

The Nursing Activities Score and its association with healthcare-associated infections in a Brazilian adult intensive care unit

O Nursing Activities Score e sua associação com as infecções relacionadas à assistência à saúde em uma unidade de terapia intensiva adulto brasileira

El Nursing Activities Score y su asociación con infecciones relacionadas con la atención médica en una unidad de cuidados intensivos brasileña para adultos

Received: 07/22/2022 | Reviewed: 08/08/2022 | Accept: 08/10/2022 | Published: 08/19/2022

Gabriela Rodrigues dos Santos

ORCID: <https://orcid.org/0000-0002-2220-2856>
Federal University of Uberlândia, Brazil
E-mail: gabrielasantos0947@gmail.com

Elias Rodrigues de Almeida Júnior

ORCID: <https://orcid.org/0000-0003-3322-0694>
Federal University of Uberlândia, Brazil
E-mail: juniorelias@hotmail.com

Daniel Braga de Oliveira

ORCID: <https://orcid.org/0000-0003-2547-1581>
Federal University of Uberlândia, Brazil
E-mail: danielbraga137@hotmail.com

Huara da Silva Pessoa Oliveira

ORCID: <https://orcid.org/0000-0002-5249-5186>
Federal University of Uberlândia, Brazil
E-mail: huarapessoa@gmail.com

Jane Eire Urzedo Cunha

ORCID: <https://orcid.org/0000-0002-3254-9765>
Federal University of Uberlândia, Brazil
E-mail: janeurzedo@hotmail.com

Ana Laura Lima de Jesus

ORCID: <https://orcid.org/0000-0001-8986-1461>
Federal University of Uberlândia, Brazil
E-mail: analaurljesus@gmail.com

Fabiola Alves Gomes

ORCID: <https://orcid.org/0000-0002-3597-1566>
Federal University of Uberlândia, Brazil
E-mail: fabiola@ufu.br

Clesnan Mendes-Rodrigues

ORCID: <https://orcid.org/0000-0002-8871-7422>
Federal University of Uberlândia, Brazil
E-mail: clesnan@ufu.br

Abstract

The intensive care unit (ICU) requires a specialized team with adequate human resources, including nursing. For an adequate measurement of the workload of nursing professionals of Brazilian ICUs, the Nursing Activities Score (NAS) has been used to promote better adequacy of work scales. Work overload can increase the incidence of adverse events, including healthcare-associated infections (HAI). *Objective:* To associate the nursing workload measured by the NAS with the rates of HAI in an Adult ICU of a university hospital, in addition to evaluating the impact of the separation of ICUs by unit, or type of specialization. *Method:* Data collection was performed at Brazil, in the Adult ICU: stratified by the Surgical, Neurological and Medical specialties; including the calculation of the means of NAS and the monthly rates of HAI of each ICU unit, from 2016 to April 2019. NAS data were collected from secondary spreadsheets, without identification of the patient, and the rates of HAIs were collected from information from the Hospital Infection Control Service. *Results:* The mean NAS was different for each unit, with Neurological unit with the highest mean. In relation to HAIs, neurological unit patients had a higher incidence of HAIs and patients with HAIs. Pneumonia associated with mechanical ventilation (VAP) was higher in Surgical and Neurological units.

Bloodstream and urinary tract infection were higher in the Medical unit. There was a positive correlation for NAS and VAP in the Medical unit and with urinary tract infection in the Surgical unit. In the Neurological unit there was a negative correlation with the rate of HAI and rate of patients with HAI. *Conclusion:* The mean NAS observed by us was lower when compared to other ICUs and variations may be associated with the type of hospital and clinical profile of patients. It was possible to observe that each unit has its particularity regarding the incidence of HAIs and the association between NAS (nursing workload) and rates, reinforcing the need for stratification and association of indicators per unit.

Keywords: Hospital infection; Workload; Nursing; Intensive care unit; Nursing Activities Score.

Resumo

A unidade de terapia intensiva (UTI) requer uma equipe especializada e com recursos humanos adequados, inclui-se nestes a Enfermagem. Para uma mensuração adequada à carga de trabalho dos profissionais de Enfermagem das UTIs brasileiras têm-se utilizado o Nursing Activities Score (NAS) com intuito de promover melhor adequação das escalas de trabalho. A sobrecarga de trabalho pode aumentar a incidência de eventos adversos, dentre eles, as infecções relacionadas à assistência à saúde (IRAS). *Objetivo:* Associar a carga de trabalho em Enfermagem mensurada pelo NAS com as taxas IRAS em uma UTI Adulto de um hospital universitário, além de avaliar o impacto da separação das UTIs por tipo de especialização. *Método:* A coleta dos dados foi realizada em uma UTI Adulto: estratificada em função especialidades Cirúrgica, Neurológica e Médica; englobando o cálculo do NAS médio e as taxas de IRAS mensais de cada unidade da UTI, no período de 2016 a abril de 2019. Os dados do NAS foram coletados de planilhas secundárias, sem identificação do paciente, e as taxas de IRAS foram coletadas de informativos do Serviço de Controle de Infecção Hospitalar. Esses dados são de caráter administrativo e público. *Resultados:* O NAS médio foi diferente para cada unidade sendo a Neurológica com a maior carga de trabalho. Em relação às IRAS a unidade Neurológica apresentou maior incidência de IRAS e pacientes com IRAS. A pneumonia associada à ventilação mecânica foi maior nas unidades Cirúrgica e Neurológica. A infecção de corrente sanguínea e do trato urinário foi maior na unidade Clínica. Houve correlação positiva para NAS com PAV na unidade Médica e com infecção do trato urinário na unidade Cirúrgica. Na unidade Neurológica houve correlação negativa do NAS com taxa de IRAS e taxa de pacientes com IRAS. *Conclusão:* O NAS médio observado por nós foi inferior quando comparado a outras UTIs brasileiras, e estas variações podem estar associadas quanto ao tipo de hospital e perfil clínico dos pacientes. Foi possível observar que cada unidade tem sua particularidade quanto à incidência das IRAS e quanto à associação entre NAS (carga de trabalho) e as taxas de IRAS, reforçando a necessidade da estratificação e associação dos indicadores por unidade.

