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Original research article

The cornerstones of the ventilator-associated pneumonia preventive bundle in critically ill adults – a Czech national survey

Kateřina Rambousková [1, 2] *, Šárka Línková [1, 2], Kateřina Jiroutková [1, 2], Veronika Šnorbertová (born Hložková) [2], Veronika Dorazilová [3], Zuzana Klikarová [4], Johanka Hrdinová (born Pumprová) [2], Barbora Havelková [2]

[1] *Charles University, 3rd Faculty of Medicine, Prague, Czech Republic*
[2] *Královské Vinohrady University Hospital, Department of Anaesthesiology and Resuscitation, Prague, Czech Republic*
[3] *Královské Vinohrady University Hospital, Surgical Clinic, Prague, Czech Republic*
[4] *Institute of Clinical and Experimental Medicine, Department of Transplant Surgery, Prague, Czech Republic*

Abstract
Background: Ventilator-associated pneumonia (VAP) is the most common hospital-acquired infection in the intensive care unit (ICU). Given that prevention is key, efforts to develop effective measures have been encouraged. In 2004, the first "ventilator bundle" was introduced, consisting of four components. Daily oral care with chlorhexidine was added in 2010. This issue remains a subject of ongoing debate.
Aim: Identify current practices regarding the VAP bundle for invasively ventilated patients in ICUs in the Czech Republic, focusing on nursing intervention bundles, VAP incidence, VAP prevention education, and oral care protocols.
Results: A questionnaire was sent to a single representative of each ICU in the Czech Republic. The response rate was 32% (43 ICUs). We found substantial heterogeneity in the intensity and combinations of preventive measures; some of our findings are particularly concerning. 74% of ICUs did not keep VAP incidence records. 21% of ICUs did not provide education on the VAP preventive measures. 61% of ICUs used a suction pump connected to a central vacuum line or an electrical supply for subglottic secretion suction. 31% of ICUs used both active and passive humidification simultaneously.
Conclusion: A uniform VAP bundle is lacking in the Czech Republic, and potentially harmful interventions persist. There is an urgent need for national guidelines.

Keywords: Education; Intensive care; Nursing staff and preventive bundle; Ventilator-associated pneumonia

Introduction

Ventilator-associated pneumonia (VAP) is pneumonia that occurs after the patient has been on mechanical ventilation for more than 48 hours (Modi and Kovacs, 2020). It is associated with significant morbidity and mortality (Khan et al., 2016). VAP is a prevalent complication (von Elm et al., 2008); its treatment is troublesome, prolonging the duration of mechanical ventilation, increasing length of hospital stay, elevating healthcare costs, and placing an increased workload on medical staff (Osman et al., 2020). Up to 55% of VAP cases are preventable through both medical and nursing interventions (Plata-Menchaca and Ferrer, 2022). Evidence-based guidelines demonstrated that VAP prevention is feasible through the implementation of specific interventions together and at the same time. This strategy is known as "a VAP bundle" (Hellyer et al., 2016). The "bundle" has been evolving, and its effectiveness in the reduction of VAP has been examined in a significant number of studies, followed by systematic reviews in this field (Kallet, 2019; Thapa et al., 2023). When adhered to, these evidence-based interventions significantly reduce the risk of VAP (Santacruz et al., 2019). Consistent implementation of the VAP bundle, coupled with nursing staff education, plays a critical role in VAP prevention (Branco et al., 2020; Cant and Cooper, 2017; Wip and Napolitano, 2009).

The "VAP bundle" components have continued to evolve as some interventions within intensive care nursing have been challenged, including oral care with chlorhexidine or heat and moisture exchanger replacement frequency. Yet standard protocols are lacking. Several international organisations address VAP prevention, including the British Society for Antimicrobial Chemotherapy (BSAC) in the United Kingdom, and the National Healthcare Safety Network (NHSN), part of the

* **Corresponding author:** Kateřina Rambousková, Charles University, 3rd Faculty of Medicine, Prague, Czech Republic;
e-mail: katerina.rambouskova@fnkv.cz
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Infectious Diseases Society of America (IDSA), in the United States. In the European Union, the European Centre for Disease Prevention and Control (ECDC, 2024) collects VAP incidence data to support efforts in combating infectious diseases (Mogyoródi et al, 2016).

