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# Risk factors for healthcare-associated infections in intensive care units

*Fatores de risco para infecções relacionadas à assistência à saúde em unidades de terapia intensiva*

*Factores de riesgo de infecciones asociadas a la atención de la salud en unidades de cuidados intensivos*

***Priscilla Perez da Silva Pereira*[1]**
ORCID: 0000-0001-8900-6801
***Andriely Alayne Carvalho Sabini*[1]**
ORCID: 0000-0003-1200-7464
***Josimeire Cantanhêde de Deus*[1]**
ORCID: 0000-0002-2001-1212
***Laís Xavier de Araújo*[1]**
ORCID: 0000-0002-6739-2518
***Daniela Oliveira Pontes*[1]**
ORCID: 0000-0001-7280-0638
***Adriana Tavares Hang*[1]**
ORCID: 0000-0002-5185-0473
***Caren Juliana Moura de Souza*[1]**
ORCID: 0000-0002-0278-0368
***Jeanne Lúcia Gadelha Freitas*[1]**
ORCID: 0000-0002-6556-0522

**Abstract**

**Objective:** To investigate the risk factors for infections related to care among patients hospitalized in an Intensive Care Unit in a capital in northern Brazil. **Methods:** A prospective cohort study, with 267 patients hospitalized from October 1, 2017 to January 30, 2019. Information was collected from electronic and physical medical records and patients' follow-up pattern. Information was collected from electronic and physical medical records and patients' follow-up pattern. Demographic information about hospitalization and treatment was investigated. Poisson regression was performed to assess the variables with the outcome. **Results:** Infection incidence was 10.49 cases per 100 patients, with the highest frequency for surgical site infection. In the adjusted analysis, hospitalization for more than five days (RR: 6.98; 95%CI: 1.42; 34.15), cardiopulmonary arrest (RR: 2.89; 95%CI:1.05;7.96), having an ostomy (RR: 9.22; 95%CI:1.47; 57.65) or tracheostomy (RR: 10.23; 95%CI: 1.56;67.22) were associated with healthcare-associated infections. **Conclusion:** The incidence of infections found was higher than in other Brazilian regions. Active surveillance is recommended, especially in patients with prolonged hospitalization and ostomy, careful assessment of the need for devices and use of protocols for the adoption of good practices.

**Descriptors:** Cross Infection; Intensive Care Units; Patient Safety.

[1]Fundação Universidade Federal de Rondônia, Porto Velho, Rondônia, Brazil.

Corresponding author:
Andriely Alayne Carvalho Sabini
E-mail: Andriely.alayne@gmail.com

**Whats is already known on this?**
Health care-associated infections impact treatment, length of stay, costs and mortality and are mainly associated with length of stay, prognosis and use of devices.

**What this study adds?**
The incidence of infections in Rondônia was higher than in Brazilian studies, the main topography was the bloodstream and the risk factors were cardiorespiratory arrest, prolonged hospitalization and ostomy.

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***Resumo***

***Objetivo:*** *Investigar os fatores de risco para infecções relacionadas à assistência entre pacientes internados em uma Unidade de Terapia Intensiva de uma capital do Norte do Brasil.* ***Métodos:*** *Estudo de coorte prospectiva, com 267 pacientes internados no período de 01 de outubro de 2017 a 30 de janeiro 2019. As informações foram coletadas de prontuário eletrônico, físico e padrão de acompanhamento dos pacientes. Investigaram-se informações demográficas sobre a internação e tratamento. Realizada regressão de Poisson para avaliação das variáveis com o desfecho.* ***Resultados:*** *A incidência de infecções foi de 10,49 casos por 100 pacientes, com a maior frequência para infecção de sítio cirúrgico. Na análise ajustada, internação por mais de cinco dias (RR: 6,98; IC95%: 1,42; 34,15), parada cardiorrespiratória (RR: 2,89; IC95%:1,05;7,96), ter ostomia (RR: 9,22; IC95%:1,47; 57,65) ou traqueostomia (RR: 10,23; IC95%: 1,56;67,22) foram associados às infecções relacionadas à assistência.* ***Conclusão:*** *A incidência de infecções encontrada foi superior às outras regiões brasileiras. Recomenda-se vigilância ativa, principalmente em pacientes com internação prolongada e ostomias, avaliação criteriosa da necessidade de dispositivos e uso de protocolos para adoção de boas práticas.*

