsee Singkun, Wisit Chaveepojnkamjorn, Peeraya Ekcjariyawat, Sirima Mongkolsomlit , "Association Between Length of Stay and Healthcare-Associated Infections among Inpatients in a Secondary Health Care Hospital," Universal Journal of Public Health, Vol. 11, No. 6, pp. 792-799, 2023. DOI: 10.13189/ujph.2023.110602.*

(b): *Songsee Singkun, Wisit Chaveepojnkamjorn, Peeraya Ekcjariyawat, Sirima Mongkolsomlit (2023). Association Between Length of Stay and Healthcare-Associated Infections among Inpatients in a Secondary Health Care Hospital. Universal Journal of Public Health, 11(6), 792-799. DOI: 10.13189/ujph.2023.110602.*

Abstract **Introduction:** Healthcare-associated infections (HAIs) are a major health problem issue in patients during the care process after hospital admission globally**.** The present study aimed to determine the length of stay related to HAIs among inpatients in the Bangkok Metropolitan- Administration Latkrabang (BMAL) Hospital from January 1, 2015-December 31, 2020. **Methods:** A hospital-based case-control study was conducted among inpatients of a secondary health care hospital in Bangkok. The data recording form was used to gather information from 300 medical records of inpatients who were hospitalized between 2015 and 2020 including 100 cases and 200 controls. Analysis was conducted using conditional logistic regression. **Results:** Hospital-acquired pneumonia (HAP) was the most frequently encountered site of HAI (42.4%), followed by catheter-associated urinary tract infection (CAUTI) (20.8%). Conditional logistic regression showed that a length of stay of 8 - 14 days, 15 - 21 days, and > 21 days were 3.56, 10.70 and 22.33 times at risk of HAIs compared with those of ≤ 7 days, respectively. Most of the bacteria were collected from sepsis/bloodstream infections of the cases, dominated by *Acinetobacter baumannii* (28.7%) and *Klebsiella pneumoniae* (19.5%). **Conclusion:** The result from this study can be used as a basic guideline for improving the clinical practice guideline and the policy of infectious prevention and control for patient safety.

Keywords Length of Stay, Healthcare-Associated Infections, Inpatients, Hospital-Based Case-Control Study, Infection Control, Nosocomial Infections

1. Introduction

HAIs are the critical health problems worldwide and occur in hospitals at all levels, including both developed countries and the developing countries. It is an infection occurring in a patient during the process of care in a hospital that was not present or incubating at the time of admission. In the event that the incubation period was not known, the infection must occur up to 48 hours after hospital admission [1,2]. In 2015, the National Healthcare Safety Network)NHSN (of the Centers for Disease Control and Prevention)CDC (conducted a prevalence survey of HAIs, the study found that the prevalence of HAIs was 3.2% [3]. In 2017, the European Center for Disease Prevention and Control conducted a prevalence survey of HAIs from the member states of the European Union and European Economic Area, the prevalence of patients with at least one HAIs was 5.9% [4]. In Australia, the point prevalence of HAIs in acute adult inpatients in 2018 was 9.9 %and hospital prevalence rates ranged from 5.7 %to 17.0 %which varied between hospitals [5]. While in Ethiopia, the incidence rate of HAIs was 28.2 per 1,000 patient days while the overall prevalence was 19.4 %[6] . Also surveyed were Southeast Asian Countries including Indonesia, Malaysia, Philippines, Singapore, Vietnam, and Thailand showing the prevalence of HAIs in 2015 .The pooled prevalence of overall HAIs was 9.0%, whereas the pooled incidence density of HAIs was 20 cases per 1,000 intensive care unit days [7]. In Thailand, a preliminary study of health and economic impacts of antimicrobial-resistant infections in 2010 was conducted from 1,023 hospitals; including private care hospitals, secondary care hospitals, tertiary care hospitals, and university hospitals, the occurrence of infections in each hospital varied according to the level of the hospital, namely university hospitals showed the highest of HAIs at 7.6%, tertiary care hospitals were 5.3%, secondary care hospitals were 2.1 %and private care hospitals were 4.9%, respectively [8]. BMAL Hospital is a secondary health care hospital with 60 beds under the Medical Services Department, Bangkok, which provides comprehensive health services for both outpatients and inpatients through 7 specialists division; medicine, surgery, orthopedics, ophthalmology, gynecology, pediatric, and rehabilitation. Most of the patients were patients who had been treated with medicine. There were 3,426, 3,764, 3,764, 3,585, 3,690, and 3,692 inpatients in 2015-2019, respectively. The hospital conducted the surveillance of prevention and control according to professional standards and the policies of the Medical Services Department. The rate of HAIs was 2.2, 0.6, 1.5, 1.5, and 1.7 per 1,000 patient-days [9]. It revealed that the HAIs rate of BMAL Hospital was lower than previously reported but HAIs would greatly affect as mentioned above. Days of hospitalization/ length of stay (LOS) were discussed as one of the risk factors for HAIs. Some of the previous studies supported this one [10-12]. However, the author would like to further analyze the relationship between the length of stay and the risk of HAIs among hospital inpatients. This study was conducted to analyze the relationship between LOS and HAIs among inpatient in the BMAL Hospital, Bangkok, Thailand.

