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FACTORS RELATED TO HEALTH CARE- ASSOCIATED INFECTIONS IN AN ADULT INTENSIVE CARE UNIT IN PERU

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Abstract: Objective: To identify the factors associated with the prevalence of healthcare-associated infections (HAI) in patients in the Intensive Care Unit (ICU) of the Hospital Es-Salud Tumbes, Peru, during the period 2020-2022. **Material and methods:** An analytical cross-sectional study was carried out with 348 epidemiological surveillance records. Data were collected through documentary observation and analyzed with descriptive and inferential statistics, applying logistic regression to determine risk factors. **Results:** Comorbidities increased the risk of HAIs by 48.8 times (ORa: 48.8; 95 % CI: 0.6-1.9; $p < 0.001$). In addition, the use of central venous catheter (ORa: 67.2; $p < 0.001$), urinary catheter (ORa: 20.5; $p < 0.001$), mechanical ventilation (ORa: 83.7; $p < 0.001$) and prolonged hospital stay (ORa: 31.0; $p < 0.001$) were significantly associated with HAIs. No association was found with age, sex or specific microorganisms. **Conclusions:** Extrinsic factors and prolonged stay are key determinants for HAIs in ICU. Implementing specific protocols for invasive devices and optimizing the length of stay could reduce the risk of HAIs in this context. **Keywords:** Hospital infection; Intensive care units; Public health; Risk factors; Comorbidity.

INTRODUCTION

Healthcare-associated infections (HAIs) represent a constant challenge in hospital settings, especially in intensive care units (ICUs), where critically ill patients are highly vulnerable to developing serious infections.⁽¹⁾ This phenomenon is largely attributed to the frequent use of invasive devices, such as catheters and mechanical ventilation, as well as to the immunosuppression of many patients.⁽²⁾ The increase in HAIs not only impacts the health of patients, but also significantly increases hospital costs and prolongs ICU stays, placing additional demands on health system resources.^(3, 4) In the Peruvian context, HCAIs in the

ICU, such as ventilator-associated pneumonia and catheter-related urinary tract infections, are highly prevalent and constitute a relevant public health problem due to the mortality and complications they cause in patients.⁽⁵⁾

The control of HAIs in the ICU is an area of interest to the scientific community, and several studies have addressed the risk factors that contribute to their prevalence.⁽⁶⁾ Globally, research has identified that factors such as the severity of the patient's.^(7, 8) Research has identified that factors such as severity of patient illness, length of ICU stay and exposure to multidrug-resistant pathogens are closely related to the occurrence of HAIs. Previous studies have found that pathogens such as *Escherichia*^(9, 10) have found that pathogens such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Acinetobacter baumannii* are some of the main causes of infections in these settings, and that the growth of their antimicrobial resistance increasingly complicates efforts to control hospital infections. In Peru, evidence on HCAI in ICU is limited, although some reports point out the presence of these same pathogens as the most prevalent in nosocomial infections, suggesting a similar scenario to the international one, but with particularities that require further research.⁽¹¹⁾

The literature suggests that despite advances in the identification of HCAI risk factors, certain knowledge gaps persist, especially in contexts such as Peru, where epidemiological data on HCAI in the ICU are scarce and fragmented. Most studies have been carried out in developed countries, where sanitary conditions and infection control practices may differ significantly from those of developing countries. In this sense, the lack of detailed information on the specific factors that contribute to HAIs in adult ICUs in Peru represents a knowledge gap, which limits the possibility of implementing prevention and control measures adapted to the local context.⁽¹²⁾ Further-

more, there are limitations in previous studies regarding the identification of specific factors associated with the development of HAIs in ICUs in the Peruvian population, such as the influence of the clinical and sociodemographic profile of patients and the impact of the hospital environment.

Therefore, the main objective of this study is to identify and analyze the factors related to the prevalence of HCAI in an adult intensive care unit in Peru in order to generate evidence to support the design of specific interventions in HCAI prevention, allowing the implementation of control practices, such as protocols for the use of invasive devices and hygiene and disinfection programs adapted to the intensive care environment. The study contributes with valuable data for the development of health policies and epidemiological surveillance programs in the hospital setting, strengthening knowledge on HAIs in the country.