***Descritores:*** *Infecção Hospitalar; Unidades de Terapia Intensiva; Segurança do Paciente.*

***Resumén***

***Objetivo:*** *Investigar los factores de riesgo de infecciones relacionadas con la atención entre pacientes internados en una Unidad de Cuidados Intensivos de una capital del Norte de Brasil.* ***Métodos:*** *Estudio de cohorte prospectivo, con 267 pacientes hospitalizados del 1 de octubre de 2017 al 30 de enero de 2019. La información se recolectó de la historia clínica electrónica y física y del patrón de seguimiento de los pacientes. La información se recolectó de la historia clínica electrónica y física y del patrón de seguimiento de los pacientes. Se investigó información demográfica sobre hospitalización y tratamiento. Se realizó una regresión de Poisson para evaluar las variables con el resultado.* ***Resultados:*** *La incidencia de infecciones fue de 10,49 casos por 100 pacientes, con la mayor frecuencia para la infección del sitio quirúrgico. En el análisis ajustado, hospitalización por más de cinco días (RR: 6,98; IC 95%: 1,42; 34,15), parada cardiorrespiratoria (RR: 2,89; IC 95%: 1,05; 7,96), ostomía (RR: 9,22; 95 %IC:1,47; 57,65) o traqueotomía (RR: 10,23; 95%IC: 1,56;67,22) se asociaron con infecciones asociadas a la atención sanitaria.* ***Conclusión:*** *La incidencia de infecciones encontrada fue mayor que en otras regiones brasileñas. Se recomienda vigilancia activa, especialmente en pacientes con hospitalización prolongada y ostomizados, evaluación cuidadosa de la necesidad de dispositivos y uso de protocolos para la adopción de buenas prácticas.*

***Descriptores****: Infección Hospitalaria; Unidades de Cuidados Intensivos; Seguridad del Paciente.*


## INTRODUCTION

Healthcare-associated infections (HAIs) are infections acquired as a result of healthcare treatment and are considered adverse health events.[1] HAIs are classified into four main topographies of the human body: bloodstream infection (BSI), urinary tract infection (UTI), surgical site infection (SSI) and ventilator-associated pneumonia (VAP). Among the main causes of HAI are inadequate hand hygiene, indiscriminate use of antibiotics, breach of care protocols and environmental contamination.[2]

When it affects patients undergoing treatment in the Intensive Care Unit (ICU), HAI can impact treatment, lengthen hospitalization, patient mortality and increase treatment costs. Thus, surveillance of such infections is of worldwide interest.[3-4]

It is estimated that 2,609,911 new cases of HAI occur each year in the European Union, causing approximately 37,000 deaths and a financial impact of seven billion euros.[4-5] In turn, in the United States (USA), about two million cases of HAI occur annually, leading to the death of 80,000 people, representing an estimated cost between 4.5 and 5.7 million dollars.[5]

In Brazil, according to a publication by the Brazilian National Health Regulatory Agency (ANVISA - *Agência Nacional de Vigilância Sanitária*) with data from 2017, the incidence density of HAI in adult ICUs was 11.5 for VAP, 4.0 for UTI associated with the use of a urinary catheter and 4.1 for BSI associated with the use of a central venous catheter (CVC), representing an increase of 3.64% compared to 2015 data.[6]

Although the reporting of HAI indicators and microbial resistance were instituted in Brazil in 2010 by ANVISA, with a review of indicators in 2021,[7] Brazil and other countries are conducting studies in search of the best strategies for HAI surveillance and training of teams that work in notifying institutions.[7-9] The development of information technologies has favored the HAI surveillance overview. In this sense, electronic availability and the incorporation of routine care data into surveillance algorithms increase health surveillance practices' reliability, efficiency and standardization.[10]

Survey-type studies on HAI surveillance in Brazil are still poorly documented. There are some surveys conducted occasionally in the states, mainly in the South, Southeast and Northeast regions of the country, being scarce in the North region.[11-12]

According to data from the state of Rondônia report, from 2012 to 2020, there was an increase in HAI reporting in adult ICUs in the state, however, in 2020, only half of hospitals with ICUs (16 hospitals) made at least one reporting that year. For laboratory-confirmed primary bloodstream infections (IPCSL),

the 2020 incidence density (DI) for the state was 4.9, for VAP, 17.4, and for UTI, 6.1. For SSI, data were presented for six specific procedures for neurological bypass, with a DI of 5.9, and for myocardial revascularization, with a DI of 11.3, in 2020.[13]

Knowing the negative outcomes related to health care and their risk factors is essential for the planning, implementation and assessment of actions. Thus, actions can be specific and efficient, directed to the hospital institution's real needs. Considering the above, the objective of this study was to investigate the risk factors for HAI among patients admitted to the ICU of a capital in northern Brazil.