In the Czech Republic, VAP prevention is advocated by neither any professional society nor by the Ministry of Health of the Czech Republic. Reporting VAP cases to the European Surveillance System (TESSy) is the responsibility of the attending physician, who collaborates with the hospital epidemiologist. The effectiveness of this reporting system varies depending on the hospital organisation and cooperation among clinicians, microbiologists, and epidemiologists (ECDC, 2024).

The approaches to VAP prevention differ substantially worldwide, with variations in the types and quality of preventive interventions and the recording of VAP incidence. In some departments, no attention is paid to VAP. Others use its prevalence as a quality-of-care indicator. The current practice regarding VAP prevention in the Czech Republic is generally unknown.

Oral decontamination is a highly topical issue in VAP prevention. Nursing protocols for oral care lack standardisation, and many rely on chlorhexidine-based antiseptic solutions, a practice which has become controversial in light of current evidence that advises against routine use. The most suitable alternative to chlorhexidine remains unclear. Validated oral mucosa assessment scales for intensive care patients can provide objective evaluation and support best practices.

Recommendations for preventive measures, such as inhaled gas humidification, HME filter replacement frequency, and ventilation circuit care, vary significantly, creating uncertainty in clinical practice and affecting patient outcomes.

A comprehensive national-level assessment of VAP prevention practices is crucial for future guideline-setting, leading to improved outcomes for mechanically ventilated patients in intensive care units across the Czech Republic. Research of this scope and focus has not been previously performed at this scale in the Czech Republic.

Our objective was to determine current preventive care practices in intensive care nursing regarding compliance with the individual components of the "VAP bundle" and "VAP bundle" education in the Czech Republic. A secondary objective was to investigate perceptions of the necessity and efficacy of these interventions, including tracking VAP prevalence records. We hypothesised that current practice is highly variable and based on established routines within individual ICUs, due to the lack of national-level guidelines.

Materials and methods

Inspired by Dr. Stilma et al. (2021), who conducted a national survey on airway interventions in the Netherlands in 2021, our research team developed an online questionnaire and distributed it to a pre-appointed representative of each ICU across the Czech Republic.

Study design

We used a self-reported, web-based, cross-sectional survey.

Survey development and formatting

We requested data from the Institute of Health Information and Statistics of the Czech Republic (UZIS), receiving information on ventilator counts but not specific ICU units. This data served as a checklist, supplemented by publicly available records from the Ministry of Health of the Czech Republic (MOH). The contact list, organised by region, included nursing deputy directors and chief nurses, sourced from official hospital websites. The research was conducted as a national study under the patronage of the Czech Association of Nurses (CAS), Section of Anaesthesiology, Resuscitation, and Intensive Care (ARIP).

Survey pilot testing

The questionnaire included 66 items across five sections: facility demographics, nursing interventions, VAP incidence, nurse education, and oral care practices. A pilot test was conducted with three experienced ICU professionals.

Sample

The pragmatic sample included all ICUs in the Czech Republic capable of providing mechanical ventilation to adult patients. The questionnaire was sent to 133 hospitals. We obtained responses from 43 departments.

Survey administration

The survey was distributed in early February 2024 to nursing deputy directors and chief nurses. The target respondents were head nurses, station nurses, physicians, or bedside nurses who would complete the questionnaire on behalf of the entire intensive care unit. The research team divided the Czech Republic into regions and, based on a list of all ICUs obtained from the Institute of Health Information and Statistics, kept a list of respondents who had already answered. Those who did not respond were contacted repeatedly. None of the answers are duplicated. In total, 400 emails were sent, including follow-up reminders.

Analysis plan

Descriptive statistics were used to summarise the characteristics of the participating ICUs and the responses to individual questionnaire items. Comparative analyses were performed to examine associations between ICU characteristics (e.g., teaching vs. non-teaching hospitals, presence of internal protocols, availability of regular education) and key outcomes such as reported VAP incidence, adherence to specific bundle components, and availability of training programs. The Chi-square test or Fisher's exact test was used for categorical variables, depending on expected frequencies. For comparisons of paired proportions, McNemar's test was applied. All statistical analyses were conducted using Microsoft Excel, supplemented by the Real Statistics Resource Pack add-in. A significance level of $p < 0.05$ was considered statistically significant.

