ORIGINAL ARTICLE

Knowledge and adherence to preventive measures for ventilator-associated pneumonia during the COVID-19 pandemic
Conhecimento e adesão às medidas preventivas da pneumonia associada à ventilação mecânica na pandemia de COVID-19
Conocimiento y adherencia a las medidas preventivas de la neumonía asociada a ventilador en la pandemia de COVID-19

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ABSTRACT

Background and Objectives: adherence to measures to prevent mechanical ventilation-associated pneumonia (VAP) significantly reduces this hospital infection, and knowledge of the measures is essential to ensure adherence. COVID-19 has increased the demand for intensive care and increases the risks and severity of VAP. Thus, the objective was to assess the knowledge referred to about the VAP prevention bundle and its associated factors and multidisciplinary team professionals' perspective about adherence during the COVID-19 pandemic. **Methods:** this is a cross-sectional study, carried out from December 2020 to July 2021, with professionals from the Intensive Care Unit of a university hospital. Bivariate and multivariate analyzes were performed to assess factors associated with professionals' knowledge. **Results:** of the 61 professionals interviewed, 85.2% were nursing professionals and 14.7% were physical therapists. Physical therapists obtained a higher percentage of correct answers in relation to the VAP prevention bundle items. Nursing professionals have little knowledge about the elements that make up the bundle, highlighting the need for training throughout the entire process of training and professional performance. Lack of training was the main difficulty reported (14.75%). Age was a factor associated with knowledge of the bundle (p=0.017). **Conclusion:** there is a lack of knowledge and adherence to the VAP prevention bundle among nursing professionals. However, these professionals demonstrated a willingness to receive training to improve bundle adherence rates and current good VAP prevention practices.

Keywords: *Pneumonia, Ventilator-Associated. Intensive Care Units. Pandemics. Infection Control. COVID-19.*

RESUMO

Justificativa e Objetivos: a COVID-19 aumentou a demanda pela terapia intensiva e intensificou a necessidade de ventilação mecânica e a gravidade da pneumonia associada à

ventilação mecânica (PAV). A adoção de medidas preventivas da PAV no contexto da pandemia tem grande impacto para salvar vidas. Assim, objetivou-se avaliar o conhecimento referido sobre o *bundle* de prevenção da PAV e seus fatores associados e a percepção dos profissionais da equipe multiprofissional sobre a adesão em vigência da pandemia de COVID-19. **Métodos:** trata-se de estudo transversal, realizado no período de dezembro de 2020 a julho de 2021, com profissionais da Unidade de Terapia Intensiva de hospital universitário. Foram realizadas análises bivariadas e multivariadas para avaliar os fatores associados ao conhecimento dos profissionais. **Resultados:** dos 61 profissionais entrevistados, 85,25% eram profissionais de enfermagem e 14,75% eram fisioterapeutas. Os fisioterapeutas obtiveram maior porcentagem de acertos em relação aos itens do *bundle* de prevenção da PAV. Os profissionais de enfermagem possuem pouco conhecimento sobre os elementos que compõem o *bundle*, remetendo à necessidade de capacitação ao longo de todo o processo de formação e atuação profissional. Falta de treinamento foi a principal dificuldade relatada (14,75%). A idade foi um fator associado ao conhecimento do *bundle* (p=0,017). **Conclusão:** há deficiência no conhecimento e na adesão ao *bundle* de prevenção de PAV entre os profissionais de enfermagem. No entanto, esses profissionais demonstraram disposição em receber capacitação para melhoria das taxas de adesão ao *bundle* e das boas práticas de prevenção da PAV vigentes.