Palavras-chave: Infecção hospitalar; Carga de trabalho; Enfermagem; Unidade de terapia intensiva; Nursing Activities Score.

Resumen

La unidad de cuidados intensivos (UCI) requiere un equipo especializado con recursos humanos adecuados, incluida la enfermería. Para una medición adecuada de la carga de trabajo de los profesionales de enfermería de las UCI brasileñas, se ha utilizado el *Nursing Activities Score* (NAS) para promover una mejor adecuación de las escalas de trabajo. La sobrecarga de trabajo puede aumentar la incidencia de eventos adversos, incluidas las infecciones relacionadas con la atención médica (IRAM). *Objetivo:* Asociar la carga de trabajo de enfermería medida por el NAS con las tasas de IRAM en una UCI de Adultos de un hospital universitario, además de evaluar el impacto de la separación de las UCI por unidad, por tipo de especialización. *Método:* La recolección de datos se realizó en la UCI de Adultos brasileña: estratificada por las especialidades Quirúrgica, Neurológica y Clínica; incluyendo el cálculo de la media de NAS y las tasas mensuales de IRAM de cada unidad de UCI, desde 2016 hasta abril de 2019. Los datos de NAS se recogieron a partir de hojas de cálculo secundarias, sin identificación del paciente, y las tasas de IRAM se recogieron a partir de información del Servicio de Control de Infecciones Hospitalarias. *Resultados:* La media de NAS fue diferente para cada unidad, siendo la neurológica la media más alta carga. En relación con las IRAM, los pacientes neurológicos tuvieron una mayor incidencia de IRAM y los pacientes con IRAM. La neumonía asociada a la ventilación mecánica fue mayor en unidades Quirúrgico y Neurológico. La infección del torrente sanguíneo y del tracto urinario fue mayor en la unida Clínica. Hubo una correlación positiva para NAS y PAV en la unidad Clínica y con la infección del tracto urinario en la unidad Quirúrgica. En el unidad Neurológico hubo una correlación negativa del NAS con la tasa de IRAM y la tasa de pacientes con IRAS. *Conclusión:* La media de NAS observada por nosotros fue menor en comparación con otras UCI brasileñas y las variaciones pueden estar asociadas con el tipo de hospital y el perfil clínico de los pacientes. Se pudo observar que cada unidad tiene su particularidad en cuanto a la incidencia de IRAM y la asociación entre NAS (carga de trabajo) y tasas, reforzando la necesidad de estratificación y asociación de indicadores por unidad.

Palabras clave: Infección hospitalaria; Carga de trabajo; Enfermería; Unidad de cuidados intensivos; Nursing Activities Score.

1. Introduction

The intensive care unit (ICU) is a hospital inpatient unit consisting of continuous and high complexity care for patients with severe clinical conditions at risk of imminent death using technological resources, and monitoring of specialized and multidisciplinary teams (Lima et al., 2013). In tertiary hospitals where most ICUs are located, patients who arrive are assigned to different modalities of ICUs according to their age group: neonatal ICU newborns up to 28 days; Pediatric ICU patients aged 29 days to 14 years incomplete; patients aged 14 years and under 18 years of age can be seen in the adult ICU or pediatric ICU according to the standards of each institution; although patients over 14 years of age are predominantly seen in adult ICU. In addition, there are specialized ICUs that differ from general ICUs to assist patients with a certain medical specialty or selected by a set of similar diseases that may include, for example: cardiac, medical, neurological, surgical, and other ICUs (Brazil, 2010).

The complexity and specificity of ICU care infers in the way these units should be adequate and planned according to the needs presented by patients, often these criteria are determined by legislation (Brazil, 2010). Thus, the physical structure, human resources and material resources should be adequate to provide satisfactory care to these patients (Tranquitelli & Ciampone, 2007). In the case of human resources, studies show that specifically the overload of nursing work and the inadequate dimensioning of these professionals have contributed to occurrences of adverse events to patients hospitalized in ICU (Novaretti et al., 2014; Gonçalves et al., 2012). Thus, ICU patients usually have a higher degree of dependence on nursing care and therefore, the dimensioning of nursing professionals should be adequate for each degree of care these patients need (Inoue & Matsuda, 2009). A study conducted in an ICU specialized in trauma presented a high nursing workload and this work overload can directly reflect on the quality of care and hospital outcomes (Goulart, et al., 2014), which is why the adequate dimensioning of professionals is so significant within an ICU.

Over the years, several scales and instruments have been developed that have become a means to assist in quantifying the workload of the nursing team according to the demand for care (Inoue & Matsuda, 2009). Being widely used in ICUs around the world (Leite, et al., 2012) the Nursing Activities Score (NAS) (Miranda, et al., 2003) is an instrument for measuring workload related to time spent in nursing activities, which in Brazil received translation and validation by Queijo and Padilha (Queijo & Padilha, 2009). The NAS provides a retrospective workload estimate taking into account the last 24 hours of care in which the patient was hospitalized (Miranda et al., 2003); but it also has good prospective applicability (Ducci & Padilha, 2008).