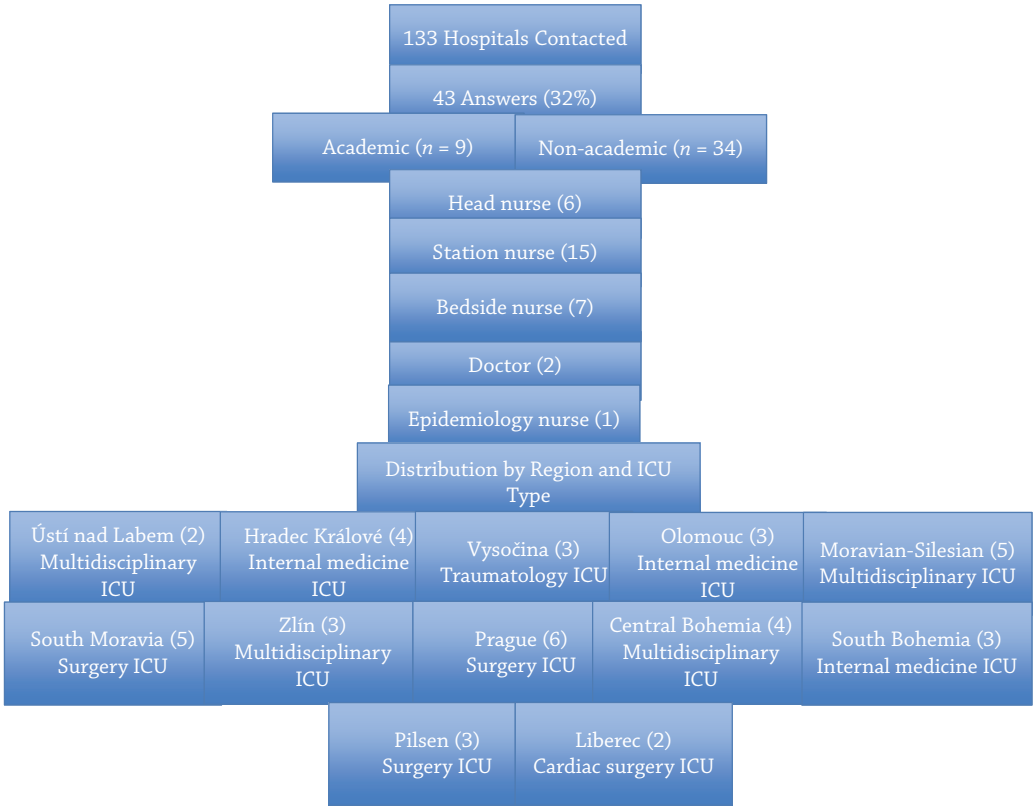
Ethical considerations

Participation in the study was voluntary and limited to senior staff members of hospitals and individual departments. Where required, formal participation requests were submitted and archived by the authors. The research was institutionally supported by the Department of Anaesthesiology and Resuscitation at the University Hospital Královské Vinohrady, and the 3rd Faculty of Medicine, Charles University. Approval to conduct the study was obtained either directly from hospital deputy directors or through institutional research permission processes. Two hospitals granted formal approval; one hospital declined participation. The questionnaire was fully anonymous, and it was not possible to identify individual departments.

Results

Responses

All 133 hospitals with ICUs providing care to mechanically ventilated patients in the Czech Republic were approached. However, despite repeated appeals, requests, and CAS patronage, the return rate was low. Both academic and non-academic hospitals were represented in the responses (Scheme 1). The results from a total of 43 respondents/departments are summarised.



Scheme 1. Flowchart of responses

VAP incidence

Between January 2022 and December 2023, a total of 3,921 patients underwent mechanical ventilation across nine departments that tracked VAP. 754 cases were confirmed, resulting in an incidence rate of 19% over the two-year period. Despite recognising and diagnosing VAP, 74% of participating ICUs did not maintain VAP incidence records. Among the departments recording VAP, it was found that VAP most often occurs after five days of mechanical ventilation (MV). Specifically, 64% (7 of 11 who keep records of VAP incidence) of departments report the occurrence of VAP after five days of MV. The remaining 36% of ICUs do not monitor the duration of MV until the diagnosis of VAP is made, hence it is not possible to distinguish early and late onset of VAP.