Descritores: *Pneumonia Associada à Ventilação Mecânica. Unidades de Terapia Intensiva. Pandemias. Controle de Infecções. COVID-19.*

RESUMEN

Justificación y Objetivos: el cumplimiento de las medidas para prevenir la neumonía asociada a la ventilación mecánica (NAV) reduce significativamente esta infección hospitalaria, y el conocimiento de las medidas es fundamental para garantizar el cumplimiento. COVID-19 ha aumentado la demanda de cuidados intensivos y aumenta los riesgos y la gravedad de la NAV. Así, el objetivo fue evaluar los conocimientos referidos sobre el paquete de prevención de NAV y sus factores asociados y la percepción de los profesionales del equipo multidisciplinario sobre la adherencia durante la pandemia de COVID-19. **Métodos**: se trata de un estudio transversal, realizado de diciembre de 2020 a julio de 2021, con profesionales de la Unidad de Cuidados Intensivos de un hospital universitario. Se realizaron análisis bivariados y multivariados para evaluar los factores asociados al conocimiento de los profesionales. **Resultados**: de los 61 profesionales entrevistados, el 85,25% eran profesionales de enfermería y el 14,75% eran fisioterapeutas. Los fisioterapeutas obtuvieron un mayor porcentaje de respuestas correctas en relación con los ítems del paquete de prevención de NAV. Los profesionales de enfermería tienen poco conocimiento sobre los elementos que componen el paquete, destacándose la necesidad de capacitación durante todo el proceso de formación y desempeño profesional. La falta de formación fue la principal dificultad reportada (14,75%). La edad fue un factor asociado al conocimiento del paquete (p=0,017). **Conclusión**: existe falta de conocimiento y adherencia al paquete de prevención de NAV entre los profesionales de enfermería. Sin embargo, estos profesionales demostraron voluntad de recibir capacitación para mejorar las tasas de cumplimiento del paquete y las buenas prácticas actuales de prevención de NAV.

Palabras Clave: *Neumonía Asociada al Ventilador. Unidades de Cuidados Intensivos. Pandemias. Control de Infecciones. COVID-19.*

INTRODUCTION

The clinical picture of patients with COVID-19 can range from mild flu-like symptoms to more severe conditions, with systemic manifestations.[1] One of the most frequent

complications of severe COVID-19 is acute respiratory distress syndrome (ARDS), causing diffuse alveolar damage, pulmonary capillary thrombi, and endothelial dysfunction, culminating in lung collapse and respiratory failure. This syndrome is the main indication for invasive mechanical ventilation (IMV) in COVID-19.[2]

When subjected to IMV for more than 48 hours, patients are at risk of acquiring ventilator-associated pneumonia (VAP), which occurs when there is contamination of the lungs by exogenous or endogenous bacteria.[3] The occurrence of VAP prolongs the time of ventilator use, increases the length of hospital stay and hospitalization costs, and can contribute to a higher risk of death.[3] Therefore, preventive measures for VAP, offered through a bundle, are essential for the care of critically ill patients with COVID-19 on mechanical ventilation.

The VAP prevention bundle is defined as a set of evidence-based interventions that, when implemented in combination, reduce the risk of VAP.[4] The implementation of the VAP prevention bundle has resulted in a significant reduction in VAP incidence worldwide. In a hospital in Turkey, the VAP rate decreased from 15.91 per 1,000 ventilator days to 8.50 per 1,000 ventilator days.[5] In a hospital in Taiwan, VAP incidence density decreased significantly from 3.3 to 1.4 cases per 1,000 ventilator days after the bundle implementation.[6]

Likewise in Brazil, studies have shown that the bundle implementation reduces the number of VAP cases, mortality and hospital costs, improving the quality of care for patients in intensive care.[7-8]

The increase in new cases of severe pneumonia caused by COVID-19 has led to overcrowding and pressure in Intensive Care Units (ICUs), resulting in a high rate of mechanical ventilation use. Moreover, it has changed the way these units operate, requiring new isolation spaces, new facilities and urgent hiring to meet this demand.[9]

The increased need for IMV leads to an increased risk of VAP, which, for patients with COVID-19 and ARDS, increases the severity of patients' condition and the chance of shock, septicemia, and death.[10] Therefore, the need to apply the VAP prevention bundle becomes even more expressive to reduce complications and promote patient recovery.

Thus, during the COVID-19 pandemic, in which ICU utilization rates reached 100% of their capacity, it is important to investigate the healthcare professionals' knowledge about the VAP prevention bundle and their adherence in this context. Identifying barriers to adherence can help establish measures to strengthen the application of these care measures, thus helping to reduce VAP rates in ICUs. Thus, the objective of this study was to assess the knowledge reported on the VAP prevention bundle and its associated factors and the perception of nursing

and physical therapy team professionals regarding adherence, during the COVID-19 pandemic, in a hospital in Goiânia, Goiás.