MATERIAL AND METHODS

The study is observational, cross-sectional and descriptive-analytical, which allowed us to examine the factors associated with infections in the adult intensive care unit (ICU) at the Hospital EsSalud Alberto Cortez Jiménez, Peru, during the period 2020-2022. The study population included the entire epidemiological surveillance data collection cards of patients admitted to the hospital's ICU during the study period, with a total of 348 cards. The inclusion of the records followed the following criteria: only those that corresponded to patients whose stay in the ICU was longer than 48 hours and whose epidemiological information was complete were included. The records of patients who did not belong to the hospital were excluded, as well as those with a history of health care-associated infection before admission to the ICU or whose stay was less than 48 hours.

This study was approved by the Ethics Committee for the Analysis of Hospital Research Projects of the Carlos Cortez Jiménez Hospital. Data confidentiality was strictly maintained, and the study was conducted without any risk to the study subjects, in line with the ethical principles of beneficence, justice and respect for persons, in accordance with the Belmont Report. No informed consents were required, since the study was based on the review of epidemiological surveillance instruments without the direct participation of the patients.

The deductive method was used, with the techniques of observation and documentary review to collect the necessary information. The main instrument was an epidemiological surveillance data collection form, which is an official document of the Peruvian State. This instrument is validated and standardized according to the Technical Health Standard for the Surveillance of Health Care-Associated Infections, NTS 163-MINSA/2020/CDC, which ensures its validity and reliability.⁽¹³⁾ The collection form allowed recording key variables related to the occurrence of health care-associated infections, and was obtained from the database of the statistical center of the hospital's Health Intelligence Unit, ensuring the accuracy and relevance of the data to meet the objectives of the study.

Data were processed using Microsoft Excel and SPSS version 27 statistical software. For descriptive analysis, frequency distribution was used for categorical variables, while bivariate inferential analysis to identify associated factors included nonparametric tests. For the multivariate analysis, binomial logistic regression was applied, allowing determination of the factors predictive of infection by obtaining beta regression coefficients and calculating the estimated odds ratio (ORa).

RESULTS

The present study analyzed the intrinsic, extrinsic and microorganism-related factors in the prevalence of healthcare-associated infections (HAIs) in an intensive care unit (ICU) in Tumbes, Peru, during the period 2020-2022.

The study population included 348 patients admitted to the ICU, 85.6 % of whom were over 41 years of age. Most of the patients were male (64.9 %), 94.5 % were hospital patients and 94.8 % had no comorbidities. Among the procedures, 5.7 % required a central venous catheter, 10.6 % a urinary catheter and 7.2 % mechanical ventilation.

ce of comorbidities and the risk of HAI (OR: 48.8; 95 % CI: 0.6-1.9; $p < 0.001$). Other factors such as the use of invasive devices showed a significant relationship with the occurrence of HAIs: central venous catheter (OR: 67.2; 95 % CI: 21.7-208.1; $p < 0.001$), urinary catheter (OR: 20.5; 95 % CI: 8.3-51; $p < 0.001$) and mechanical ventilation (OR: 83.7; 95 % CI: 28-250.1; $p < 0.001$) were statistically significantly associated with HAIs. Prolonged hospital stay also showed a strong association with the presence of HAIs (OR: 31; 95 % CI: 8.3-115.8; $p < 0.001$). Other factors, such as advanced age, sex, patient origin and the presence of microorganisms, did not reach statistical significance in this analysis.

		Frequency	Percentage
Age	0 a 40	50	14,4%
	41 to more	298	85,6%
Comorbidities	No	330	94,8%
	Yes	18	5,2%
Origin	Own	329	94,5%
	Referred to	19	5,5%
Sex	Male	226	64,9%
	Female	122	35,1%
Central venous catheter	No	328	94,3%
	Yes	20	5,7%
Total parenteral nutrition	No	330	94,8%
	Yes	18	5,2%
Urinary catheter	No	311	89,4%
	Yes	37	10,6%
Hemodialysis catheter	No	328	94,3%
	Yes	20	5,7%
Mechanical ventilation	No	323	92,8%
	Yes	25	7,2%

Table 1. Characteristics of the ICU population - EsSalud Tumbes, 2020 - 2022

Of the total number of patients studied, 7.2 % developed an HAI during their stay in the ICU, with 92.8 % of the patients having no reported infections (Table 2). On the other hand, Table 3 presents the bivariate analysis of the factors related to healthcare-associated infections (HAIs) in ICU patients. A significant association was observed between the presen-

		Frequency	Percentage
IAAS	Presence	25	7,2%
	Absence	323	92,8%
Total		348	100,0%

Table 2. Prevalence of HCAI in ICU patients - EsSalud Tumbes, 2020 - 2022
HCAI: Healthcare-associated infections.

Bivariate analysis of factors associated with HAIs in ICU patients.