Education

Nurse education on VAP prevention was reported in most departments (34/43, 79%), with nearly half (16/34, 47%) indicating it was mandatory. Training was offered intermittently in 74% of these ICUs (25/34) and included in the onboarding in 60% (20/34). The most common educational methods were lectures with presentations (17 departments), discussions or brainstorming sessions (15), and practical training (14) – Chart 1. Case studies were rarely used (5 departments). Only five departments reported having an internal VAP prevention protocol.

Interventions

Semi-recumbent position

95% of departments (41/43) used the semi-recumbent position. However, the degree of elevation varied (Chart 2).

More than 80% of ICUs maintained the semi-recumbent position throughout the day, excluding short procedures such as hygiene or X-rays. Four ICUs reported maintaining this position permanently. Beyond head-of-bed elevation, 59% of units practised semi-circular position changes, 20% used prone positioning, and 7% relied solely on elevation. "Other" practices (14.7%) included alternating lateral, supine, and prone positions.

Tracheal suctioning

Tracheal suctioning was reported by 93% of ICUs (40/43), with 88% (35/40) preferring a closed system; five departments used both open and closed methods. Suctioning frequency varied but was most commonly performed as needed (95%) and before major procedures (60%).

Subglottic suctioning was used in 84% of ICUs (36/43), with 75% (27/36) performing it based on clinical need. Additionally, 47% (17/36) were suctioned before patient handling or airway manipulation. Techniques varied: 47% (17/36) used suction pumps connected to a central vacuum source, 36% (13/36) used a 5–10 ml syringe, and a few used a 20 ml syringe or electric suction pumps (5 departments).

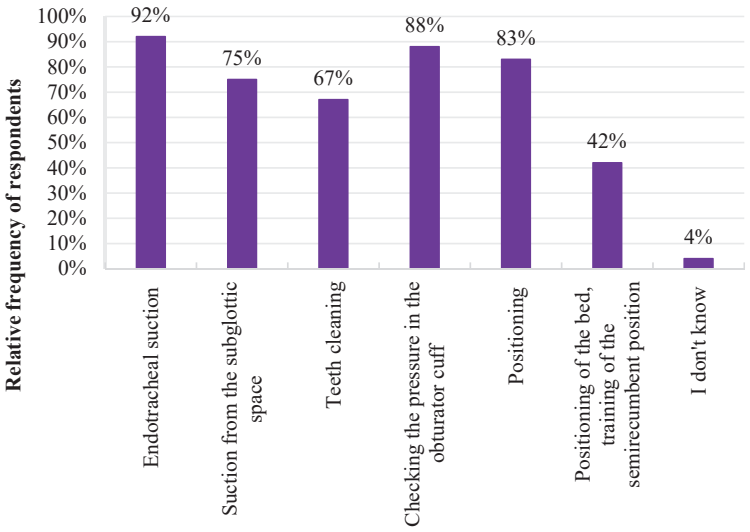


Chart 1. Activities of practical training. The practical training involved the appropriate procedures for endotracheal suctioning (22 departments), suctioning from the subglottic space (18 departments), oral care (16 departments), obturator cuff pressure monitoring (21 departments), and patient positioning (20 departments). Semi-recumbent positioning is less frequently practised (10 departments).