METHODS

Study design, period and site

This is a cross-sectional study conducted in an ICU specifically for the care of patients with COVID-19 in a large hospital in Goiânia, Goiás, Brazil, from January to December 2021.

Sample and eligibility criteria

The study population consisted of professionals directly involved in the implementation of the actions that make up the VAP prevention bundle, such as nurses, nursing technicians and physical therapists. The sampling process for this study was by convenience, in which all ICU professionals were invited to participate, following the following inclusion criteria: having worked for more than five months in the unit and being part of the nursing or physical therapy team. Participants who responded less than 50% of the instrument were excluded. Of the 80 professionals eligible for the study, 71 agreed to participate; of these, ten were excluded due to incomplete completion of the instrument. Thus, the sample consisted of 61 professionals, representing 76.2% of the intended population.

Data collection

Data were collected from January to August 2021. Professionals were contacted personally at their work unit and invited to participate in the study. Those who accepted agreed to participate with the data collection team, depending on their availability to respond to the instrument. Data were collected in a room attached to the unit, where the professional responded to the instrument and, at the end, returned it to the researcher.

The data collection instrument was structured in three parts, namely: 1. Sociodemographic data; 2. Professional participation in continuing education activities addressing VAP prevention measures and their perception of adherence to the bundle during the pandemic (dichotomous closed-ended questions); 3. Open-ended question: "What interventions make up the VAP prevention bundle?". The instrument was developed by the research team, based on the Brazilian National Health Regulatory Agency (In Portuguese, *Agência Nacional de Vigilância Sanitária* - ANVISA) Healthcare-Associated Infection Prevention Measures.[11-12] It was submitted for analysis by three judges with PhDs in nursing and working in healthcare-associated infection control (HAI) services. After adjustments, the instrument was validated by a pilot test in the ICU of another institution.

Study variables

The dependent variable was knowledge of elements that make up the VAP prevention bundle (oral hygiene, elevated head of the bed, checking cuff pressure, possibility of extubation, daily awakening/reduction of sedation and adequate ventilation system maintenance). For each participant, the number of items that make up the bundle was counted, categorized as: knows up to three elements of the bundle and knows more than three elements of the bundle. Independent variables were divided into sociodemographic and professional data, and information related to participation in continuing education activities, detailed in Table 1.

Table 1. Characterization of predictor variables of professionals' knowledge about the elements that make up the ventilator-associated pneumonia prevention bundle. Goiânia, GO, Brazil, 2021

Type	Variables	Type of variable	Categorization
Sociodemographic and professional data	Sex	Qualitative	Female Male
	Age		
	Profession	Qualitative	Nursing technicians Nurses Physical therapists
	Training period	Quantitative	In years
	Job tenure in the unit	Quantitative	In months
	Other employment relationship	Qualitative	Yes No
Participation in continuing education activities	Participation in training on the bundle (in the unit)	Qualitative	Yes No
	Participation in training on the bundle (in the other link)	Qualitative	Yes No
	Felt encouraged to apply the bundle (before the pandemic)	Qualitative	Yes No
	Felt encouraged to apply the bundle (during the pandemic)	Qualitative	Yes No
	Believe that the pandemic influenced the bundle implementation	Qualitative	Yes No
	Believe that the pandemic influenced the bundle completion	Qualitative	Yes No

Data analysis

The data were analyzed using the statistical program R version 4.3.1. Descriptive analyses were performed with presentation of qualitative data in the form of absolute and relative frequencies and quantitative data in the form of median and interquartile range. The relative frequencies with respective confidence intervals on the incentive to adhere to the prevention bundle and knowledge of each element were presented in the form of a bar graph. The chi-square test for trend was used to compare the encouragement to adhere to the bundle before the pandemic with the period during the pandemic. Logistic regression models were used to perform bivariate and multivariate analyses of factors associated with knowledge of elements of the VAP prevention bundle, from which unadjusted and adjusted Odds Ratios (OR) were obtained.