2. Methods

2.1. Ethics Approval

This study offered to request an ethical review of human research from the ethics committee of the Faculty of Public Health Mahidol University (Committee's reference number: 44/2564 on 3rd March 2021) and the ethics committee of Bangkok Metropolitan (Committee's reference number: U008h/64_EXP on 5th May 2021) and agreed with the Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP). It requested permission to use the patient's information from the director of BMAL Hospital. The authors used the secondary data from the medical records of the inpatients of the BMAL Hospital during 2015-2020. Participants' names were unidentified in questionnaires, confidentiality was conducted throughout the study by the anonymous technique and the results were analyzed as a whole group.

2.2. Study Design

The study was a hospital-based case-control study. The study subjects were patients aged 15 years and over who were admitted as inpatients at BMAL Hospital from January 1, 2015 to December 31, 2020.

2.3. Definition

Healthcare-associated infections (HAIs) refer to an infection with occurring in a patient during the process of care in a hospital that was not present or incubating at the time of admission. If the incubation period is not known, the infection must occur up to 48 hours after hospital admission which is diagnosed by the medical doctor by using the criteria for HAIs diagnosis of the Bamrasnaradura Institute, 2013 [13,14].

2.4. Sample Size Estimation

The sample size was calculated using a formula [15,16], with $Z_{\alpha/2}$=1.96, Z_{β} =1.28, p_0 =0.77, p_1=0.62, c=2. The calculated sample size was at least 222. A samples size of 100 was used in the cases and 200 in the controls. Therefore, the total number of samples used in this study was 300.

2.5. Data Collection

Samples were selected from the medical records of inpatients of the BMAL Hospital. Cases and controls were patients who were admitted as inpatients, they had been hospitalized for more than 48 hours, aged ≥15 years, both female and male. Cases have been diagnosed with HAIs according to the doctor's diagnosis criteria while controls were not diagnosed with HAIs. The questionnaire comprised of demographic characteristics, treatment factors and HAIs results of study subjects.

2.6. Data Analysis

The verified data were entered into the code and analyzed by using the statistical software package. Descriptive statistics were expressed using: frequency, percentage and some of them are also expressed using mean, and standard deviation. Univariable analysis was used to determine between the independent variables and

HAIs by the conditional logistic regression for the crude odds ratio. A p-value < 0.05 was considered statistically significant. Adjusted odds ratio (OR_{adj}) and 95% CI of OR of the multivariable analysis was used to assess the magnitude of the relationship among LOS related to HAIs using the conditional logistic regression, for adjusting the confounders. All statistical analyses were performed using two-sided tests and a p-value of < 0.05 was considered statistically significant.

3. Results

3.1. Characteristics of the Participants

Patients admitted at the BMAL Hospital were male (62.0%) and ≥ 70 years old (58.0%). Most of their education levels were primary school (62.3%). Approximately 82.3% of them were underlying diseases, which included hypertension, diabetic mellitus, cardiovascular diseases, chronic kidney diseases, chronic obstructive pulmonary disease, and cancer, respectively (Table 1).

