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Nursing workload: is it a predictor of healthcare associated infection in intensive care unit?

Carga de trabalho de enfermagem: preditor de infecção relacionada à assistência à saúde na terapia intensiva?

La carga de trabajo de enfermeira: predictor de infección hospitalaria en unidades de cuidados intensivos?

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ABSTRACT

Objective: To analyze the influence of nursing workload on the occurrence of healthcare associated infection (HAI) in patients in the intensive care unit (ICU), according to type of treatment. **Method:** Retrospective cohort study developed in nine ICUs in São Paulo, Brazil, from September to December 2012. Nursing workload was measured by the Nursing Activities Score (NAS). The Student's t and Fisher's exact tests and logistic regressions were used in the analyses. **Results:** The sample was composed of 835 patients (54.3±17.3 years; 57.5% male), of which 12.5% acquired HAI in the ICU. The NAS of the patients admitted for clinical treatment was 71.3±10.9, and for surgery 71.6±9.2. Length of stay in ICU and severity were predictive factors for occurrence of HAI in patients admitted to the unit for clinical or surgical treatment, and male sex only for surgical patients. When considering the admissions independent of type of treatment, in addition to the variables mentioned above, index of comorbidities also remained in the regression model. The NAS was not a predictive factor of HAI. **Conclusion:** Nursing workload did not influence occurrence of HAI in the patients included in this study.

DESCRIPTORS

Workload; Risk Factors; Cross Infection; Nursing; Team; Intensive Care Units.

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INTRODUCTION

Healthcare associated infections (HAI) are a public health problem that represent significant risk to patient safety, besides generating adverse economic impact, especially in developing countries. Lower levels of economic development correlate to higher rates of HAI[1-2].

Despite being the most frequent adverse event in hospitals, the low quality of records, difficulty in obtaining reliable data and lack of standardization of terms hinder surveillance of HAI[3].

HAI acquired in intensive care units (ICU) represent almost 20% of all hospital acquired infections diagnosed among hospitalized patients, with significant morbidity and mortality rates and high costs for the health care system, patients and their families[3-5].

Because they are critically ill and require various invasive procedures, patients admitted to ICU are often affected by various types of HAI. It is estimated that about 30% of patients admitted to ICU have at least one episode of infection, especially urinary tract infection (UTI), ventilator-associated pneumonia (VAP) and bloodstream infection (BSI)[3-5].

The occurrence of these infections is associated with an aging population and the increasing complexity of patients treated in the ICU, combined with the presence, type and duration of many invasive procedures such as vesical and venous catheterization, orotracheal intubation for mechanical ventilation, and failures related to the use of antimicrobial agents[1].

It should be noted that development of HAI combined with the inherent complexity of care for ICU patients can directly impact nursing care and cause overload in the staff. On the other hand, overloading of the nursing staff in an ICU may favor or predispose development of HAI.

Excessive nursing workload was indicated as one of the main risk factors for the development of HAI in clinical patients admitted to ICU, regardless of other factors related to the patient and some procedures[6].

Recent studies that analyzed more than 300 ICUs reported that work environments with higher nurse-patient ratios are associated with decreased rates of HAI and mortality. It is also significant that the greater the number of nursing professionals with higher education in nursing, the greater the impact on patient survival[5,7].

In fact, the nursing workload has been shown to be an important factor in the development of adverse events in patients admitted to the ICU. Moreover, it is reasonable to assert that the occurrence of such events is directly reflected in the rupture from the assumptions of patient safety. Considering the scarcity of studies that investigate the relationship between nursing workload and HAI in critical care patients, this study aimed to analyze the influence of nursing workload on the occurrence of HAI in patients admitted to ICU according to type of treatment.

METHOD

This was a retrospective cohort study conducted in nine specialized ICU (surgery, clinical medicine, emergency clinical medicine, infectious diseases, nephrology, neurology, pneumology, trauma and burns) of a highly complexity public hospital in the city of São Paulo, Brazil. Together, these ICU have about 75 beds. The research project was approved by the local ethics committee (protocol number 0196/2011), and current recommendations for research involving human subjects were followed[8].

Sampling was non-probabilistic, and the following inclusion criteria were considered in the selection of patients: age of 18 years or older, and admission in one of the ICU in the institution during the period from September 03 to December 1, 2012, for clinical or surgical treatment. The data were collected by means of analysis of patients' medical records; patients whose records were not located in the institution's department of medical records by January 31, 2013 were excluded.