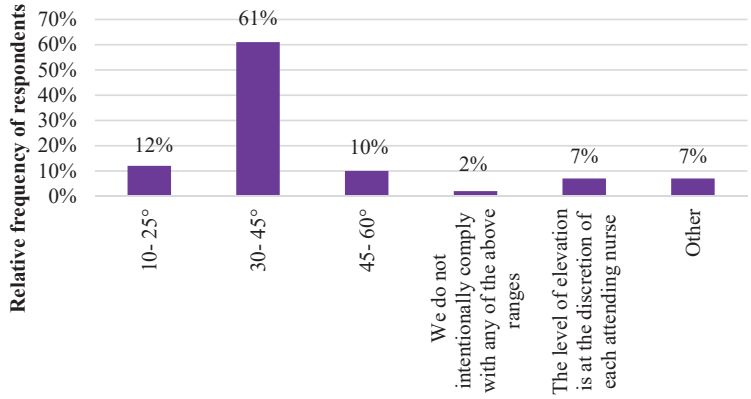


Chart 2. Level of upper body elevation. 61% reported a head-of-bed elevation of 30–45°, 12% (5 departments) used 10–25°, and 10% used 45–60°. In 7% of departments (3), the elevation level was left to the attending nurse's discretion. "Other" responses included: "Usually 30°, if the patient's condition allows," "Depends on the attending physician and patient condition," and "25–30°". One respondent (2%) stated: "We do not purposely follow any of the above ranges."

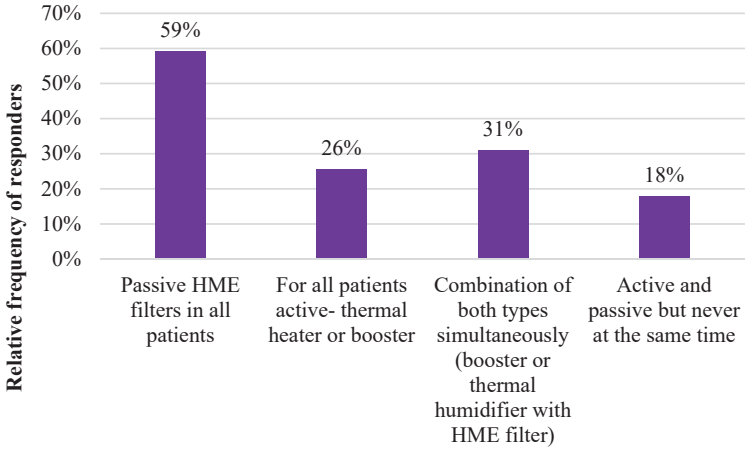


Chart 3. Types of heating and humidification. Passive HME filters were applied in all patients by 59% (23/39), while 31% (12/39) reported simultaneous use of passive and active systems (e.g., booster or thermal humidifier with HME). A quarter (26%, 10/39) used only active humidification, and 18% (7/39) used both types, but never concurrently. Decisions on technique were typically based on departmental standards or patient safety.

Heated humidification
Most ICUs (39/43, 91%) routinely used humidification (Chart 3). Decisions on technique were typically based on departmental standards or patient safety. Notably, 65% (28/43) stated that water condensation in the ventilator circuit was not observed.

The obturator cuff pressure
Almost all responding ICUs reported monitoring pressure in the obturator cuff (41/43, 95%), primarily through one-time manometer measurements (31/41, 76%). Continuous monitoring was the second most frequent answer.

Standards of oral care and oral decontamination
Of 43 respondents, only one reported that oral care was not part of their VAP prevention practices; thus, 42 continued with follow-up questions.

Local oral care documentation was present in 93% (40/43) of ICUs. A few included it under VAP protocols, general care, or did not document it at all. Chlorhexidine mouthwash was most commonly used, either at 0.1% (21/42, 50%) or 0.2% (15/42, 36%). Borglycerin was also reported very frequently (20/42, 48%). Toothbrushing was reported twice daily in 38% of ICUs, though duration was often unspecified (64.3%); 29% provided brushing for two minutes.

Discussion

10% of ICU patients ventilated for >48 hours develop ICU-acquired pneumonia, and roughly two-thirds of these cases qualify as VAP (ECDC, 2024). The overall VAP incidence density in Europe is circa 12 per 1,000 ventilator days, but rates vary widely between countries and units (from ~2 to 19 per 1,000 ventilator days) (ECDC, 2024).

In some European countries, ICUs follow formal ventilator bundles based on the Institute for Healthcare Improvement (IHI) recommendations, while others follow locally adapted guidelines, e.g., in the UK, a High Impact Intervention was introduced by the Department of Health in 2009. In Spain, the "Pneumonia Zero" initiative launched in 2011–2012 achieved VAP rate reductions by reinforcing bundle adherence (Álvarez Lerma et al., 2014). European professional societies also contribute; the European Respiratory Society (ERS) and European Society of Intensive Care Medicine (ESICM) have published HAP/VAP management guidelines (Torres et al., 2017), which reiterates the importance of prevention strategies. In addition, the ESICM endorses ventilator bundle use as part of its patient safety initiatives.