Table 1. Demographic characteristics of patients among cases and controls

	Total	**Cases**	**Controls**
Characteristics	**Number (%)**	**Number (%)**	**Number (%)**
Gender			
Male	186 (62.0)	62 (62.0)	124 (62.0)
Female	114 (38.0)	38 (38.0)	76 (38.0)
Age group (Years)			
<40	17 (5.6)	5 (5.0)	12 (6.0)
40-59	50 (16.7)	20 (20.0)	30 (15.0)
60-69	59 (19.7)	14 (14.0)	45 (22.5)
≥70	174 (58.0)	61 (61.0)	113 (56.5)
Mean (SD)	68.4 (15.5)	68.7 (16.1)	68.3 (15.2)
Education level			
None	39 (13.0)	22 (22.0)	17 (8.5)
Primary school	187 (62.3)	54 (54.0)	133 (66.5)
Secondary school	37(12.3)	13 (13.0)	24 (12.0)
Diploma and higher	11 (3.7)	2 (2.0)	9 (4.5)
Not applicable	26 (8.7)	9 (9.0)	17 (8.5)
Underlying diseases			
No	53 (17.7)	13 (13.0)	40 (20.0)
Yes	247 (82.3)	87 (87.0)	160 (80.0)
HT	175 (58.3)	59 (59.0)	116 (58.0)
DM	98 (32.7)	32 (32.0)	66 (33.0)
CVD	56 (18.7)	23 (23.0)	56 (16.5)
CKD	41 (13.7)	17 (17.0)	24 (12.0)
COPD	27 (9.0)	8 (8.0)	19 (9.5)
CA	20 (6.7)	7 (7.0)	13 (6.5)
1 Co- morbidity	99 (40.1)	37 (42.5)	62 (38.8)
2 Co-morbidities	79 (32.0)	26 (29.9)	53 (33.1)
3 Co-morbidities	59 (23.9)	21 (24.1)	38 (23.0)
≥4 Co-morbidities	10 (4.1)	3 (3.4)	7 (4.4)

Abbreviation: n=Number, HT=hypertension, DM= diabetes mellitus, CVD= cardiovascular diseases, CKD= chronic kidney diseases, COPD= chronic obstructive pulmonary disease, CA= cancer

Table 2. showed the results of a univariable analysis of the relationship between the treatment factors including LOS, patient types, medical invasive procedures, and HAIs. It was found that a LOS was statistically significant related to HAIs ($p < 0.05$). Patients with a LOS of 8 - 14 days, 15 - 21 days, and >21 days were related to HAIs compared with those of a LOS ≤ 7 days (OR = 7.58; 95%CI: 2.75 - 20.90), (OR = 30.24; 95%CI = 8.46 - 108.05), (OR = 70.15; 95%CI: 19.60 - 251.04), respectively. The patient types were also related to HAIs ($p < 0.05$). The patients who were classified as having severe illness and most severe illness were at higher risk of HAIs than the patients who were classified as having recovered or having moderate illness, and the highest risk were patients who were classified as having a most severe illness (OR = 5.05; 95%CI: 2.57 - 9.89), (OR = 9.44; 95%CI, 4.31 - 20.68), respectively. There was a statistically significant relation between patients who utilized medical invasive device procedures and HAIs, Foley's catheter, endotracheal tube, tracheostomy tube, mechanical ventilator, and nasogastric tube ($p < 0.05$). The patients who had received Foley's catheterization were at high risk of HAIs compared with those who were absent of Foley's catheterization (OR = 7.66; 95%CI: 4.11 - 14.30). The patients who had received endotracheal tube intubation were at higher risk of HAIs compared with those who were absent of endotracheal tube intubation (OR = 7.09; 95%CI: 3.65 - 13.79). The patients who had been inserted with a tracheostomy tube were at higher risk of HAIs compared with those who were absent of tracheostomy tube insertion (OR = 30.00; 95%CI: 3.96 - 227.11). In addition, the patients who had received a mechanical ventilator were at higher risk of HAIs than those who were absent of mechanical ventilator utilization (OR = 7.09; 95%CI: 3.65 - 13.79). Additionally, the patients who had received nasogastric tube insertion were at higher risk of HAIs compared with those who were absent of nasogastric tube insertion (OR = 20.31; 95%CI: 8.14 - 50.66).