Variables that presented $p < 0.2$ were included in the multivariate model, so the stepwise strategy was established as the input method for these variables into the model, in which they are included in the model so that the adjustment identifies whether it is feasible to include or remove them, with the model starting without any variables until a model with a better fit is identified. As a criterion for defining the model's fit, we established the Akaike Information Criterion (AIC). Thus, the final model included only the variables that fit best. Variables that presented a p-value < 0.05 were considered statistically significant.

The study protocol was submitted to and approved by the Research Ethics Committee of the *Hospital das Clínicas* at the *Universidade Federal de Goiás* (CAAE 41340620.3.0000.5078, approval protocol 4,499,285 on 01/14/2021), and followed all ethical recommendations of Resolution 466/2012.

RESULTS

Sixty-one professionals from an ICU dedicated to treating patients with COVID-19 participated in the study. Table 2 presents participant sociodemographic and professional profile. The aim was to determine whether the professionals received training on the VAP prevention bundle before and during the pandemic. Before the pandemic, 37.4% of professionals reported having received training on the VAP prevention bundle, and 26.2% of professionals interviewed reported training on the VAP prevention bundle in the study unit during the pandemic period. There was an increase in the incentive to adhere to the VAP prevention bundle during the pandemic period in relation to the pre-pandemic period ($p < 0.001$) (Figure 1).

Table 2. Sociodemographic characteristics and adherence to the ventilator-associated pneumonia prevention bundle among professionals in an Intensive Care Unit for COVID-19 patients participating in the study. Goiânia, GO, Brazil, 2021

| Variables	N(%)
Sex	
Female	52 (85.2%)
Male	9 (14.8%)
Profession	
Nursing technicians	31 (50.8%)
Nurses	21 (34.4%)
Physical therapists	9 (14.8%)
Other employment relationship	
Yes	48 (78.7%)
No	13 (21.3%)
Participation in training on the bundle (in the unit)	
Yes	19 (31.1%)
No	42 (68.9%)
Participation in training on the bundle (in the other link)	
Yes	14 (22.9%)
No	47 (77.1%)
Felt encouraged to apply the bundle (before the pandemic)	
Yes	40 (65.6%)
No	21 (34.4%)
Felt encouraged to apply the bundle (during the pandemic)	
Yes	57 (93.4%)
No	4 (6.6%)
Believe that the pandemic influenced the bundle implementation	
Yes	40 (65.4%)
No	21 (34.4%)
Believe that the pandemic influenced the bundle completion	
Yes	39 (65%)
No	21(35%)
Age (years) [median (IQR*)]	50 (47 – 54)
Time since graduation [median (IQR*)]	19 (14 – 25)
Job tenure in the unit [median (IQR*)]	12 (6 – 15)

Note: *IQR = interquartile range.
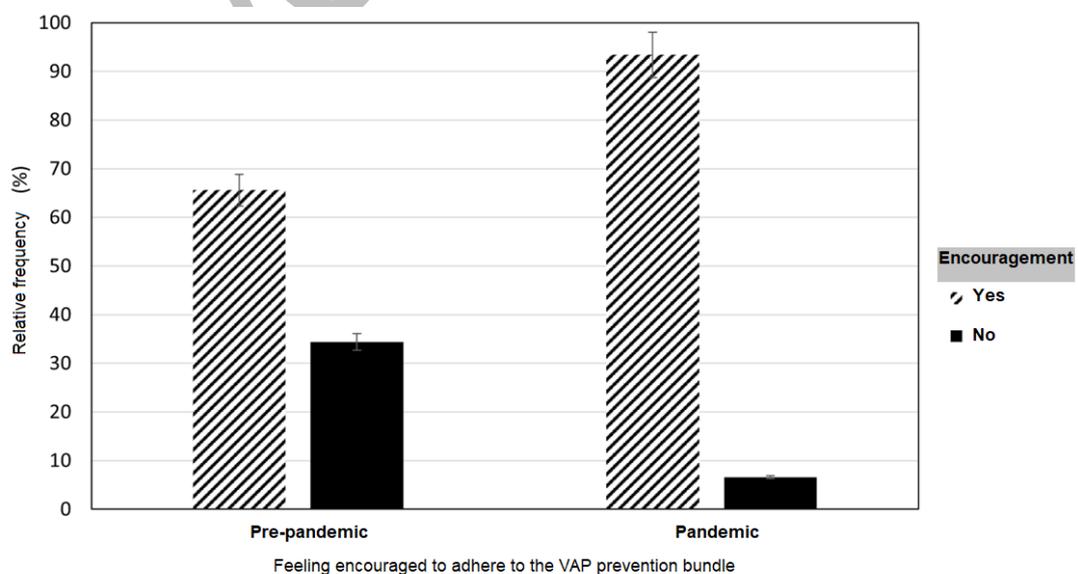
Figure 1. The COVID-19 pandemic increased the frequency of professionals who felt encouraged to adhere to the ventilator-associated pneumonia prevention bundle. Goiânia, GO, Brazil, 2020-2021