Since there is no national VAP guidance in the Czech Republic, we wanted to know what the daily bedside practice actually looks like. This is the first survey to describe the current practice of VAP prevention in intensive care nursing for adult mechanically-ventilated patients admitted to an ICU in the Czech Republic. There was a remarkably low interest from potential participants in the research (the response rate was 32%, representing 43 ICUs), but our findings indicate substantial heterogeneity in the intensity and combinations of preventive measures, regardless of hospital type or ICU size. Some of our findings are particularly concerning.

Three-quarters of the participating ICUs (32/43, 74%) do not systematically monitor VAP incidence. Although they are aware of it, which may imply that VAP is perceived as a minor issue.

This survey reports that a high proportion of ICUs use head-of-the-bed elevation as a routine approach for all ventilated patients. Still, only circa 60% maintain the proper 30–45° angle. The silver lining is that 81% of departments maintain a semi-recumbent position throughout the day; a 2017 Cochrane systematic review confirms the positive effect of this approach (Alarcon et al., 2017; Fernández-Crehuet et al., 1997).

93% of responding ICUs reported using routine tracheal suctioning in mechanically ventilated patients. Prevalent use of a closed suction system is currently a standard of care in 88% of the ICUs, which is recommended practice and safer for both patients and staff (Bartůněk et al., 2016; Sanaie et al., 2022). Nearly half of the wards reported using a suction device connected to a central vacuum line to suction from the subglottic space, which may potentially harm the patient (Horáčková et. al., 2018). The use of the continuous suction technique was reported frequently as well. However, there is not enough evidence to recommend against this practice (Anand et al., 2021; Wen et al., 2017).

The 2012 European ICU survey found that Heat Moisture Exchanger (HME) usage was one of the highest-compliance measures (82% adoption), indicating that most ICUs routinely use disposable heat-and-moisture exchangers in the ventilator circuit (Ricard et al., 2012). Our results show that almost 60% of the respondents reported using the passive HME filters for all patients (without exception), which is a noteworthy finding, knowing the obvious contraindications for passive humidification (e.g., in patients with thick, copious, or bloody secretions).

Safety guidance in Europe emphasises not using HMEs and heated humidifiers simultaneously. Employing an HME in a ventilator circuit that also has an active heated humidifier can cause excessive resistance, drying or clogging of the HME, and a build-up of condensation, all potentially leading to impaired ventilation. Hence, one-third of ICUs reported simultaneous application of passive and active humidifying, which is dangerous (Hallo-Carrasco et al., 2023).

European guidelines also recommend avoiding unnecessary circuit disconnections and changes, and studies have noted that not changing ventilator circuits routinely (only when soiled) can reduce VAP (Gillespie, 2010; Heyland et al., 1999). The Spanish Zero-VAP guidelines included "discouraging scheduled changes of ventilator circuits, humidifiers, and endotracheal tubes" as a key recommendation (Álvarez Lerma et al., 2014). Our survey reports that the prevailing routine approach in the Czech Republic is a ventilator circuit exchange once a week.

95% of ICUs reported measuring the pressure in the obturator cuff of an endotracheal or tracheostomy cannula in all ventilated patients, either one-time (76%) or continuously. Evidence to support one approach over the other is limited (Dat et al., 2022; Pozuelo-Carrascosa et al., 2022).

The practice of oral hygiene in ICUs also varies across Europe when it comes to the use of antiseptics – mainly chlorhexidine (Álvarez Lerma et al., 2014) and frequency of care. In the UK, guidelines include brushing all mechanically-ventilated patients teeth at least twice daily for two minutes to remove plaque. Additionally, suctioning, moistening, and cleaning the oral cavity with oral hygiene sticks should be performed every two to four hours (Gregorczyk-Maga et al., 2023). However, in recent years, the efficacy and safety of chlorhexidine have been questioned – and this is reflected in revised expert recommendations (Klompas et al., 2022). Many European ICUs have re-

sponded by tailoring oral care policies by reducing concentration or using it in certain patient groups. Our results show that this is not a common practice in the Czech Republic – in the absence of a national guideline, most ICUs (over 74%) do not even have nursing standards for oral care. Among those who do, teaching hospitals prevail, with 75% reporting following it.