## METHODS

This is a prospective cohort study, whose outcome is HAI, considering the four main topographies.[2] The research was carried out in a large public hospital of reference for the state of Rondônia, located in the city of Porto Velho, with approximately 620 hospital beds; of these, 18 are in the adult ICU, where around 700 surgeries are performed per month.[14]

The sample consisted of individuals of both genders aged 18 years or older, admitted to the ICU sector. Individuals with a stay of less than 48 hours in the ICU, death within 48 hours of admission to the ICU, patients with a psychiatric diagnosis, with a history of nosocomial infection or previous infection in the investigated topographies confirmed within 48 hours of ICU admission, or under treatment before ICU admission, were excluded.

The cohort refers to patients hospitalized from October 1, 2017 to January 30, 2019. Sociodemographic information, clinical conditions and reporting of nosocomial infection were collected from the hospital management system (Hospub) through electronic and/or physical medical records. A standard form was used for periodic monitoring of patients, tested through a pilot project, conducted in the first half of 2017 with 20 patients, and the data collected in the pilot project were not used in the results presented in this manuscript. All researchers were previously trained in filling out the form.

HAIs defined by the physician on duty or infectious disease specialist of the Hospital Infection Control Commission (HICC) was considered as a dependent variable. Independent variables were organized into three groups: demographic characteristics; information about hospitalization; and information about the treatment performed.

The incidence was calculated considering the number of patients with HAI in the numerator, and the total number of patients undergoing surgical procedures in the denominator and considering the rate per 100 patients, calculating the 95% confidence interval. Descriptive analysis was performed using frequency and measures of central tendency to assess the associations of variables with HAI. Bivariate analysis was also performed using Pearson's chi-square test and Fisher's exact test to verify the association between the dependent variable and the other variables. All variables with a significance test lower than 0.05 ($p<0.05$) were submitted to multiple analysis through Poisson regression, using the stepwise forward selection strategy.

Covariates were tested for the possible presence of multicollinearity - represented by correlations greater than 0.80, and these variables were not included in the final model. Statistical analysis was performed using STATA®, version 16.0 (College Station, Texas, USA).

This research is part of the project "*Infecções relacionadas à assistência a saúde no estado de Rondônia: incidência e fatores associados*", under Certificate of Presentation for Ethical Consideration (CAAE - *Certificado de Apresentação para Apreciação Ética*) 69602817.1.0000.5300. It was approved by the Research Ethics Committee of the *Universidade Federal de Rondônia*, under Opinion 2,866,650. The ethical principles for research involving human beings were respected in accordance with Resolution 466/2012 of the Brazilian National Health Council.[15] The research report was elaborated according to the quality criteria available in STrengthening the Reporting of OBservational studies in Epidemiology (STROBE).[16]

## RESULTS

Of the total of 1,090 patients in the ICU during the study period, 52.57% remained hospitalized in the sector for less than 48 hours; 20.55% had a previous diagnosis of untreated HAI or received a diagnosis of HAI within 48 hours of admission to the ICU; three (0.27%) patients were excluded due to psychiatric diagnosis; there were 1.10% losses due to record inconsistency; and 26.61% were included in this study.

The final sample consisted of 267 patients, of which 28 had HAI, resulting in an incidence of 10.49 cases of HAI per 100 patients (95%CI: 7.36; 14.74), with the most frequent topography being the SSI (21.43%; Table 1).