Note: *Chi-square test for trend.

Concerning knowledge of items that make up the VAP prevention bundle, oral hygiene was the most reported item (65.7%), followed by elevating the head of the bed (45.9%) and checking cuff pressure (19.6%). When analyzed by professional category, physical therapists obtained a higher percentage of correct answers. In this professional category, all elements of the bundle were mentioned, although some elements appeared more frequently than others. No member of the nursing team listed all the elements that make up the VAP prevention bundle. Nurses mentioned up to four (66.7%) of the six recommended practices, and nursing technicians mentioned a maximum of three (50%). Oral hygiene was the most frequently reported intervention in the bundle among nursing professionals, followed by elevated headboard and cuff pressure check, which was mentioned by 47.6% and 14.3% of nurses, respectively, and 35.2% and 5.5% of nursing technicians, respectively. Daily awakening from sedation was reported only by physical therapists.
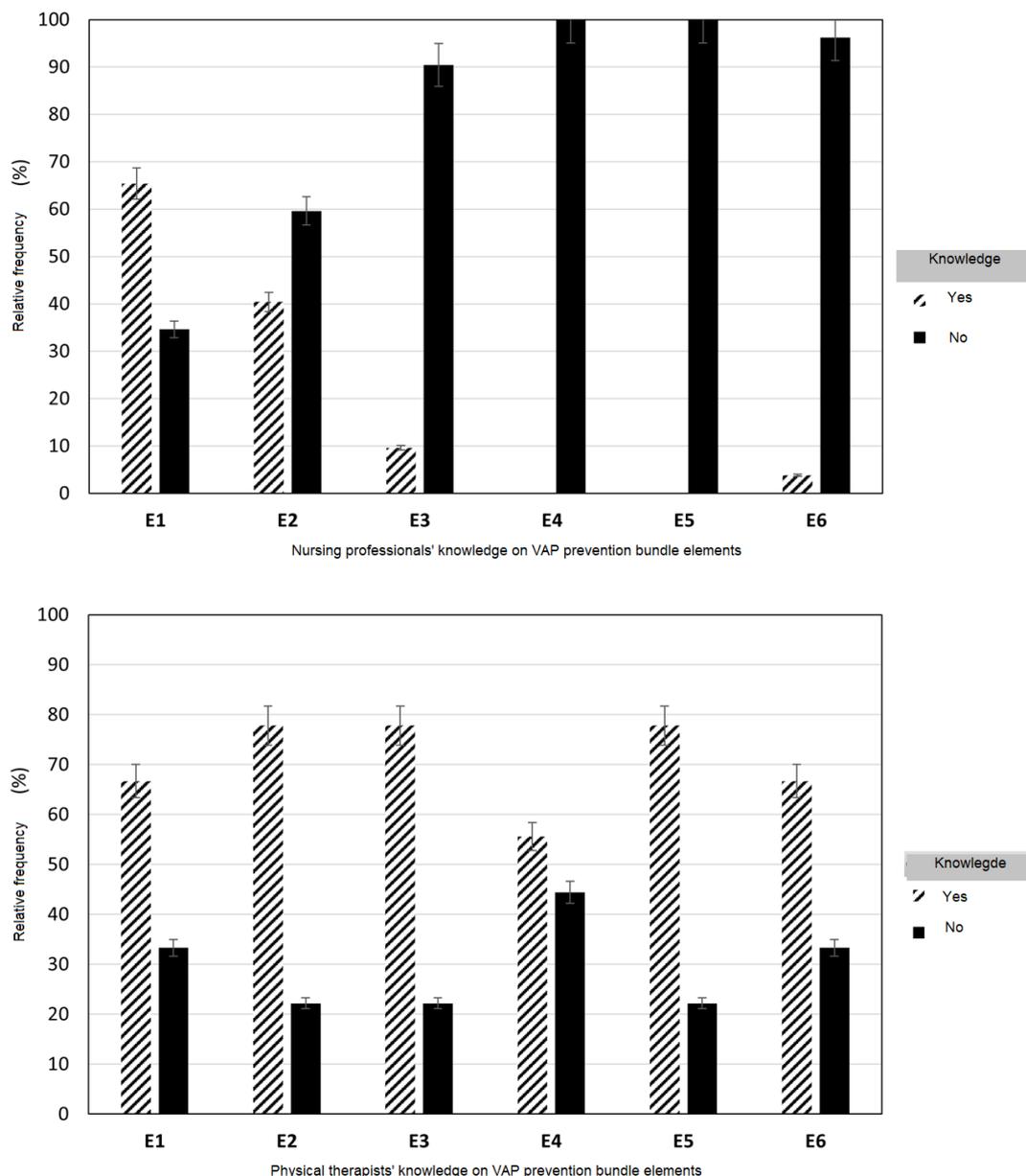
Figure 2. Knowledge of ventilator-associated pneumonia prevention bundle elements among Intensive Care Unit professionals during the COVID-19 pandemic. Goiânia, GO, Brazil, 2021
Note: A: nursing professionals; B: physical therapists; E1: oral hygiene; E2: elevated head of bed; E3: checking cuff pressure; E4: possibility of extubation; E5: daily awakening/reduction of sedation; E6: adequate ventilation system maintenance.