Table 2. Univariable analysis of the treatment factors and HAIs

Variables	Cases	Controls	OR	95%CI	p-value
	Number (%)	Number. (%)			
LOS (days)					
≤ 7	10 (1.0)	139 (69.5)	1		
8 - 14	23 (23.0)	38 (19.0)	7.58	2.75 – 20.90	< 0.001*
15 - 21	22 (22.0)	14 (7.0)	30.24	8.46 – 108.05	< 0.001*
> 21	45 (45.0)	9 (4.5)	70.15	19.60 – 251.04	< 0.001*
Mean (SD)	23.4 (14.6)	7.1 (7.1)			
Patient types					
Recovery- Moderate	20 (14.5)	118 (85.5)	1		
Severe	43 (43.0)	54 (27.0)	5.05	2.57 – 9.89	< 0.001*
Most severe	37 (37.0)	28 (14.0)	9.44	4.31 – 20.68	< 0.001*
Endotracheal tube					
No	52 (52.0)	175 (87.5)	1		
Yes	48 (48.0)	12.5 (25)	7.09	3.65 – 13.79	< 0.001*
Foley's catheter					
No	21 (21.0)	137 (68.5)	1		
Yes	79 (79.0)	63 (31.5)	7.66	4.11 - 14.30	< 0.001*
Tracheostomy tube					
No	85 (85.0)	199 (99.5)	1		
Yes	15 (15.0)	1 (0.5)	30.00	3.96 – 227.11	< 0.001*
Mechanical ventilator					
No	52 (52.0)	175 (87.5)	1		
Yes	48 (48.0)	25 (12.5)	7.09	3.65 – 13.79	< 0.001*
Nasogastric tube					
No	22 (22.0)	154 (77.0)	1		
Yes	78 (78.0)	46 (23.0)	20.31	8.14 – 50.66	<0.001*
Ward admission					
GF ward	22 (22.0)	70 (35.0)	1		
GM ward and ICU	78 (78.0)	130 (65.5)	13.55	3.08 – 59.64	0.001

* Statistically significance at *p-value* < 0.05

Abbreviation: LOS = length of stay, GF = general female, GM = general male, ICU = intensive care unit, OR = odds ratio, CI = confidence interval

Table 3 showed that multivariable analysis was confirmed to assess the magnitude of the relationship between LOS and HAIs. Some factors with a p-value < 0.05 were selected into the model of the conditional logistic regression with the enter method. There were 6 factors selected into the model: LOS, patient types, Foley's catheter, mechanical ventilator, nasogastric tube, and ward admission. The dependent variable was HAIs. The result of the final analysis when adjusted for confounding factors, patients who had a LOS of 8 - 14 days, 5 - 21 days, and > 21 days were 3.56, 10.70, and 22.33 times higher risk of HAIs than the patients who had been a LOS ≤ 7 days (OR_{adj} = 3.56; 95%CI: 1.16 – 10.90), (OR_{adj} =10.70; 95%CI: 2.48 - 46.22), (OR_{adj} = 22.33; 95%CI: 5.65 - 87.47), respectively.

Table 4 showed the infectious sites of HAIs among cases. HAP was the most frequently encountered site of HAIs, accounting for 53 episodes (42.4%), followed by CAUTI, VAP, and UTI, accounting for 26, 19, and 17 episodes (20.8%, 15.2%, 13.6%), respectively. whereas skin and soft tissue infection (SST) was only found in 1 episode (0.8%). Most of the bacteria were collected from sepsis/bloodstream infections of the cases, dominated by *Acinetobacter baumannii* (28.7%), *Klebsiella pneumoniae* (19.5%), *Pseudomonas. aeruginosa* (14.6%), and *Escherichia coli* (14.0%), respectively.

Table 3. Multivariable analysis of LOS and HAIs

Variables	Crude		Adjusted		
	OR	95%CI	OR	95%CI	p-value
LOS (days)					
≤ 7	1				
8 – 14	7.58	2.75 - 20.90	3.56	1.16 – 10.90	0.026*
15 – 21	30.24	8.46 - 108.05	10.70	2.48 – 46.22	0.002*
> 21	70.15	19.60 - 251.04	22.33	5.65 – 87.47	< 0.001*

* Statistically significance at *p-value* < 0.05

Abbreviation: LOS = length of stay, OR = odds ratio, CI = confidence interval

Conditional logistic regression: adjusted by patient types, Foley's catheter, mechanical ventilator, nasogastric tube and ward admission

Table 4. Number and percentage of the infectious sites and types of pathogens among cases