**Table 1**. Health care-associated infection by topography in the Intensive Care Unit and after transfer to other sectors, Porto Velho. Rondônia, Brazil, 2017-2019, (n=267).

| Topography* | N= 28 (%) |
|---|---|
| BSI | 5 (17,86) |
| UTI | 2 (7,14) |
| SSI | 6 (21,43) |
| VAP | 5 (17,86) |
| VAP and UTI | 4 (14,29) |
| BSI and SSI | 1 (3,33) |
| BSI and UTI | 1 (3,33) |
| BSI and VAP | 0 (0,00) |
| UTI and SSI | 1 (3,33) |
| Undefined | 3 (10,00) |

*BSI – bloodstream infection; UTI – urinary tract infection; SSI – surgical site infection; VAP – ventilator-associated pneumonia.

**Source:** Prepared by the authors (2019).

As for patients' sociodemographic profile, most were over 60 years old, female, had a partner and had a non-eutrophic nutritional profile (Table 2). Moreover, most had a history of hypertension, less than half were diabetic, and only seven patients had community-acquired infection. There was no risk association for HAI with the demographic characteristics studied.

**Table 2**. Sociodemographic information and previous history of patients admitted to the Intensive Care Unit, Porto Velho. Rondônia, Brazil, 2017-2019, (n=267).

| Variable | Without HAI n = 239 n (%) | With HAI n = 28 n (%) | Raw RR (95%CI) | p-value |
|---|---|---|---|---|
| **Age** | | | | |
| < 60 years | 119 (88,81) | 15 (11,19) | 1 | |
| > 60 years | 120 (90,23) | 13 (9,77) | 0,87 (0,41 – 1,83) | 0,72 |
| **Sex** | | | | |
| Female | 122 (89,05) | 15 (10,95) | 1 | |
| Male | 117 (90) | 13 (10) | 0,91 (0,43 – 1,91) | 0,81 |
| **Marital status*** | | | | |
| With partner | 121 (85,21) | 21 (14,79) | 1 | |
| Without partner | 75 (92,59) | 6 (7,41) | 0,50 (0,20 – 1,24) | 0,13 |
| **Body Mass Index** | | | | |
| Eutrophic | 96 (87,27) | 14 (12,73) | 1 | |
| Non-eutrophic | 143 (91,08) | 14 (8,92) | 0,70 (0,33 – 1,47) | 0,35 |
| **Hypertension** | | | | |
| No | 83 (85,57) | 14 (14,43) | 1 | |
| Yes | 156 (91,76) | 14 (8,24) | 0,57 (0,27 – 1,20) | 0,14 |
| **Diabetes mellitus** | | | | |
| No | 185 (88,52) | 24 (11,48) | 1 | |
| Yes | 54 (93,10) | 4 (6,90) | 0,60 (0,20 – 1,73) | 0,34 |
| **Community acquired infection** | | | | |
| No | 234 (90) | 26 (10) | 1 | |
| Yes | 5 (71,43) | 2 (28,57) | 2,86 (0,68 – 12,04) | 0,15 |

*Missing data.

**Source:** Prepared by the authors (2019).

Just over half of patients were hospitalized in the ICU for more than five days; most had circulatory system disorders as their underlying disease; hospitalization occurred after surgery; patients were from another health institution; and just over half left the unit (Table 3). Regarding the surgery characteristics, most were classified as clean, did not receive prophylactic antibiotics and eight patients needed to undergo a second surgical procedure.

**Table 3.** Information on Intensive Care Unit admission and surgery characteristics. Porto Velho, Rondônia, Brazil, 2017-2019, (n=267).