In relation to factors associated with knowledge of the bundle, bivariate analyses showed an association with age, participation in training on bundle V in the other employment relationship, feeling encouraged to apply the bundle and believing that the pandemic influenced the bundle implementation. In the multivariate analysis, only age remained statistically significant, showing that the younger the age, the greater the knowledge about the bundle (OR: 0.83; 95% CI: 0.71 – 0.96; p=0.017) (Table 3).

Table 3. Factors related to knowledge of ventilator-associated pneumonia prevention bundle elements among Intensive Care Unit professionals during the COVID-19 pandemic. Goiânia, GO, Brazil, 2020-2021

Variables	Knowledge [n (%)]		Unadjusted OR* (95% CI)	*p*-value	Adjusted OR* (95% CI)	β†	*p*-value‡
	> three elements (n=6)	Up to three elements (n=55)					
Sex							
Female	5 (9.6)	47 (90.4)	0.85 (0.08; 8.27)	0.889			
Male	1 (11.1)	8 (88.9)	1				
Age [median (IQR§)]	36.5 (33.2; 43.5)	51.0 (49.0; 54.0)	0.80 (0.69; 0.93)	**0.003**	0.83 (0.71; 0.96)	-0.185	**0,017**
Profession							
Nurse	1 (4.8)	20 (95.2)	-	0.998			
Physical therapist	5 (55.6)	4 (44.4)	-	0.997			
Nursing technician	0 (0.0)	31 (100.0)	1				
Another employment relationship							
Yes	6 (12.5)	42 (87.5)	-	0.995			
No	0 (0.0)	13 (100.0)	1				
Time since training [median (IQR§)]	15.0 (10.7; 17.7)	6.8 (14.0; 25.0)	0.84 (0.71; 1.00)	0.052			
Job tenure in the unit [median (IQR§)]	7.5 (6.2; 13.2)	12.0 (6.0; 15.0)	0.94 (0.79; 1.12)	0.531			
Participation in training on the bundle (in the unit) [during the pandemic]							
Yes	1 (5.26)	18 (94.7)	0.41 (0.04; 3.78)	0.433			
No	5 (11.9)	37 (88.1)	1				
Participation in training on the bundle (in the other link)							
Yes	4 (28.6)	10 (71.4)	8.99 (1.44; 56.12)	**0.018**			
No	4 (4.3)	45 (95.7)	1				
Feel encouraged to apply the bundle							
Yes	4 (7.0)	53 (93.0)	0.07 (0.01; 0.68)	**0.021**			
No	2 (50.0)	2 (50.0)	1				
Believe that the pandemic influenced the bundle implementation							
Yes	1 (2.5)	39 (97.5)	0.08 (0.01; 0.75)	**0.027**	0.17 (0.01; 1.89)	-1.76	0,149
No	5 (23.8)	16 (76.2)	1		1		