Continuous training and education of ICU staff is a cornerstone of VAP prevention efforts, as well-trained personnel are necessary for translating guidelines into practice (Akın et al., 2014; Yazdani et al., 2015; Zed and Mohammed, 2019). In 2012, a landmark survey in 13 European countries reported considerable heterogeneity in ICU staff compliance with VAP prevention practices and notable differences among countries (Ricard et al., 2012). Our survey revealed again a substantial heterogeneity regarding education. In 75% of ICUs, only one-time educational sessions were reported, which is undoubtedly a time-saving approach. This is in line with a study by Mishra and Rani (2020) with a single 45-minute educational session, but as opposed to the research by Parisi et al. (2016), where the VAP bundle education took place bi-weekly for over three monthsand staff knowledge was significantly higher. The latter approach was recommended in 2016 by the American Association of Critical-Care Nurses.

95% of our respondents recognised the importance of education in VAP prevention, believing in the reduction of iatrogenic harm, costs of care, or length of hospital stay. ICUs that implemented regular educational programmes reported a lower incidence of VAP compared to ICUs without educational programmes or those that provided them on a sporadic basis (16% versus 26%), which is in line with previous studies (Abad et al., 2021; Mogyoródi et al., 2023; Samra et al., 2017).

There appears to be a lower VAP incidence (17% of responding ICUs) in the departments using a local nursing standard of care, including the VAP bundle, compared to those without any (21%). Similarly, a systematic review by Mastrogianni et al. (2023), analysing 38 studies, reported that implementing care bundles led to a significant (up to 64%) reduction in VAP incidence. However, the presence of internal protocols may be associated with a lower incidence of VAP, but without sustained support and education, the compliance of nurses is low (Leong et al., 2024).

Limitations

The main limitation of our study is the low response rate. This may have been influenced by the length of the questionnaire and the complexity of the questions regarding the prevalence of VAP – which required detailed statistical data. Cooperation on national research was also primarily rejected. At other institutions, we were surprised by the complicated approval process. This is a national survey, therefore our results may not be generalisable to other countries.

Conclusion

We found a huge variability in the intensity and combinations of preventive measures regarding VAP. It is frequently considered to be a marginal issue; only 26% of ICUs keep VAP incidence records. Our results show that only 5 in 43 ICUs have a local protocol for VAP prevention, and in some ICUs the individual interventions are provided in an inappropriate or even unsafe manner.

Europe's experience with VAP highlights the importance of trustworthy data to promote change, the need for high compliance with VAP bundles, and the importance of education. We recommend developing national guidelines for VAP prevention based on the available current evidence. It is important to initiate the creation of expert groups, which, in cooperation with NCO NZO, ČAS, and ČSIM, could implement this operational procedure in practice and ensure its pilot testing. We also recommend conducting follow-up longitudinal monitoring after the national procedure has been implemented across the country.

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We would like to thank all those who actively contributed with their answers to the obtained results and thus fundamentally to the new recommendations leading to the improvement of preventive measures in the field of VAP prevention in the Czech Republic.

We would also like to thank all the collaborators who supported data collection, project preparation, and implementation. We are especially grateful to Kateřina Ťopková and Šárka Vosalová.

Authors' statement

We confirm the uniqueness of this project given its nature to conduct a national scale survey. The data obtained may provide valuable insights into nursing care practices.

The statistics were checked prior to submission by an expert statistician and state their name and e-mail address: Ing. Petr Hadraba (PHadraba@seznam.cz).

We affirm that the methods used in the data analyses are suitably applied to their data within their study design and context, and the statistical findings have been implemented and interpreted correctly.

Informed consent

Survey participation was voluntary, and consent was implied through return of survey.

Data availability statement

Data are available on request from the corresponding author.

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Conflict of interest

The authors have no conflict of interest to declare.

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