| Variable | Without HAI n = 239 n (%) | With HAI n = 28 n (%) | Raw RR (95%CI) | p-value |
|---|---|---|---|---|
| **Total days spent in the Intensive Care Unit** | | | | |
| < 5 days | 113 (97,41) | 3 (2,59) | 1 | |
| ≥ 5 days | 126 (83,11) | 25 (16,89) | 6,53 (1,97 – 21,63) | **< 0,01** |
| **Underlying disease according to ICD-10*** | | | | |
| Circulatory system | 139 (90,26) | 15 (9,74) | 1 | |
| Neoplasms | 30 (88,24) | 4 (11,76) | 1,021 (0,40 – 3,64) | 0,74 |
| External causes | 19 (90,48) | 2 (9,52) | 0,98 (0,22 – 4,27) | 0,98 |
| Others | 51 (87,93) | 7 (12,07) | 1,24 (0,50 – 3,04) | 0,64 |
| **Type of hospitalization** | | | | |
| Clinical | 57 (85,07) | 10 (14,93) | 1 | |
| Surgical | 182 (91) | 18 (9) | 0,60 (0,27 – 1,31) | 0,20 |
| **Origin** | | | | |
| Community | 37 (94,87) | 2 (5,13) | 1 | |
| Other health institution | 202 (88,60) | 26 (11,40) | 2,22 (0,53 – 9,37) | 0,28 |
| **Unit departure** | | | | |
| No | 131 (94,24) | 8 (5,76) | 1 | |
| Yes | 108 (84,38) | 20 (15,63) | 2,71 (1,19 – 6,16) | **0,02** |
| **Cardiopulmonary arrest** | | | | |
| No | 222 (94,47) | 13 (5,53) | 1 | |
| Yes | 17 (53,13) | 15 (46,88) | 8,47 (4,03 – 17,81) | **< 0,01** |
| **Performance of invasive exam*** | | | | |
| No | 221 (91,70) | 20 (8,30) | 1 | |
| Yes | 16 (66,67) | 8 (33,33) | 4,02 (1,77 – 9,12) | **< 0,01** |
| **Performance of surgical procedure** | | | | |
| No | 45 (86,54) | 7 (13,46) | 1 | |
| Yes | 194 (90,23) | 21 (9,77) | 0,72 (0,30 – 1,71) | 0,46 |
| **Type of surgery*** | | | | |
| Clean | 162 (91,53) | 15 (8,47) | 1 | |
| Not clean | 32 (84,21) | 6 (15,79) | 1,86 (0,72 – 4,80) | 0,20 |
| **Prophylactic antibiotic*** | | | | |
| No | 135 (91,22) | 13 (8,78) | 1 | |
| Yes | 47 (88,68) | 6 (11,32) | 1,28 (0,49 – 3,39) | 0,61 |
| **Performance of more than one surgical procedure*** | | | | |
| No | 234 (90,70) | 24 (9,30) | 1 | |
| Yes | 4 (50) | 4 (50) | 5,37 (1,86 – 15,50) | **< 0,01** |

*ICD – 1997 International Classification of Diseases; *Missing data.
**Source:** Prepared by the authors (2019).

In the raw risk analysis, patients who had been hospitalized for more than five days in the sector had a risk of 6.53 times more of having HAI when compared to those with fewer days of hospitalization (95%CI: 1.97 - 21.63). Leaving the unit for exams or surgical procedures was also a risk factor for HAI (RR: 2.71; 95%CI: 1.19 – 6.16) as well as cardiopulmonary arrest occurrence (RR: 8.47; 95%CI: 4.03 - 17.8), performance of invasive tests (RR: 4.02; 95%CI: 1.77 - 9.12) and the need for more than one surgical procedure (RR: 5.37; 95%CI: 1.86 – 15.50).

Regarding the use of devices during ICU stay, most patients used CVC, mechanical ventilation and indwelling urinary catheter (Table 4). In the raw analysis, all devices used were at risk for HAI. Length of use of CVC and number of exchanges, use of nasogastric tube for more than 16 days, use of mechanical ventilation for more than six days, use of indwelling urinary catheter for more than six days, number of indwelling urinary catheter changes and use of drain for more than six days also presented a risk for the outcome.

**Table 4.** Information on the use of devices used during Intensive Care Unit stay. Porto Velho, Rondônia, Brazil, 2017-2019, (n=267).