The NAS is the instrument that is widely used in Brazilian ICUs (Inoue & Matsuda, 2009), and should be applied daily according to the legal needs of health surveillance agencies that recommend monitoring the workload of ICU professionals (Brazil, 2010). Any workload indicator can be easily associated with other indicators of quality of health and care practices, such as adverse events, mortality and healthcare-associated infections (HAI). HAI are characterized by infections acquired after the patient's admission or that manifests after discharge being related to hospitalization or hospital procedures (Brazil, 1998). To monitor the evolution of rates of HAI in Brazilian hospital units, it is recommended through Resolution N. 7 of February 24, 2010 (Brazil, 2010) that the Hospital Infection Control Commission ("Comissão de Controle de Infecção Hospitalar" in Portuguese) must evaluate the ICUs in a routine and active way and, in addition, interpret and disseminate the institution's infection rates. This monitoring generates mandatory and public domain indicators in health services (Brazil, 2010). Often these indicators are not associated with each other or with others, being only collected and informed to the services for legal reasons.

Taking into account, that ICUs have a density of use of invasive devices and patients with complex clinical conditions it is necessary to know if work overload occurs in the unit and understand how this has an impact on HAI, since invasive procedures, work overload and inadequate sizing may be directly related to the development of hospital infections (Aycan et

al., 2015). In this sense, the workload also plays an important role even in the process of prevention of HAIs, as observed in the case of implementation of bundles that involves simple prevention measures, these actions proposed by bundles have led to an increase in workload that eventually proves imperceptible to nurses (Branch-Elliman et al, 2015). For better management, it is essential to associate the workload in the units with the assistance indicators.

Infection rates in ICUs have shown wide variation between units, in a study for Brazilian units, there has been a variation in the prevalence of 4 to 69% of patients with HAIs depending on the state or mesoregion (Braga et al., 2018). This wide variation is often related to the profile of each unit, such as whether the ICU is specialized or general, whether the hospital is teaching or not and the number of beds of the institution; both may affect the incidence of HAI and together could explain such variation (e.g. Braga et al., 2018). This is also reflected in the Nursing workload, since different unit profiles present differences in care needs and workload measured by NAS (Mendes-Rodrigues et al., 2017). As observed in some studies, the indication of one nursing professional for every two ICU patients is often below the needs of institutions, since the mean NAS in most cases has shown values higher than 50 points (Mendes-Rodrigues et al., 2017; Nogueira et al., 2015). Knowing the factors associated with increased workload and how this influences patient care and the development of HAI can generate contributions to health services, promoting improvements in health care practices.

The use of NAS as an instrument evaluating the nursing workload has been considered important for the service in the care and management issue in ICUs for promoting better dimensioning and adequacy of their work scales according to the clinical profile of patients and, from this, being able to elaborate a care planning involving quality in patient care (Inoue & Matsuda, 2009). As in health services there are other health indicators that also interfere in the quality of health care, associating workload and infection indicators can bring us results that show the impact of this association directly on nursing care planning.

In view of the above, this study aims to associate the Nursing workload with the incidence rates of healthcare-associated infections in an adult Intensive Care Unit of a Brazilian university hospital stratified by unit (or specialty), in addition to evaluating the difference in nursing workload and rates of healthcare-associated infections between Medical, Surgical and Neurological units.

2. Methodology

2.1 Study site

This is a quantitative, analytical, descriptive, ecological, documentary, retrospective and correlational research. The study was carried out at the *Hospital de Clínicas de Uberlândia* of the Federal University of Uberlândia (HCU-UFU), Uberlândia – state of Minas Gerais, Brazil. The HCU-UFU is a tertiary, teaching and university hospital of reference in medium and high complexity care for the city of Uberlândia and the region of *Triângulo Mineiro*.

Data were collected in the Adult Intensive Care Unit, which is subdivided into the Surgical, Neurological and Medical specialty units. In total, the three units have 30 beds (9 for Surgical unit, 9 for Neurological unit and 12 for Medical ICU). The ICU provides assistance to the various patient profiles that are divided for each type of unit: in the Surgical unit, postoperative patients with high complexity trauma victims are treated predominantly, in the Neurological unit are profiles of clinical and surgical neurological involvement and in the Medical unit are patients who have other underlying diseases, except cardiac diseases. The institution has a Cardiology ICU that has not been evaluated here; the NAS data from this unit was previously presented (Almeida Júnior et al. 2021).

2.2 Collection of the indicator Nursing Activities Score

The NAS is a workload instrument applied daily in the units evaluated, although there is no data for long periods in them. This data is recorded in official service documents, physically stored on paper in the units. The total NAS score of each of the 30 beds was collected for the period, typed in electronic spreadsheets, and organized by ICU type. The descriptive statistics of NAS was calculated for each unit and the mean NAS for each month from January 2016 to April 2019. The mean NAS value was considered as a monthly indicator of workload and was associated with other health indicators such as the incidence rates of HAIs.