Among the intrinsic factors, Table 3 shows in the multivariate analysis, that comorbidities had a significant relationship with HAIs ($p = 0.000$), indicating that patients with these conditions are 60.9 times more likely (ORa: 60.9; 95 % CI: 16.878-220.025) to develop HAIs compared to patients without comorbidities. No significant statistical association was found for age, sex or patient origin.

Multivariate factor analysis identified central venous catheter (ORa: 9.2; 95 % CI: 1.802-46.473; $p = 0.008$), urinary catheter (ORa: 5.2; 95 % CI: 1.209-22.665; $p = 0.027$) and mechanical ventilation (ORa: 41.6; 95 % CI: 10.800-160.213; $p = 0.000$) as extrinsic factors significantly associated with HAIs. No significant association was found with total parenteral nutrition or hemodialysis catheter (Table 4).

Factors	Presence IAAS n=25	Absence IAAS n=323	OR (95% CI)	p*
Age				
41 years and older	24 (96%)	273 (84,5%)	OR: 4.4	0,092
≤ 40 years	1 (4%)	50 (15,5%)	(IC 95% 0.6-33.2)	
Comorbidities				
Yes	12 (48%)	6 (1,9%)	OR: 48.8	<0,001**
No	13 (52%)	317 (98,1%)	(IC 95% 0.6-1.9)	
Origin				
Referred to	3 (12%)	16 (5%)	OR: 2.6	0,147
Own	22 (88%)	307 (95%)	(IC 95% 0.7-9.7)	
Sex				
Female	9 (36%)	113 (35%)	OR: 1.04	0,538
Male	16 (64%)	210 (65%)	(IC 95% 0.4-2.4)	
Central venous catheter				
Yes	14 (56%)	6 (1,9%)	OR: 67.2	<0,001**
No	11 (44%)	317 (98,1%)	(IC 95% 21.7-208.1)	
Total Parenteral Nut.				
Yes	5 (20%)	13 (4%)	OR: 6.0	0,006**
No	20 (80%)	310 (96%)	(IC 95% 1.9-18.4)	
Urinary catheter				
Yes	15 (60%)	22 (6,8%)	OR: 20.5	<0,001**
No	10 (40%)	301 (93,2%)	(IC 95% 8.3-51)	
Hemodialysis catheter				
Yes	1 (4%)	19 (5,9%)	OR: 0.7	0,570
No	24 (96%)	304 (94,1%)	(IC 95% 0.1-5.2)	
Mechanical ventilation				
Yes	17 (68%)	8 (2,5%)	OR: 83.7	<0,001**
No	8 (32%)	315 (97,5%)	(IC 95% 28-250.1)	
Microorganisms				
Yes	3 (12%)	13 (4%)	OR: 3.3	0,098
No	22 (88%)	310 (96%)	(IC 95% 0.9-12.3)	
Hospital stay				
31 to 150 days	7 (28%)	4 (1,2%)	OR: 31	<0,001**
2 to 30 days	18 (72%)	319 (98,8%)	(IC 95% 8.3-115.8)	

*Fisher's Exact Test; **p<0.05. HCAI: Healthcare-associated infections; OR: odds ratio.

Factors	Statisticians				p*
	ORa	95% CI	Wald	Coefficient B	
Age	10	0,9 - 109,8	3,55	2,303	0,059
Comorbidities	60,8	17,3 - 213,5	41,07	4,107	<0,001*
Origin	1,8	0,3 - 10,2	0,42	0,576	0,519
Sex	1,0	0,4 - 2,9	,002	0,021	0,968

Multivariate analysis of intrinsic factors associated with HAIs in ICU patients.

OR: Odds ratio, **CI:** Confidence interval, **Wald:** Wald statistic, **Coefficient B:** Regression coefficient B, ***p-value < 0.05:** Statistically significant.

Factors	Statisticians				p*
	ORa	95% CI	Wald	Coefficient B	
Central venous catheter	9,2	1,8 - 46,5	7,13	2,214	0,008*
Total parenteral nutrition	2,3	0,2 - 26,2	0,44	0,827	0,505
Urinary catheter	5,2	1,2 - 22,7	4,90	1,655	0,027*
Hemodialysis catheter	3,4	0,3 - 34,5	1,08	1,228	0,298
Mechanical ventilation	41,6	10,8-160,2	29,36	3,728	<0,001*

Multivariate analysis of extrinsic factors associated with HAIs in ICU patients.

OR: Odds ratio, **CI:** Confidence interval, **Wald:** Wald statistic, **Coefficient B:** Regression coefficient B, ***p-value < 0.05:** Statistically significant.