Variables	Knowledge [n (%)]		Unadjusted OR* (95% CI)	p-value	Adjusted OR* (95% CI)	β†	p-value‡
	> three elements (n=6)	Up to three elements (n=55)					
Believe that the pandemic influenced the bundle completion							
Yes	2 (5.1)	37 (94.9)	0.23 (0.04; 1.37)	0.107			
No	4 (19.1)	17 (80.9)	1				

Note: *OR = Odds Ratio; † β = model coefficients; ‡p-value = significance level; §IQR = interquartile range; model fit parameter: AIC=53.89.

DISCUSSION

VAP is one of the most common HAIs in ICUs, and can worsen patients' clinical conditions and increase their chances of death. However, correctly implemented prevention measures can reduce the incidence of this infection and its impacts.[6]

The COVID-19 pandemic, in which the management of the severe form of the disease requires ventilatory support in the ICU, has caused overcrowding, increased rates of mechanical ventilation use and contributed to the increased risk of VAP incidence.[13] Therefore, it is essential to diagnose the knowledge and practice of professionals in the application of VAP prevention measures which, if well targeted, can significantly reduce this complication.[6,14]

In the ICU assessed in this study, the physical therapy team was directly responsible for registering the bundle, but most studies regarding adherence to this tool, in different parts of the world, are aimed at the nursing team,[15-16] which highlights the leading role of this professional team in the application of VAP preventive measures. Thus, our study innovated by including physical therapists as participants, in addition to nursing professionals, due to their institutional responsibility in the bundle application and registration and their recognized interprofessional performance in VAP prevention.[17]

Only 26% of professionals reported having received training on the VAP prevention bundle at the institution. Since VAP is one of the main adverse events for critical care patients, it would be essential for workers in this sector to be periodically updated. The number of professionals who received training at other institutions was also low, showing that not only at the study institution, but also in other services, investment in continuing education for VAP prevention is insufficient.

It has been shown that patients with COVID-19 are at higher risk of developing VAP[21] and that VAP in patients with COVID-19 was associated with greater complications, such as shock (71% vs. 48%, $p = 0.009$), ICU death (52% vs. 30%, $p = 0.011$), and bacteremia (26% vs. 13%, $p = 0.038$), than patients who develop VAP without COVID-19.[10] These findings make the application of VAP prevention bundles essential in the context of the COVID-19 pandemic.

Considering the importance of applying VAP prevention bundles, some factors can be suggested for the low number of professionals who reported training in VAP prevention, such as a shortage of professionals, due to the expansion in the number of beds, and high turnover, due to the replacement of infected professionals, generating emergency hiring of professionals with little experience, in addition to a large number of new management and assistance demands related to preventive measures against infection in the unit.

Before the pandemic, only 65% of survey participants reported feeling encouraged to apply the bundle, a worrying fact, since this infection is preventable and has harmful consequences for patients and healthcare services, increasing their costs.[8-11]

It is noteworthy that, during the pandemic, most professionals felt more encouraged to apply the VAP prevention bundle (93%), compared to the period before the pandemic (p<0.001). It is important to highlight that the variable feeling encouraged to apply the bundle was a self-report by participants and does not reflect real adherence, which was not the target of this investigation. Despite this, low knowledge among nursing professionals was evidenced, which supports the lack of training reported in the interviews, contrasting with the increased encouragement to apply the bundle during the pandemic. In practice, this may represent inconsistent care and reinforces the need for training teams, since feeling encouraged to apply it may result in greater interest in learning. However, this was a period marked, at times, by greater adherence to protective measures, resulting in a reduction in healthcare-associated infections, and, at times, by relaxation and an increase in HAI rates.[19,20]

The practices selected for knowledge assessment correspond to six care procedures that make up the bundle: 1 - positioning of the headboard between 30º and 45º; 2 - checking the cuff pressure between 20-30 cmH2O; 3 - oral hygiene with chlorhexidine 0.12%; 4 - respiratory and motor physical therapy; 5 - care with the aspiration of secretions; 6 - interruption of sedative infusion.[11,21]