2.3 Collection of the nosocomial infection indicator

Hospital-associated infection rates are calculated by the hospital for the three types of infection considered most important and compulsory notification for Adult ICUs in Brazil: central-line-associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infections (CAUTI; long-term catheters); in addition to overall rate of HAI per unit. To perform the diagnoses of these infections, NAS uses criteria recommended by the National Health Surveillance Agency (ANVISA 2017). This criterion did not change in the period

According to the National Health Surveillance Agency (ANVISA 2017) CLABSI should be considered a pathogen identified in one or more blood cultures and the identified microorganism should not be related to another infectious focus. For the diagnosis of VAP, microbiological signs are considered, clinical signs such as fever greater than 38 °C, leukopenia less than 4000 cells per mm³ or leukocytosis greater than 1200 cells per mm³, purulent secretion, auscultation with snoring or rales and also radiological examinations such as tomography or chest X-ray. And for CAUTI, it is considered the presentation of one of the signs and symptoms without other known causes such as fever (greater than 38 °C), suprapubic or lumbar pain and if it has positive urine culture with up to two microbial species with greater than or equal to 10⁵ colony-forming units per milliliter.

2.4 Ethical and legal aspects

Infection rates are public data and for institutions are mandatory to perform calculations and disseminate results according to legislation (ANVISA 2017). All indicators were collected without the identification of the patients who generated the data, since data already treated by the units were collected. All data are secondary, public, administrative in nature and do not allow the identification of any patient. There will be no criteria for excluding the monthly data provided by the unit, since they are official indicators. The work for involving secondary and public data was not submitted for evaluation by the Research Ethics Committee of the institution for evaluation.

2.5 Statistical analyses

Continuous quantitative data were presented as mean and standard error. Data normality was tested using the Kolmogorov Smirnov Lilliefors test. For the analyses, the data will be tested and presented by subunit of the ICU, representing the specialties. For all analyses, a significance of 0.05 was adopted. The analyses were performed in the IBM SPSS program or in the R environment (R CORE TEAM 2022).

2.5.1 Comparison of ICU specialties: For the characterization of NAS and infection rates in subunit or specialty, data available from January 2017 to April 2019 were included, a period where data are available per subunit. All records for the period were included. NAS data were tested for adjustment to Gaussian probability distribution by Kolmogorov-Smirnov Lilliefors test (`lillie.test`, package `nortest`) and Gamma with unknown parameters (`gamma_test`, package `goft`, library

fitdistrplus; results not shown). All period data were included. For comparison between the NAS of adult ICU subunits, generalized linear models were used, adopting Gaussian distribution function and identity link function (better AIC compared to Gamma). For pair-to-pair, Tukey test (library multcomp) was used. Generalized linear models and the test of the least significant difference for multiple comparisons were also used to compare infection rates, adopting Gaussian distribution function and identity-type binding function. In these analyses, the subunit factor and the month factor in the model were considered.

2.5.2 Correlation between mean NAS and infection rates:

For the calculation of the correlation of the mean NAS with the infection rates, three analyses were performed, since both variables suffered the effect of the specialty or unit. Spearman's correlation coefficient was adopted for all correlations. The significance of the coefficient was tested with student's *t*-test for correlation.

In the first correlation, for the Adult ICU unit, the effect of NAS on HAI rates without stratification of ICUs per specialty was tested, and the available data from January 2016 to April 2019 were included, totaling 40 months. In this case, the mean NAS and infection rates were calculated for all ICU beds for each of the months without considering the specialty. This correlation measured the overall correlation for the Adult ICU, regardless of specialty.

In the second correlation, the data were correlated for each subunit independently. For stratification according to the Surgical, Medical and Neurological units, data were included from January 2017 to April 2019, since subunit infection rates are only available by unit from 2017. NAS means were calculated for each subunit only for the months where there were more than 50 NAS evaluations. 23 months were included, respectively; 22 and 22 months respectively for Surgical unit, Medical unit and Neurological unit. It was necessary to exclude one month from the Neurological unit, with a mean NAS value much higher than usual (November 2017 = 73.67) and the one-month data of the incidence rate of VAP for the Surgical unit that presented a very atypical value (January 2017 = 103.45). There was no justification for the inclusion of these two discrepant data in the analysis, and they were considered as extreme data or outliers. This correlation measure the effect of NAS in each ICU unit.

From the data described above for the units, a third correlation measure was performed. This was performed with data from each unit standardized (residuals use) to remove the effect of the subunit. For standardization, we calculated the residuals of each observation by the subtraction of the observation of the month minus the mean of the unit later divided by the standard deviation of the unit (see theoretical justification for residuals use in Santana & Ranal 2006). This correlation measure the correlation of the NAS and the ICU rates, without the effect of the unit. This analysis may be necessary since the units may differ in terms of the mean value.

3. Results

The three subunits showed mean NAS values different from each other (Deviance = 32703; *d.f.* = 2, $p < 0.0001$), and in the pair-to-pair comparisons show that all units were different from each other ($p < 0.001$). The Neurological unit had the highest mean NAS with 55.10 points; followed by the Medical unit with 51.84 points and the Surgical unit with 51.16 points. The NAS data did not adjust the probability distributions tested in some cases, and only the Neurological unit followed the Gamma distribution (Table 1). Although the day of the week, month and year of each daily NAS evaluation for both subunits was recorded, its effect on the determination of the NAS were not evaluated and discussed here, there were no longer any specific hypotheses to be tested and studied for the data set. We only demonstrated that the months differ within each subunit, which could interfere with the result of the correlations between the NAS. In the Surgical unit the months differed from each

other (Deviance = 12.23; $df = 24$, $p < 0.0001$), the same happened with the Medical unit (Deviance = 27.64; $df = 23$, $p < 0.0001$) and in the Neurological unit (Deviance = 18.03; $df = 22$, $p < 0.0001$).