| Variable | Without HAI n = 239 n (%) | With HAI n = 28 n (%) | Raw RR (95%CI) | p-value |
|---|---|---|---|---|
| **Central venous catheter** | | | | |
| No | 97 (97,98) | 2 (2,02) | 1 | |
| Yes | 142 (84,52) | 26 (15,48) | 7,66 (1,82 – 32,28) | **< 0,01** |
| **Total days with central venous catheter*** | | | | |
| ≤ 5 days | 81 (93,10) | 6 (6,90) | 1 | |
| > 5 days | 61 (75,31) | 20 (24,69) | 1,03 (1,00 – 1,07) | **0,04** |
| **Number of central venous catheter changes*** | | | | |
| At least once | 3 (27,27) | 8 (72,73) | 1 | |
| None | 139 (88,54) | 18 (11,46) | 6,34 (2,76 – 14,59) | **< 0,01** |
| **Peripheral venous catheter** | | | | |
| No | 71 (81,61) | 16 (18,39) | 1 | |
| Yes | 168 (93,33) | 12 (6,67) | 0,36 (0,17 – 0,77) | **< 0,01** |
| **Total days with peripheral venous catheter*** | | | | |
| < 5 days | 117 (95,12) | 6 (4,88) | 1 | |
| > 5 days | 52 (89,66) | 6 (10,34) | 2,12 (0,68 – 6,57) | 0,19 |
| **Number of peripheral venous catheter changes*** | | | | |
| At least once | 49 (89,09) | 6 (10,91) | 1 | |
| None | 118 (95,16) | 6 (4,84) | 0,44 (0,14 – 1,37) | 0,16 |
| **Nasogastric tube** | | | | |
| No | 192 (96) | 8 (4) | 1 | |
| Yes | 47 (70,15) | 20 (29,85) | 7,46 (3,29 – 16,94) | **< 0,01** |
| **Total days with enteral feeding device*** | | | | |
| 1 to 5 days | 29 (85,29) | 5 (14,71) | 1 | |
| 6 to 15 days | 17 (73,91) | 6 (26,09) | 1,77 (0,54 – 5,81) | < 0,34 |
| Above 16 days | 1 (10) | 9 (90) | 6,12 (2,05 – 18,26) | **< 0,01** |
| **Number of device changes*** | | | | |
| At least once | 41 (70,69) | 17 (29,31) | 1 | |
| None | 6 (66,67) | 3 (33,33) | 1,13 (0,33 – 3,88) | 0,83 |
| **Parenteral nutrition** | | | | |
| No | 236 (91,12) | 23 (8,88) | 1 | |
| Yes | 3 (37,50) | 5 (62,50) | 7,04 (2,67 – 18,51) | **< 0,01** |
| **Ostomy** | | | | |
| No | 233 (91,02) | 23 (8,98) | 1 | |
| Yes | 6 (54,55) | 5 (45,45) | 5,06 (1,92 -13,31) | **< 0,01** |
| **Mechanical ventilation by TOT or TCT** | | | | |
| No | 175 (96,69) | 6 (3,31) | 1 | |
| Yes | 64 (74,42) | 22 (25,58) | 7,72 (3,13 – 19,03) | **< 0,01** |
| **Total days with mechanical ventilation device** | | | | |
| 1 to 5 days | 55 (88,71) | 7 (11,29) | 1 | |
| Above 6 days | 10 (40) | 15 (60) | 5,31 (2,17 – 13,03) | **< 0,01** |
| **Tracheostomy** | | | | |
| No | 232 (93,17) | 17 (6,83) | 1 | |
| Yes | 7 (38,89) | 11 (61,11) | 8,95 (4,19 – 19,11) | **< 0,01** |
| **Use of indwelling urinary catheter** | | | | |
| No | 76 (98,70) | 1 (1,30) | 1 | |
| Yes | 163 (85,79) | 27 (14,21) | 10,94 (1,49 – 80,52) | **0,02** |
| **Total days with indwelling urinary catheter** | | | | |
| 1 to 5 days | 112 (95,73) | 5 (4,27) | 1 | |
| 6 to 15 days | 46 (80,70) | 11 (19,30) | 4,51 (1,57 – 13,00) | **< 0,01** |
| Above 16 days | 5 (31,25) | 11 (68,75) | 16,09 (5,59 – 46,30) | **< 0,01** |
| **Number of indwelling urinary catheter changes** | | | | |
| At least once | 155 (89,60) | 18 (10,40) | 1 | |
| None | 7 (43,75) | 9 (56,25) | 5,41 (2,43 – 12,03) | **< 0,01** |
| **Drain** | | | | |
| No | 142 (93,42) | 10 (6,58) | 1 | |
| Yes | 97 (84,35) | 18 (15,65) | 2,38 (1,10 – 5,15) | **0,03** |

| | | | | |
|---|---|---|---|---|
| **Total days with drain*** | | | | |
| 1 to 5 days | 79 (89,77) | 9 (10,23) | 1 | |
| Above 6 days | 18 (66,67) | 9 (33,33) | 3,26 (1,29 – 8,21) | **0,01** |

*Missing data.
**Source:** Prepared by the authors (2019).