The dependent variable of the study was the occurrence of HAI during the patients' stay in the ICU, distributed into two groups according to absence or presence of HAI. For identification of HAI, the classification of adverse events/incidents (AE/I) proposed by the World Health Organization was used[9].

By definition, incidents are events or circumstances that have resulted or may result in unnecessary damage to the patient, and are divided into four subgroups: circumstance of risk, condition, near miss, and incident without damage or adverse event (known as incident with damage). Adverse events/incidents are classified into 13 groups[9], of which hospital infection is the focus of this study.

Independent variables analyzed were sex, age, length of stay in ICU, nursing workload according to the Nursing Activities Score (NAS)[10], comorbidities according to Charlson's Comorbidity Index (CCI)[11], and severity according to risk of death calculated by the Simplified Acute Physiologic II (SAPS II)[12] and Logistic Organ Dysfunction System (LODS)[13] indexes.

Descriptive analyses were performed to indicate measures of central tendency and dispersion. The Student's t-test was used for comparison of means between continuous variables, and Fisher's exact test was used to test the association between nominal variables.

Multiple logistic regressions were used to identify the predictive factors of occurrence of HAI in the ICU according to cause of admission. Three models were built: 1) for the total number of admissions, regardless of cause; 2) for admissions for clinical treatment; and 3) for admissions for surgery treatment. For construction of the final models of these regressions, all variables of the study were tested by the method of stepwise backward. The predictive ability of the models was evaluated by Receiver Operating Characteristics curve (ROC curve). For analysis of the discriminatory power of the model, the value

of the area under the curve (AUC) was set at >0.70, to be regarded as the indicator of acceptable discriminatory power[14]. All tests were two-tailed, and the value of *p* was set at 0.05 for an α of 5%.

RESULTS

The sample was composed of 835 participants, most of which were men (57.5%), admitted into the nine ICUs. The mean age of the participants was 54.3±17.3 years, and the mean age of the women was significantly higher than that of the men (56.3±17.8 *vs.* 52.8±16.8; *p*<0.003).

With regard to causes of admission, 63.4% of the patients were admitted into ICU for clinical treatment and 36.6% for surgical treatment. There were a higher number of admissions to ICU of emergency clinical medicine (26.6%) and trauma (22.8%), followed by surgery (17.0%) and neurology (15.1%); 4.2% of cases were admitted to the ICU of infectious diseases.

The median length of stay of patients was 4.0 days (zero to 118 days), with the longest median length of stay in the burn ICU: 22.5 days (one to 71 days). The second longest length of stay was observed in the Infectious Disease ICU, with seven days (zero to 42 days). In the other ICU, the median length of stay varied from three to five days.

Of the total number of participants, 104 (12.5%) presented HAI during their stay in ICU, the majority of them (n=57, 54.8%) had only one infectious event. The others (n=47; 45.2%) presented two to eight infectious events. The occurrence of HAI was more frequent in the trauma (26.9%) and emergency clinical medicine (19.2%) ICU.

The male patients had more episodes of HAI than the female (67.3% vs. 32.7%; p<0.034), and occurrence of HAI was significantly higher in admissions for clinical than surgery treatment (p<0.003). Length of stay in ICU (18.6±16.7 days) and risk of death estimated by means of the LODS (27.9±10.6 points) and the SAPS II (23.8±8.5 points) were associated with the occurrence of HAI (p<0.001). Table 1 presents the characteristics of study subjects according to cause of admission to ICU (clinical or surgical).

Table 1 - Characteristics of participants with HAI, according to cause of admission – São Paulo, SP, Brazil, 2012.

	Cause of Admission	
	Clinical Treatment (n=529)	**Surgical Treatment (n=306)**
Sex (N;%)		
Male	42; 40.4	28; 26.9
Female	26; 25.0	8; 7.7
Age (mean±SD)	55.2±17.4	53.8±16.3
Nursing Activities Score (mean±SD)	71.3±10.9	71.6±9.2
Charlson's Comorbidity Index (mean±SD)	1.9±1.8	1.6±2.0
SAPS II* (mean±SD)	22.3±7.5	26.8±9.7
LODS ** (mean±SD)	25.9±9.9	31.6±11.2
Length of stay in the ICU (median; variation)	13.5; 1-118	16.0; 0-55

* Risk of death estimated by the SAPS II; ** Estimated risk of death by the LODS. Note: (n=104).