We observed that the Neurological unit presented the highest average in relation to the incidence rate of healthcare-associated infections (IRHAI) and the incidence rate of patients with healthcare-associated infections (IRPHAI) (43.85 HAIs per 1000 patient-day and 37.75 patients with HAI per 1000 patient-day). Regarding the incidence rate of central-line-associated bloodstream infection (IRCLABSI), the Medical unit had a higher incidence, followed by the Neurological unit and Surgical unit. The incidence rate of ventilator-associated pneumonia (VAP) was higher and equal in the Surgical unit and Neurological unit with an average of 19.51 and 18.12 VAP per 1000 ventilator-day, respectively. For the incidence rate of catheter-associated urinary tract infection (IRCAUTI), the Medical and Neurological units had a higher incidence than the Surgical unit (Table 2). The three units also showed differences in the utilization rates of central catheter, ventilator and urinary catheter. (Table 2)

Evaluating the correlation for each unit independently, the results were different between the specialties (Table 3). The correlation between NAS and infection rate was positive for incidence rate of catheter-associated urinary tract infection in the Surgical unit ($rs = 0.6021$; $p = 0.0024$), while in the Medical unit the correlation was positive for incidence rate of ventilator-associated pneumonia ($rs = 0.4661$; $p = 0.0288$). In these cases, the high nursing workload can lead to an increase in these types of infection related to healthcare. In the Neurological unit, the correlation was negative with IRHAI ($rs = -0.5506$; $p = 0.0097$) and with IRPHAI ($rs = -0.6104$; $p = 0.0033$), an inverse relationship showing that the high workload can lead to lowest infection rate in this unity.

The correlation between infection rates and NAS for the ICU showed contradictory results when calculated by originals data or residuals in the period where the rates were calculated per unit. In the correlations based on residuals, only the correlation between NAS and IRHAI was significant ($rs = -0.2719$; $p = 0.0272$). Taking into account the data calculated for the ICU as a whole that include the period from 2016 to April 2019, without discriminating the units; the IRVAP had a positive correlation with the NAS ($rs = 0.3497$; $p = 0.0279$). In this period, the correlation was also significant and negative between the NAS and the IRHAI ($rs = -0.4386$; $p = 0.0046$) and with the IRPHAI ($rs = -0.3296$; $p = 0.0378$). (Table 3)

These contradictory results for the ICU can be explained by the effect of the subunits and time on the correlation, since the results differ from the original data, with the use of residuals and when they are evaluated for the ICU without stratification. The analyses reinforce the need for ICU stratification to better understand the relationships between indicators and the effect of inclusion or not of long periods in the analysis.

Table 1: Descriptive statistics for Nursing workload measured by the Nursing Activities Score (NAS) in an adult intensive care unit structured by specialty in a Brazilian tertiary university hospital.

Statistic	Adult ICU stratified by specialty or unit			Adult ICU (all specialties)
	Surgical	Medical	Neurological	
N	4246	3112	3556	10914
Minimum	19.70	27.60	32.40	19.70
Quartile 1	44.90	48.00	50.90	48.00
Median	51.30	51.20	55.85	52.80
Quartile 3	55.90	56.20	59.00	55.90
Maximum	102.20	86.60	86.70	102.20
Mean	51.16	51.84	55.10	52.64
Standard error	0.13	0.14	0.12	0.08
Standard deviation	8.77	7.86	6.99	8.15
Coefficient of variation	17.15	15.17	12.69	15.49
Interquartile range	11.00	8.20	8.10	7.90
<i>D</i>	0.0592	0.0789	0.0592	0.0538
<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001
<i>V</i>	-4.12	0.42	-8.15	-12.08
<i>P</i>	0.003	0.765	< 0.001	< 0.001

Note: *D* statistic for the Kolmogorov-Smirnov Lilliefors test for normality, *V*: test statistic for adjustment of the Gamma distribution, *p*: probability associated with test statistic. Source: Authors (2019)

Table 2. Healthcare-associated infections incidence rates of an adult Intensive Care Unit (ICU) stratified specialty from January 2017 to April 2019 in a Brazilian tertiary university hospital.

Rate	Incidence rates by ICU specialty ¹				Probability ²	
	Surgical	Medical	Neurological	Unit	Month	
IRHAI	35.78 ± 2.49 b	38.04 ± 2.23 b	43.85 ± 3.39 a	0.007	<0.001	
IRPHAI	31.05 ± 2.2 b	32.36 ± 1.53 b	37.75 ± 2.41 a	0.003	<0.001	
IRCLABSI	7.63 ± 1.22 b	13.12 ± 1.68 a	8.16 ± 1.34 b	<0.001	<0.001	
IRVAP	19.51 ± 3.56 a	10.32 ± 1.26 b	18.12 ± 1.47 a	<0.001	<0.001	
IRCAUTI	7.78 ± 1.83 b	15.67 ± 2.52 a	14.40 ± 3.32 a	0.022	0.140	
Rate	Device utilization incidence rates and by ICU specialty ¹					
DUIR-CL	686.61 ± 23.89 a	708.68 ± 30.76 a	665.31 ± 20.44 a	0.204	<0.001	
DUIR-V	545.08 ± 22.86 c	691.99 ± 25.96 a	635.20 ± 24.99 b	<0.001	<0.001	
DUIR-UC	337.36 ± 19.77 b	324.04 ± 12.84 b	380.33 ± 17.12 a	<0.001	<0.001	
Indicator	Monthly calculation bases by ICU specialty					
N. of HAI	9.54 ± 0.65	13.25 ± 0.84	11.61 ± 0.90			
N. of patients with HAI	8.29 ± 0.58	11.25 ± 0.59	10.00 ± 0.65			
N. of patient-day	268.04 ± 2.29	346.39 ± 6.13	265.18 ± 2.6			
N. of CL-day	184.21 ± 6.87	246.39 ± 11.55	176.64 ± 5.99			
N. of V-day	146.14 ± 6.44	240.50 ± 10.11	168.93 ± 7.43			
N. of UC-day	89.64 ± 4.69	111.36 ± 3.99	100.50 ± 4.32			
N. of NAS by month	182.70 ± 11.97	139.14 ± 10.18	161.23 ± 14.47			
Monthly mean NAS ^{1,2}	51.86 ± 0.71 b	51.6 ± 0.94 b	55.48 ± 1.03 a	0.004	0.005	