In the adjusted analysis, cardiopulmonary arrest increased the risk by 2.89 times (95%CI: 1.05 - 7.95) for HAI occurrence; having been hospitalized for more than five days in the ICU increased the odds by 6.97 times (95%CI 1.42 – 34.1); having an ostomy (RR 9.22; 95%CI 1.47 – 57.6) and a tracheostomy (RR10.2; 95%CI1.55 – 67.2) also increased the risk for HAI (Table 5).

**Table 5.** Adjusted analysis of variables related to Intensive Care Unit stay and surgery characteristics. Porto Velho, Rondônia, Brazil, 2017-2019. (n=267)

| Variable | Adjusted RR (95%CI) | p-value |
|---|---|---|
| **Total days in the Intensive Care Unit*** | | |
| < 5 days | 1 | |
| ≥ 5 days | 6,98 (1,42 – 34,15) | **0,02** |
| **Unit departure** | | |
| No | 1 | |
| Yes | 2,73 (0,88 – 8,43) | 0,08 |
| **Cardiopulmonary arrest*** | | |
| No | 1 | |
| Yes | 2,89 (1,05 – 7,96) | **0,04** |
| **Performance of invasive exam** | | |
| No | 1 | |
| Yes | 0,93 (0,32 - 2,70) | 0,89 |
| **Performance of more than one surgical procedure** | | |
| No | 1 | |
| Yes | 0,55 (0,08 – 3,68) | 0,54 |
| **Central venous catheter** | | |
| No | 1 | |
| Yes | 1,09 (0,16 – 7,40) | 0,92 |
| **Peripheral venous catheter** | | |
| No | 1 | |
| Yes | 0,53 (0,19 – 1,47) | 0,22 |
| **Nasogastric tube** | | |
| No | 1 | |
| Yes | 1,89 (0,72 – 4,98) | 0,20 |
| **Parenteral nutrition** | | |
| No | 1 | |
| Yes | 0,78 (0,18 – 3,38) | 0,73 |
| **Ostomy*** | | |
| No | 1 | |
| Yes | 9,22 (1,47 – 57,65) | **0,02** |
| **Mechanical ventilation by TOT or TCT** | | |
| No | 1 | |
| Yes | 1,24 (0,37 – 4,15) | 0,73 |
| **Tracheostomy*** | | |
| No | 1 | |
| Yes | 10,23 (1,56 – 67,22) | **0,01** |
| **Indwelling urinary catheter** | | |
| No | 1 | |
| Yes | 5,00 (0,44 – 56,39) | 0,19 |
| **Drain** | | |
| No | 1 | |
| Yes | 0,73 (0,26 – 2,02) | 0,55 |

*Variables with p<0.05 in the raw risk analysis were not included in the adjusted analysis due to multicollinearity > 0.80. Hosmer Lemeshow statistical test indicated good model quality (p= 0.99).
**Source:** Prepared by the authors (2019).

In this study, 14.23% of patients died, a risk of death approximately 10 times higher compared to those who did not have HAI (RR: 10.83; 95%CI: 4.18 – 27.87).

## DISCUSSION

In this study, HAI incidence in the ICU was 10.49 cases per 100 patients, with SSI being the most frequent topography. In the adjusted analysis, cardiopulmonary arrest, stay in the ICU for more than five days, having an ostomy and a tracheostomy increased the risk for HAI.

Of every 100 hospitalized patients, seven in developed countries and 10 in developing countries had at least one episode of HAI in 2016.[5] In Brazil, ANVISA data for 2017 show a global incidence density of HAI in an adult ICU of 4.4%, of which 11.50% were VAP, 4.70% UTI, and 4.40%, PBSI.[6]

In this study, SSI had the highest occurrence, followed by BSI and VAP. A study carried out in the ICU of a university hospital in Fortaleza/CE found VAP as the most frequent, followed by BSI and UTI. The authors of this study point to the divergence of which topography would be the most incident in ICU in Brazil.[17] HAI occurrence depends a lot on adherence to good practice protocols. The decrease in UTI cases in some units is related to the high compliance of the nursing team with the good practice protocol, and the use of bundle decreased infection rates.[18]

A risk association was found between the history of cardiopulmonary arrest and HAI occurrence. A study conducted in the United States with 105,184 patients with a history of cardiopulmonary arrest showed that 19.1% developed HAI, which led to a longer hospital stay, increased hospitalization costs and a higher risk of death.[19]