Considering all clinical and surgical admissions into the ICU of the study, it is observed that the male sex, length of stay in the ICU, CCI and risk of death as assessed by the SAPS II were predictive factors for occurrence of HAI in patients during their stay in ICU. The odds ratio of individuals of the male sex presenting HAI was 1.65 compared to women. In addition, for each day of hospitalization or addition of one point on the CCI and on the risk of death as calculated by the SAPS II, the likelihood of the patient acquiring an infection increased by 9%, 13% and 7%, respectively (Table 2).

Table 2 - Logistic regression model of the predictive factors of occurrence of HAI in patients admitted into the ICU of the study - São Paulo, SP, Brazil, 2012.

Variables	β	Exp (β)	CI 95% Exp (β)	*P*-value
Male sex	0.50	1.65	1.00-2.71	0.049
Length of stay in the ICU	0.07	1.09	1.07-1.12	<0.001
Charlson's Comorbidity Index	0.12	1.13	1.01-1.26	0.029
Risk of death by the SAPS II	0.06	1.07	1.03-1.10	<0.001

Note: (n=835).

By analyzing the regression model in patients admitted for clinical treatment in the different study ICUs, it was observed that length of stay in the ICU and risk of death evaluated by the SAPS II were independently associated with the occurrence of this outcome. For each day of hospitalization in the ICU or each increase of one point of

risk of death as calculated by the SAPS II, the chance of the patient acquiring infection in ICU increased by 9% and 6%, respectively. Male sex and the CCI did not remain in this model (Table 3).

Table 3 - Logistic regression model of the predictive factors of occurrence of HAI in patients admitted for clinical treatment to the ICUs of the study - São Paulo, SP, Brazil, 2012.

Variables	β	Exp (β)	CI 95% Exp (β)	*P*-value
Length of stay in the ICU	0.09	1.09	1.06-1.12	<0.001
Risk of death by the SAPS II	0.06	1.06	1.02-1.11	0.007

Note: (n=529).

Analysis of the model for patients admitted for surgical treatment indicated that the chance of acquiring HAI was approximately three times higher in men than women. Moreover, the addition of a day of hospitalization of the ICU and one point of risk of death according to the SAPS II increased the chance of the patient having HAI by 9%. The CCI did not remain in this model (Table 4).

Table 4 - Logistic regression model of the predictive factors of occurrence of HAI in patients admitted for surgical treatment in the ICU of the study - São Paulo, SP, Brazil, 2012.

Variables	β	Exp (β)	CI 95% Exp (β)	*P*-value
Male sex	1.03	2.81	1.05-7.52	0.040
Length of stay in the ICU	0.09	1.09	1.06-1.13	<0.001
Risk of death as per SAPS II	0.08	1.09	1.03-1.14	0.001

Note: (n=306).

The AUC of the regression models for the total number of admissions, admissions for clinical treatment and admissions for surgical treatment were 0.841, 0.832 and 0.849, respectively, indicating excellent discriminatory power, i.e. satisfactory capacity of the models to identify the predictive factors of occurrence of HAI in patients with different causes of admission, in the various ICU (Figure 1).