Factors	Statisticians				p*
	ORa	95% CI	Wald	Coefficient B	
Presence of microorganisms	3,3	0,7 - 14,2	2,47	1,18	0,116
Hospital stay	31,0	8,2-117,3	25,6	3,44	<0,001*

Multivariate analysis of factors related to microorganisms associated with HAIs in ICU patients.

OR: Odds ratio, **CI:** Confidence interval, **Wald:** Wald statistic, **Coefficient B:** Regression coefficient B, ***p-value < 0.05:** Statistically significant.

Finally, prolonged hospital stay showed a statistically significant association with HCAI (OR: 31.0; 95 % CI: 8.199-117.340; p=0.000), while the presence of microorganisms did not show statistical significance in its relationship with HCAI in this model.

DISCUSSION

HAIs are a significant public health problem in intensive care units (ICUs) due to their impact on morbidity, mortality and hospital costs.^(14, 15) In this study, we analyzed the factors associated with HAIs in the ICU of Hospital EsSalud Tumbes during 2020-2022, and confirmed the relevance of intrinsic and extrinsic factors in their incidence, aligning these findings with previous research in other contexts.

The results indicate a 7.2 % prevalence of HAIs in the hospital's ICU, suggesting that, although the figure is lower than that observed in other Peruvian studies, such as Calvanti-Ramírez et al.⁽¹⁶⁾ which reported 28.2 %, HAIs still represent a challenge in terms of infection control. Discrepancies in prevalence rates between different studies can be explained by variations in infection control practices, availability of resources, type of population served and specific hospital conditions, aspects also highlighted by Santos et al.⁽¹⁷⁾ in their research on HAIs in ICUs in developing countries.

Among the risk factors, comorbidities proved to be highly significant, increasing by 48.8 times the probability of developing HAIs compared to patients without comorbidities.

This finding is consistent with previous studies, such as that of Alvarez et al. ⁽¹⁸⁾ who also found that patients with chronic conditions, especially diabetes and chronic obstructive pulmonary disease (COPD), have an increased vulnerability to HAIs. Martins et al. ⁽¹⁹⁾ explains that aging and the accumulation of chronic conditions predispose to immune impairment, which facilitates the colonization and proliferation of pathogens in hospital environments. In addition, Moreno et al. ⁽¹⁵⁾ highlighted that diabetes and COPD not only increase the risk of HAIs, but are also associated with greater complications once these infections become established, as was observed in the older patients in this study.

Extrinsic factors, especially the use of invasive devices such as catheters and mechanical ventilation, showed a significant relationship with the occurrence of HCAI, in agreement with international and national studies. Assisted mechanical ventilation increased the risk of HCAI by 83.7 times, while the use of central venous catheter and urinary catheter increased the odds by 67.2 and 20.5 times, respectively. Alfouzan et al. ⁽²⁰⁾ and Moreno et al. ⁽¹⁵⁾ have reported similar results, showing that invasive devices represent an entry route for hospital microorganisms.

Prolonged hospital stay was another relevant factor, being associated with HAIs with an OR of 31.0. Studies by Santos ⁽²¹⁾ and Llanos et al. ⁽²²⁾ have indicated that a stay of more than seven days constitutes an important risk factor for nosocomial infections, due to

the constant exposure to pathogens and the progressive weakness of the patients' immune system. Llanos et al. recommend interventions such as antibiotic rotation and optimization of hygiene practices to minimize colonization by multidrug-resistant bacteria in long-stay patients.

Regarding factors related to microorganisms, the study did not find a statistically significant association between the presence of specific microorganisms and HAIs. This differs from the findings of studies such as those of Baptista et al. ⁽²³⁾ and Michelin et al. ⁽²⁴⁾ who identified *Candida* and *Acinetobacter* as prevalent agents in HAIs in ICU patients. The lack of significance in this study could be attributed to the hospital's limitations in performing high-precision microbiological cultures, which restricted the identification of specific pathogens. ⁽²⁵⁾

In conclusion, this study confirms that comorbidities, invasive device use and prolonged hospital stay are key factors associated with HAIs in the ICU. These results emphasize the importance of specific prevention protocols for device management and the need to optimize ICU length of stay. The study also highlights the need to improve the diagnostic capabilities of hospitals and to develop training programs to strengthen care and prevention protocols in the Peruvian context. These interventions would not only reduce the incidence of HAIs, but would also contribute to improving clinical outcomes and optimizing the use of resources in the country's ICUs.

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