In Rondônia, hospitalization time longer than five days was a risk factor for HAI. The complexity of the care provided in the ICU, patients' clinical profile and the type of procedure offered are factors that differentiate the average length of stay in hospitals.[20] An integrative literature review on the most prevalent microorganisms in ICU and the main risk factors for patients found that length of hospital stay, use of devices, use of antibiotics for a long time, age and gender are the most relevant risk factors for HAI occurrence in the ICU.[21]

A study conducted in an ICU at the *Universidade Federal do Ceará*, carried out between 2008 and 2011, found that the average length of stay from hospitalization to diagnosis of HAI was 11.7 days after admission and concluded that length of stay was determinant for HAI occurrence.[17] Prolonged hospitalization leads to greater environmental exposure, increasing the possibility of colonization by multidrug-resistant microorganisms and the risk of cross-infection.[22]

HAI occurrence was found to be associated with ostomy use, including tracheostomy. The main causes for infections are failure of technique in insertion, handling and maintenance of invasive devices.[23] Moreover, the microbiota in these devices has been shown to be increasingly resistant to antibiotics.[24] For the rational use of any devices, the possible clinical indications should always be considered, as provided by regulatory bodies or based on consensuses, guides or protocols. The Brazilian Institute for Patient Safety (IBSP - *Instituto Brasileiro para Segurança do Paciente*) published in 2019 some recommendations aimed at preventing infection related to catheters and devices based on an American study. They described that professionals complied well with the proposed guidelines regarding hygiene, correct techniques and the implementation of new procedures, however, the need for more engagement on the part of management in favor of HAI prevention actions was reported.[25]

In this study, patients who had HAI had a 10 times greater risk of death when compared to patients who had not had HAI. The results of the present study are also close to the findings of a study in an adult ICU of a hospital in the state of Amazonas that analyzed 75 cases of HAI and found a significant association between death and HAI.[26]

The ICU is a scenario where patients are more vulnerable to suffering adverse events related to health care, due to the complexity of actions and interventions that are offered on an emergency basis by the health team in this environment.[23-27] Among the adverse events that most threaten patient safety, HAIs stand out, either because of their high frequency or because of the associated morbidity and mortality.[1] Care safety is one of the indicators with the greatest impact on health care quality, and there is no way to dissociate quality care from safe care.[28]

The major limitation of this study was the lack of completeness of some information. For instance, 46.69% of medical records did not have records of variable skin color that cannot be considered in the analysis. Lack of data completeness is a challenge for many institutions, as pointed out by a study conducted in the state of Acre, which presented the lack of filling in data for a situational diagnosis of the

ICU as an important limiting factor for the adequate management of HAI[29] Another limitation is that HAIs were declared by the HICC physician or physician on duty, which may have been underestimated because the institution does not have a clear and precise protocol for defining HAIs. As a strength of this study is the prospective design that contributes to the information being more reliable and, therefore, the evidence produced of better quality. Another point to be considered is the scarcity of studies on the subject in northern Brazil; therefore, the results presented contribute to better planning of policies, programs and actions for this region of Brazil.

## CONCLUSION

HAI incidence in the ICU found in the investigated institution was higher than that found in other regions of Brazil. Prolonged hospital stay, history of cardiopulmonary arrest and having an ostomy increased the risk for HAI. Active surveillance is recommended in search of signs of HAI, especially among users who have the risk factors found in this study. For using devices in general, it is recommended to carefully assess the need for these devices and use protocols and bundles that enable the planning and execution of good practices in their use and maintenance.

For future studies, it is suggested to investigate professionals' perception regarding their practices to prevent HAI occurrence as well as to assess their level of knowledge on the subject. Knowing the profile of the professionals who are providing care will support planning permanent education actions in favor of infection control in the institution.

## CONTRIBUITIONS

Contributed to the conception or design of the study/research: Pereira PPS, Pontes DO, Hang AT. Contributed to data collection: Sabini AAC, Deus JC, Araújo LX. Contributed to the analysis and/or interpretation of data: Pereira PPS, Deus JC, Araújo LX, Sabini AAC. Contributed to article writing or critical review: Pereira PPS, Hang AT, Pontes DO,Souza CJS, Freitas JLG. Final approval of the version to be published: Pereira PPS, Sabini AAC, Deus JC, Araújo LX, Pontes DO, Hang AT, Souza CJS, Freitas JLG.

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