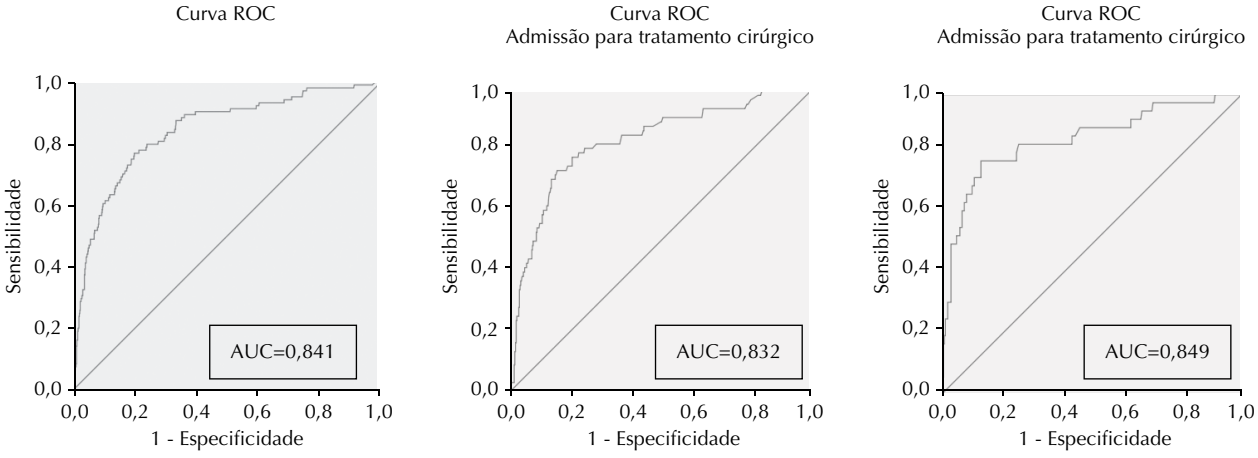

Figure 1 - ROC curves of the logistic regression models related to predictive factors of occurrence of HAI (A – total number of admissions; B – admissions for clinical treatment; C – admissions for surgical treatment) - São Paulo, SP, Brazil, 2012.

The variable NAS, the focus of this study, did not remain in any of the models described above. Therefore, the nursing workload did not influence the occurrence of HAI in the ICU of the study.

DISCUSSION

The present study identified predictive variables of HAI in clinical and surgical patients admitted to ICU. It was found that being of male sex, length of stay in the unit, severity and comorbidities were independent predictive factors of development of HAI in these patients. The occurrence of HAI was significantly associated with admissions for clinical treatment compared to admissions for surgical treatment. The scientific literature shows that the occurrence of HAI has been associated with prolonged stay in ICU, with increased mortality, costs and overload of nursing staff, regardless of age of the patient [15-16].

One recent study aiming to identify which variables were associated with mortality among clinical and surgical patients admitted to ICU observed among 827 admissions that, despite the patients admitted for clinical medicine presenting more HAI, these infections were independent risk factors for mortality only among patients hospitalized in surgical ICU. It is noteworthy that the severity of patients analyzed by the SAPS II was independently associated with mortality in the two categories of patients[17]. Despite the variable mortality not having been the focus of the present study, it highlights the influence that the infection and severity of the patients have over this outcome.

The variable NAS, of interest to this study, did not remain in any of the statistical models used, suggesting that nursing workload did not influence the occurrence of HAI in the ICU of the study. This instrument expresses the time required to provide nursing care to critically ill patients in a period of 24 hours. The NAS is calculated considering 23 activities developed by nursing staff, divided into seven major categories (basic activities, ventilatory support, cardiovascular support, renal support, neurological support, metabolic support and specific interventions)[10]. The higher the score, the greater the time required for nursing care. The NAS has been used in both public and private hospitals,[6,18-19] and is widely used to measure the workload of nursing staff.

In the present study, it was found that the NAS for clinical patients was 71.3+10.9%, and 71.6+9.2% for surgical patients. In the literature, there is great variation of NAS score relative to patients admitted to ICU of public hospitals[19-20]. Considering critical patients that developed infection during stay in ICU, some authors obtained a mean NAS of 81.2+16.2% [6].

Contrary to what was observed in the present study, researchers that analyzed 195 patients admitted to clinical ICU of a tertiary hospital identified that nursing workload as measured by the NAS was the most important risk factor for HAI[6]. Other authors found that the workload of the nursing staff was higher when caring for patients who developed adverse events, including infection, during hospitalization in ICU than those that did not[21]. The results of these studies corroborate the findings of one Brazilian study which analyzed AE/I, and identified that the greater the difference between available nursing hours and those required for patient care, the lower the frequency of EA/I [22].

Considering the multi-causal etiology of HAI, it is difficult to assess the interference of a single variable on occurrence of these infections; however, review of recent literature indicates that the decrease of nursing staff is associated with an increase in the number of HAI[23]. Yet one study that analyzed 1,313 cases of pneumonia and 513 cases of BSI acquired in ICU had a different finding. The researchers of that study identified that the nurse-patient ratio was not significantly associated with pneumonia or BSI; however, length of stay in the ICU was associated with these outcomes[24].

Another study in Greece aimed to analyze which factors affected the length of stay in ICU among patients undergoing cardiac surgery, and found that patients with NAS above 61.6% upon admission are more than five times more likely to stay hospitalized in ICU for a longer time[15]. These results show that there is a relationship between length of stay in the ICU and workload. However, it is worth pointing out that the variable length of stay was a predictive factor of HAI in the present study, which was not the case with the variable NAS.