Note: SE: standard error; HAI: healthcare-associated infections; CL: central line catheter; V: mechanical ventilator; UC: urinary catheter; NAS: Nursing Activities Scores; IRHAI: incidence rate of HAI per 1000 patient-day; IRPHAI: incidence rate of patients with HAI per 1000 patient-day; IRCLABSI: incidence rate of central line bloodstream infection per 1000 catheter-day; IRVAP: incidence rate of ventilator-associated pneumonia (VAP) per 1000 ventilator-day; IRCAUTI: incidence rate of catheter-associated urinary tract infection (UTI) per 1000 catheter-day; DUIR-CL: device utilization incidence rate of use of CL-day per 1000 patient-day; ; DUIR-V: device utilization incidence rate of use of ventilator-day per 1000 patient-day; ; DUIR-UC: device utilization incidence rate of use of UC-day per 1000 patient-day.

¹ Means followed by different letters on the line differ significantly by the least differences test ($p < 0.05$)

² probability based on the generalized linear model adopting Gaussian distribution and identity-type link function, adopting subunits and months as factors.

Source: the authors (2019)

Table 3. Spearman correlation analysis between mean monthly NAS and healthcare-associated infection incidence rates in an Adult Intensive Care Unit, stratified by specialty in a Brazilian tertiary university hospital.

		Independent by specialty			Grouped ¹		
		Surgical	Medical	Neurological	Use of Residuals	Original Data	Adult ²
		n=23	n=22	n=21	n=66	n=66	n=40
IRHAI	<i>rs</i>	-0.0089	-0.2095	-0.5506	-0.2719	-0.2309	-0.4386
	<i>P</i>	0.9679	0.3494	0.0097	0.0272	0.0622	0.0046
IRPHAI	<i>rs</i>	0.1176	0.0547	-0.6104	-0.1940	-0.0930	-0.3296
	<i>P</i>	0.5931	0.8398	0.0033	0.1185	0.4577	0.0378
IRCLABSI	<i>rs</i>	0.1602	0.1677	-0.2636	0.0448	0.0181	0.0589
	<i>P</i>	0.4652	0.4555	0.2483	0.7209	0.8855	0.7180
IRVAP	<i>rs</i>	-0.1605	0.4661	0.0623	0.0942	0.2437	0.3497
	<i>P</i>	0.4757	0.0288	0.7884	0.4555	0.0504	0.0270
IRCAUTI	<i>rs</i>	0.6021	-0.0901	-0.0695	0.1309	0.1601	0.2930
	<i>P</i>	0.0024	0.6900	0.7648	0.2949	0.1991	0.8577

Note: *rs*: Spearman's correlation coefficient, *p* probability of Student's *t* test for correlation; IRHAI: incidence rate of healthcare-associated infections (HAI) per 1000 patient-day, IRPHAI: incidence rate of patients with HAI per 1000 patient-day; IRCLABSI: incidence rate of central line bloodstream infection (BSI) per 1000 central-line-day; IRVAP: Incidence rate of ventilator-associated pneumonia (VAP) per 1000 ventilator-day; IRCAUTI: incidence rate of catheter-associated urinary tract infection (UTI) per 1000 catheter-day.

¹ Analysis performed with data from January 2017 to April 2019: analysis performed with the residuals (standardized for each subunit) and for the original data of all units together.

² Analysis performed with data from January 2016 to April 2019 regardless of subunit and with rates calculated for the ICU as a whole.

Source: Authors (2019)

4. Discussion

The workload measured by the NAS in this study was close to 52 points. This value is close to that observed in an Adult ICU in Spain where the mean NAS was 50.4 points (Adell et al., 2006). Despite this, it is low when compared to the Brazilian average, which has 71 points (Marangoni, 2019), to a university hospital with 72 points (Cyrino & Dell'Acqua, 2012), and the other ICU that showed 67 points (Queijo, 2002). In the case exclusively of the Neurological unit, which had the highest mean compared to the Surgical unit and Medical unit in this study, the mean value remains below what was found in another Brazilian Neurological ICU that presented 65 points NAS (Queijo, 2008).

NAS variations among ICUs could be explained as much as to the type of hospital (public or private), if secondary or tertiary, as well as the severity of the disease and the profile of patients. A comparative study showed that in a public hospital the NAS on the day of patient admission is 68 points while in the private one it was 56 points (Nogueira et al., 2013). In patients with sepsis, NAS was close to 80 points, while in patients diagnosed with acute respiratory failure an average of 77.6 points (Carmona-Monge et al., 2012). The occurrence of acute renal failure, so common in ICUs, is also able to increase NAS scores from 40.7 to 43.7 points (Coelho et al., 2017). The NAS of admission and the NAS-mean of hospitalization of patients under mechanical ventilation also differed between patients who had VAP or not during hospitalization (Gomes et al. 2019). The profile and diagnoses of admission and hospitalization events may be important to characterize the NAS and may explain the differences observed between the specialties.