The study showed that nursing professionals at the institution have little knowledge about the elements that make up the VAP prevention bundle, which certainly limits their ability to implement prevention actions. Some of the components of the bundle are routine nursing care, such as oral hygiene and positioning. However, it is necessary to understand these actions as part of the bundle of VAP preventive measures. A study conducted in Australia,[16] which assessed the knowledge of specialist nurses in ICUs, identified that the most mentioned element of the bundle for VAP prevention was positioning (90.9), unlike our study, in which this element was mentioned by only 28% of professionals, referred to here as elevated headboard, a highly effective nursing intervention for VAP prevention.[22]

Elevated headboard position, oral hygiene and adequate maintenance of cuff pressure represent the main preventive measures for subglottic aspiration, one of the most common causes of VAP.[4,11] They also represent routine nursing interventions and, even so, were rarely mentioned as measures to prevent VAP. Furthermore, the assessment of patients, which involves the level of consciousness and oxygenation, is also part of nursing routine, which, together, covers the other items in the bundle, such as the possibility of extubation,

awakening/reduction of sedation and adequate ventilation system maintenance. However, despite being nursing interventions, they were not mentioned as components of the VAP prevention bundle.

Considering all the elements of the bundle, in general, studies have shown a low level of knowledge among professionals, which certainly impacts adherence to the VAP bundle and incidence.[15,16] A study conducted in Brazil found that the frequency of adherence to the bundle by nursing professionals was significant only for three proposed items, namely the position of the headboard between 30º and 45º, care with suction of secretions and respiratory and motor physical therapy, with the overall adherence rate being 77.4%; therefore, no events of complete bundle implementation were observed.[23] Such data support the results of this study, and alert ICU managers to team continued education.

A study conducted in Porto Alegre (RS) assessed nursing adherence to the VAP prevention bundle and the incidence rate before and after implementing a continuing education program. The data revealed an increase in adherence to all components of the interventions proposed in the bundle and, consequently, a reduction in VAP incidence rates, which demonstrates that continuing education is an important tool for maintaining adherence to the VAP prevention bundle in favor of the safety of critically ill patients in the ICU.[8] It is worth noting that, in the present study, physical therapists were more prepared, when compared to the nursing team, in relation to all elements of the VAP prevention bundle. It is also worth noting that care should be provided in a multidisciplinary manner, resulting in substantial improvements in healthcare.[17]

Logistic regression showed that, in the present study, age was inversely related to knowledge of bundle elements, suggesting that younger professionals tend to have more knowledge; this may be due to the recent inclusion of topics related to patient safety, especially in HAI prevention, in healthcare professional training.[24-25] Therefore, it is essential to recognize the importance of HAI prevention and control actions in professional training, ensuring this content in the training curriculum for healthcare professionals, as well as prioritizing professional training, providing instruments for monitoring adherence to the bundle, in order to reduce the incidence of VAP which, especially for patients with COVID-19, culminates in unfavorable outcomes.

This study has limitations, such as the distribution of participants from the physical therapy team being smaller than that of the nursing team, but it represents the proportion between the professional categories. Self-reported knowledge may also contribute to limitations

of this study, as it may not reflect real knowledge on the subject, indicating the need for further research with more objective assessments of knowledge.

Although this study was conducted in the context of the COVID-19 pandemic, the results have the potential to qualify ICU care in different contexts, and are especially transferable to other infectious or non-infectious respiratory impairment syndromes that may increase the demand for ICUs, signaling the need for training in the face of new hires, and the maintenance of a qualified team to apply VAP prevention measures.

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Hélio Galdino-Júnior contributed to the conception, study design and project administration, bibliographic research, interpretation and description of results, manuscript writing and article critical review. **George Oliveira** contributed to the interpretation and description of results, statistical analysis, manuscript writing and final review. **Ana Clara Alves Campos** contributed to bibliographic research, field data collection, abstract writing, methodology, interpretation of results, conclusions. **Jéssica de Oliveira Montebelo** contributed to bibliographic research, field data collection, abstract writing, methodology, interpretation of results, conclusions.

All authors have approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.