Infection sites	Number	%
Infectious sites (n=125)		
HAP	53	42.4
CAUTI	26	20.8
VAP	19	15.2
UTI	17	13.6
BSI	9	7.2
SST	1	0.8
Bacterial infections (n=164)		
Gram-positive cocci (n=29)		
Enterococcus spp.	12	7.3
Staphylococcus aureus	9	5.5
Enterococcus faecium	3	1.9
Coagulate staphylococcus	3	1.9
Others	2	1.2
Gram-negative bacilli (n=135)		
Acinetobacter baumannii	47	28.7
Klebsiella pneumoniae	32	19.5
Pseudomonas aeruginosa	24	14.6
Escherichia coli	23	14.0
Enterobacter spp.	5	3.0
Proteus mirabilis	4	2.4

HAP = hospital-acquired pneumonia, CAUTI = catheter-associated urinary tract infection, VAP = ventilator-associated pneumonia, UTI = urinary tract infection, BSI = bloodstream infection, SSI = skin and soft tissue infection

17 cases had 2 infectious sites, 4 cases had 3 infectious sites and 79 cases had 1 infectious site

36 cases had 2 pathogens, 8 cases had 3 pathogens, 4 cases had 4 pathogens, and 52 cases had 1 pathogen

4. Discussion

The average LOS among cases and controls were 23.4 (±14.6) and 7.1 (±7.1) days. In the cases, most recorded a LOS > 21 days (45.0%). While in the controls, most were ≤ 7 days (69.5%). The results demonstrated that the length of hospitalization was a risk factor for HAIs. The patients who had a length of stay of 8 - 14 days, 15 - 21 days, and > 21 days were related to HAIs compared with those who had a length of stay ≤ 7 days, and patients who had a length of stay more than 21 days were at the highest risk of HAIs (OR_{adj} = 3.56; 95%CI: 1.16 - 10.90), (OR_{adj} = 10.70; 95%CI: 2.48 - 46.22), (OR_{adj} = 22.33; 95%CI: 5.65 - 87.47), respectively. As mentioned, this study indicated that most of the patients were male, > 70 years old, and were underlying diseases. They were the susceptible patients whose treatment was complicated and prolonged, so those patients had a prolonged hospitalization. The hospital is a place that has been contaminated by infected patients, visitors, and healthcare workers. Consequently, the susceptible patients who were treated in the hospital could be exposed to pathogens through receiving treatment, nursing care, patient's environment and etc. Patients who had prolonged hospitalization were more likely to be exposed to the pathogen than those of patients with a short time of hospitalization. This study demonstrated that the major pathogen was gram-negative bacilli, particularly *Acinetobacter baumannii, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Escherichia coli* which have several virulence factors that help the microorganism to resist stressful environmental conditions and occur in patients who were hospitalized and acquired by cross-infection. Our results suggested evidence of a significant association between LOS and HAIs, which is in agreement with similar studies conducted in other parts of the world [10-12,17-32]. HAIs prevention should focus on infectious preventive policies and practices, implementing the spread of evidence-based practices, with a focus on strong competencies and timely feedback on performance, compliance with practices, collaborative approaches, and stronger incentives promoting infection preventive efforts to prevent hospital infections [33-37]. While reported adherence to hand hygiene was quite high, many of the preventive practices for CAUTI, CLABSI, and VAP were used infrequently in Thailand. Policies and implementations emphasizing specific preventive practices, establishing a strong institutional safety culture, and participating in collaborations to prevent HAIs may be beneficial [38].

4.1. Study Limitations

Because this study was a small sample size and the data collection was retrospective by using secondary data, this research data collection was from only one hospital. So, the research result could not be referred to other sized hospitals.

5. Conclusions

In summary, HAP was the most of infectious site of HAIs, while CAUTI, VAP, and UTI were the major medical devices associated with infections. A LOS is one of the potential risks of HAIs in hospitals.

Acknowledgments

All authors would like to express their sincere thanks for their valuable contributions to the study provided by the study subjects, staff of the Department of Epidemiology, and staffs of the BMAL Hospital. We also thank those who were unmentioned for their kindness and encouragement.

Declarations

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors Contributions

S.S. and W.C. were responsible for the conceptualization, data curation, methodology, data validation, project administration, resource, software, supervision, writing-review and editing. P.E. was responsible for conceptualization; data curation and methodology. S.M. was responsible for data analysis, software and methodology. Subsequent drafts of the manuscript were edited and finalized by all authors The authors read and approved the final manuscript.

Conflicts of Interest

No conflict of interest was declared by the authors.

Data Availability

All data generated or analyzed during this study are included in this published article.

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