We demonstrated clear differences between ICU units, both in the incidence rate device use and in the incidence rate of the HAIs. A similar result had already been demonstrated for CLABSI in 2016 at the same unit (Silva et al., 2022). HAI are

commonly found in the Brazilian ICUs (Braga et al., 2018). Such infections are related to the severity of the patient, high need for invasive procedures and the long stay in the unit (Oliveira et al., 2012; Osme et al., 2020; Osme et al., 2021). When dealing with the incidence rate of health care-associated infections, the Neurological unit had a higher incidence compared to the other units. However, these incidence rates of the subunits differ from that found in a university hospital in Germany that showed an incidence of 25 HAI per 1000 patient-day (Dettenkofer et al., 2001). Regarding the Medical and Surgical unit, the results are lower, but close to that found in a Brazilian ICU that had an average of 36.22 HAI per 1000 patient-day (Martins, 2006).

As observed, IRVAP in the Surgical unit and Neurological unit is higher than in the Medical unit, which has the highest rate, and is higher in relation to other infections. These findings corroborate a study conducted in a mixed ICU with a profile of neurological and postoperative patients of major surgeries that, among the infections, pneumonia associated with mechanical ventilation was predominant (Sousa, 2016). The incidence of VAP in the Neurological unit was close to that observed in a study at the Hospital do Canada that showed 18.4 VAP per 1000 ventilator-day (Abulhasan et al., 2018). In a Brazilian Surgical unit, a higher value was observed than ours with an incidence of 58.2 VAP per 1000 ventilator-day (Carrilho, 2006). A value close to that observed by us was also found in an ICU with a clinical-surgical profile in which the incidence was 20.23 VAP per 1000 ventilator-day (Martins, 2006). From the international perspective, a higher incidence was also found in a Hospital in Argentina that had 46.3 VAP per 1000 ventilator-day (Rosenthal et al., 2004). Studies show that the increased incidence of ventilator-associated pneumonia is related to ICU stay and long-term use of the mechanical ventilator (Silva et al., 2011; Mota et al., 2016; Burigo, 2002). However, in this study we did not analyze length of stay of hospitalization or the time of use of mechanical ventilation. In a cohort for patients admitted to mechanical ventilation in the same unit, the time of mechanical ventilation before ICU admission was a risk factor for pneumonia associated with mechanical ventilation, while the time of ventilation in the ICU was not a factor that increased the occurrence, probably due to the better execution of preventive actions in the ICU (Gomes, 2018; Gomes et al., 2019, 2020). In the same cohort, the agreement to some measures to the VAP prevention bundle in the ICU was the same among patients with and without VAP during ICU hospitalization (Gomes et al., 2020).

The Clinical unit had a higher incidence rate for urinary tract infection than the other units, and this result differs and is higher than that found in other Brazilian hospitals that showed an incidence of 13.85 CAUTI per 1000 catheter-day (Miranda, 2016), 6.1 CAUTI per 1000 catheter-day (Prates, 2014) and 11.44 CAUTI per 1000 catheter-day (Ferrão, 2010). In addition, our incidence is also higher than that found in the Hospital of Canada, which had 9.6 CAUTI per 1000 catheter-day (Laupland et al., 2005). In Mexico, four public hospitals were analyzed and the incidence was 13.4 CAUTI per 1000 catheter-day (Barba et al., 2006). The result found in this study draws attention since it is far above what was found in the literature. In the institution evaluated here, the publication of a multiprofessional protocol of probing, training and change of catheterization performer among nursing professionals decreased the incidence rate of CAUTI from 14.41 to 4.66 CAUTI per 1000 catheter-days in 2015 (Mendes-Rodrigues et al., 2017), and perhaps this increase after the period reflects the non-continuity of preventive actions or other risk factors still unknown in this population.

Monitoring the incidence of HAI is necessary, since they are associated with mortality, increased hospitalization time and increased financial cost of health institutions (Al-Tawfiq & Tambyah, 2014; Osme et al., 2020; Osme et al., 2021). A daily expenditure of R\$666.47 related to bloodstream infection was observed in a Brazilian hospital, R\$495.00 for urinary tract infection related to urinary catheter and R\$602.17 for ventilator-associated pneumonia (Nangino et al., 2012). In addition, the total cost of hospitalization in patients who developed ventilator-associated pneumonia in a European hospital had an average cost of \$99,598 (Kollef, 2012). Since the cost to the Unified Health System, reimbursement cost, of patients with VAP is higher than those without, in the hospital studied here (Gomes, 2018; Gomes et al., 2019, 2020), mainly related to the increase

in hospitalization time. The reimbursement cost per hospitalization of patients with HAI was 75% (US\$2721) higher than patients without HAI (US\$1553) in 2018 in that same unit and a HAI in the ICU was associated with a total cost direct eight times higher compared with patients who did not develop infections in this unit, US\$11,776 versus US\$1329, respectively (Osme et al., 2020). The impact on the direct costs for Brazil public service became significant starting at a 10% prevalence of HAI, where US\$2,824,817 is added for each 1% increase in prevalence of HAI (Osme et al., 2021). In this context we can perceive the financial and administrative impact that HAI have for health services, and thus, understanding how HAI influence the units makes us have prevention strategies to reduce infections and consequently hospital costs.