When analyzing the possible influence of nursing workload on occurrence of HAI in ICU patients it is observed that the results of studies are contradictory. Yet one must consider the diversity of methodologies used, institutional policies regarding scaling of nursing staff and types of ICU.

The subject of the present study has only been recently undertaken, and only one other study was found that examined the NAS as a predictor of HAI[6]. The conclusions of that study were different from those presented here; however, the authors of the present study emphasize that their research investigated a considerably larger sample of 835 patients in nine ICU, compared to the other study which analyzed 195 subjects admitted to three ICU[6]. Thus, the authors of the present study infer that more heterogeneous samples reflect the multiple factors associated with the occurrence of infection, and minimize the effects of nursing workload in this outcome.

One limitation of this study that should be noted is that the sample was composed of patients of a single institution, and this condition should be considered when generalizing the results. It is suggested that further multicenter studies on the subject be carried out. Nevertheless, the findings of this study contribute to intensive care nursing by identifying predictive factors of occurrence of HAI, thereby supporting implementation of strategies aimed at reducing this adverse event and ensuring the safety of ICU patients.

CONCLUSION

The predictive factors of HAI in patients admitted to the ICUs analyzed were length of stay in the unit, severity of their condition, being of the male sex and comorbidities. Nursing workload did not influence the occurrence of this outcome.

RESUMO

Objetivo: Analisar a influência da carga de trabalho de enfermagem na ocorrência de infecção relacionada à assistência à saúde (IRAS) em pacientes na Unidade de Terapia Intensiva (UTI), segundo o tipo de tratamento. **Método:** Estudo de coorte retrospectivo desenvolvido em nove UTI em São Paulo, Brasil, de setembro a dezembro de 2012. A carga de trabalho de enfermagem foi mensurada pelo *Nursing Activities Score* (NAS). Os testes T-Student, Exato de Fisher e regressões logísticas foram utilizados nas análises. **Resultados:** A casuística foi composta por 835 pacientes (54,3±17,3 anos; 57,5% do sexo masculino), dentre os quais 12,5% adquiriram IRAS na UTI. O NAS dos pacientes admitidos para tratamento clínico foi de 71,3±10,9 e para cirúrgico, 71,6±9,2. O tempo de permanência na unidade e a gravidade foram fatores preditivos para ocorrência de IRAS em pacientes admitidos nas UTI para tratamento clínico ou cirúrgico e o sexo masculino apenas para pacientes cirúrgicos. Ao considerar as admissões independentes do tipo de tratamento, além

das variáveis citadas, o índice de comorbidades também permaneceu no modelo de regressão. O NAS não foi fator preditivo de IRAS. **Conclusão:** A carga de trabalho de enfermagem não exerceu influência na ocorrência de IRAS nos pacientes deste estudo.

DESCRITORES
Carga de Trabalho; Fatores de Risco; Infecção Hospitalar; Equipe de Enfermagem; Unidades de Terapia Intensiva.

RESUMEN
Objetivo: Analizar la influencia de la carga de trabajo de enfermería en caso de infección hospitalaria (IH) en pacientes en la Unidad de Cuidados Intensivos (UCI) segundo tipo de tratamiento. **Método:** Estudio retrospectivo de cohorte realizado en nueve unidades de cuidados intensivos, en Sao Paulo, Brasil, de septiembre a diciembre de 2012. La carga de trabajo de enfermería se midió por lo Nursing Activities Score (NAS). Las pruebas t de Student, test exacto de Fisher y regresiones logísticas fueron utilizados. **Resultados:** La muestra fue de 835 pacientes (54,3±17,3 años; 57,5% hombres), entre los cuales el 12,5% adquirió IH. El NAS de pacientes admitidos a tratamiento clínico fue de 71,3±10,9 y quirúrgico, 71,6±9,2. La duración de la estancia en la unidad y la gravedad fueron factores predictivos de la ocurrencia de IH en pacientes ingresados en la UCI para el tratamiento médico o quirúrgico y los hombres sólo para los pacientes quirúrgicos. Al considerar las admisiones independientes del tipo de tratamiento, índice de comorbilidad también se mantuvo en el modelo de regresión. El NAS no fue predictivo de IH. **Conclusión:** La carga de trabajo de enfermería ejerce ninguna influencia sobre la ocurrencia de IH en los pacientes analizados.

DESCRIPTORES
Carga de Trabajo; Factores de Riesgo; Infección Hospitalaria; Grupo de Enfermería; Unidades de Cuidados Intensivos.

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