As observed, the Medical unit presented a positive correlation between NAS and IRVAP, that is, the high workload increases the rate of VAP. This analysis corroborates a study conducted in a university hospital in Geneva that showed an increased risk of VAP when a lower proportion of nurse-patient occurs (Hugonnet et al., 2007). At the same time, when we analyze the Adult ICU as a whole without discriminating the type of unit, the incidence of IRVAP still positively correlates with the workload; whereas for the subunits the correlation was significant only in the Clinical ICU. We can conclude that the result of the positive correlation of the NAS and the ICU as a whole is the result of the influence of the Medical unit. Thus, it is important to highlight that analyzing the units separately can better observe the profile and determinants of infections that occur in each one and, thus, to outline strategies regarding the reduction of these infections. The causal relations between NAS and HAI need additional investigations, mainly evaluation the risk factors for each type of HAIs and ICU specialty.

Likewise, the Surgical unit of this study showed a positive correlation for NAS and incidence rate catheter-associated urinary tract infection. This finding is similar to a study carried out in a large university hospital that also observed the same type of correlation (Magalhães et al., 2017). It is known that the length of stay of the urinary catheter is a risk factor for the increased incidence of urinary tract infection, based on this, a hypothesis for this result is that an overloaded team may be inattentive to the time of use of the invasive device or specific care and this enhances the increased risk of developing urinary tract infection.

Contrary to what we would expect the Neurological unit showed a negative correlation, that is, the increased workload is associated with a decrease in infection rates for this unit. It was observed in a Neurological unit a negative correlation associating severity and NAS and, from this, they inferred that in an environment in which there is a profile of more severe patients, the team begins to have a differentiated look intensifying more attentive behaviors with regard to the care of these patients (Queijo, 2008). Thus, we could start from the same hypothesis to explain the result found in the Neurological unit of this study. Gomes et al. (2019) observed that with a greater increase in NAS in patients on mechanical ventilation, the risk of VAP decreased, this increase could serve as a warning to the team that would offer more care to these patients. Another hypothesis is that some specific variable of these patients could justify this result, but studies at the patient level are still needed to understand the result. We also need to evaluate the correlation of NAS with other HAIs like surgical site infections to understand this relation. The IRHAI and IRPHAIS included other infections not evaluated here.

Bloodstream infections rates were not correlated with the NAS indicator. Interestingly, in the ICU evaluated here, if the central line catheter was installed outside the ICU there was an increase in the chances of catheter infection; and bloodstream infection also increased the chances of mortality (Silva et al., 2017). These data reinforce that even nursing or health care outside the ICU may interfere with the incidence of HAI in the ICU. Eventually, if the patient admitted to the ICU received care prior to ICU admission to a unit with work overload, this could lead to the greatest risk of developing HAIs in the ICU. Corroborate the findings of the association of NAS and hospital infection, a study that analyzed NAS and HAI and showed that work overload was the main factor for the occurrence of infections (Daud-Gallotti et al., 2012).

Some studies have demonstrated the use of NAS associating with other health indicators. When evaluating the NAS and the Braden Scale, they showed that the higher the nursing workload, the greater the risk of developing pressure ulcers (Oliveira, 2012). Likewise, analyzing NAS and APACHE II (Acute Physiology and Chronic Health Evaluation) a system that assesses the patient's severity index, showed a positive correlation for mortality with elevated NAS (Nogueira et al., 2007). Thus, the high workload of nursing within intensive care units can lead to an increase in the occurrence of adverse events, negatively affecting the quality of nursing care (Oliveira, 2016). Thus, the NAS can be used in other comparisons besides healthcare-associated infections in order to show the effects that the workload can have on health care.

Study Limitations

For this study, the demographic characteristics and clinical profile of the patients or the severity and mortality indices were not analyzed. Other clinical variables were also not analyzed, such as the time of pre-infection hospitalization and the time of use of invasive devices. Thus, there are limitations so that it could explain the results found in this study as well as the cause-and-effect relationships. Cross-sectional cohort studies are still needed that can look for which risk factors and how each patient's workload is determinant in predicting HAI.

5. Conclusion

The mean NAS observed by us was lower and different among adult ICU specialties when compared to other Brazilian hospitals. These variations may be associated with the type of hospital and the clinical profile of patients in each unit, not evaluated here. It was possible to observe that each unit has its particularity regarding the incidence of infections and is the essential stratification in the construction of prevention strategies. There was an association in the rate of pneumonia associated with mechanical ventilation and NAS for the Medical unit, and for the Surgical unit correlation of urinary tract infection rate and NAS. Unlike the other units, in the Neurological unit the workload reduces infection rates with a negative correlation. These results corroborate the need to think and relate indicators by subunit, which provides a better picture of the reality of these specialties.

Acknowledgments

We thank the Nursing team of the Adult Intensive Care Unit of the “Hospital de Clínicas de Uberlândia” for the collection and availability of data and support. The “Empresa Brasileira de Serviços Hospitalares” (EBSERH) for its support. The “Pro-Reitoria de Graduação” (PROGRAD), “Conselho Nacional de Desenvolvimento Científico e Tecnológico” (CNPq) and the Federal University of Uberlândia for the scholarship offered to Ana Laura Lima de Jesus (PROGRAD Project 1316) and Elias Rodrigues de Almeida Júnior (PIBIC/PIBITI CNPq). This paper is part of the end-of-course work of the first author.

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