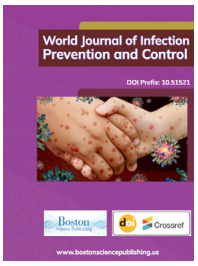
RESEARCH ARTICLE - OPEN ACCESS

World Journal of Infection Prevention and Control DOI: http://dx.doi.org/10.51521/WJIPC.2025.11101

Contents lists available at bostonsciencepublishing.us

World Journal of Infection Prevention and Control



Effect of a Nursing Practice Promotion Program in Prevention of Ventilator-Associated Pneumonia in Intensive Care Units of a Tertiary Care Hospital in a Middle-Income Country

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A R T I C L E I N F O

Article history:
Received 08 August 2025
Revised 20 August 2025
Accepted 25 August 2025
Published 30 August 2025

KEYWORDS:
Ventilator-Associated Pneumonia,
Nursing Practice,
Prevention,
Intensive Care Unit,
Herzberg's Motivation Theory,
Practice Promotion,
WHAPOS Protocol

A B S T R A C T

Background: Ventilator-associated pneumonia (VAP) poses a significant healthcare challenge in intensive care units, particularly within the cardiovascular-thoracic surgical ICU (ICU-CVT), which experiences elevated rates compared to overall hospital averages.

Objective: This quasi-experimental study aimed to assess the effectiveness of a nursing practice promotion program grounded in Herzberg's Motivation Theory to enhance VAP prevention practices and reduce incidence rates in the ICU-CVT of a tertiary care hospital.

Methods: A one-group pretest-posttest design was implemented involving 15 registered nurses and mechanically ventilated patients (48 pre-intervention, 32 post-intervention) from November 2023 and February 2024. The intervention focused on motivating factors (group discussions, feedback, recognition, training, and role modeling) and hygiene factors (clear guidelines, adequate equipment, supportive supervision, and effective communication). Data were collected via a knowledge assessment, a practice observation form based on the WHAPOS protocol (Weaning, Hand hygiene, Aspiration precautions, Prevention of contamination, Oral care, and Suction), and VAP surveillance. Statistical analysis included descriptive statistics, chi-square tests, and VAP rates per 1,000 ventilator-days.

Results: Following the intervention, compliance with VAP prevention guidelines among nurses significantly increased from 40% to 90% ($p<0.04$). Notable improvements were recorded in patient assessments using weaning protocols (10.70% to 100%, $p=0.002$), hand hygiene practices (64.50% to 100%, $p=0.003$), and oral care (29% to 100%, $p<0.001$). However, VAP incidence rates did not show a significant difference between pre- and post-intervention periods (5.18 vs. 5.78 per 1,000 ventilator-days). It is important to note that post-intervention patients had significantly higher APACHE II scores (16.71 vs. 28.22, $p<0.0001$), indicating greater illness severity.

Conclusion: The nursing practice promotion program effectively increased adherence to VAP prevention guidelines, yet did not lead to a reduction in VAP incidence rates. This outcome may be attributed to patient-specific risk factors, including higher illness severity in the post-intervention group. These findings highlight the necessity for comprehensive VAP prevention strategies that not only enhance nursing practices but also address individual patient risk, particularly in high-risk populations with complex medical conditions

Key contributions of our research include:

1. **Novel Theoretical Application:** First study to apply Herzberg's Motivation Theory as a framework for VAP prevention nursing practice promotion in Southeast Asia. Practical Implementation Focus: Demonstrates the effectiveness of motivating factors (group discussions, feedback, recognition, training) combined with hygiene factors (clear guidelines, adequate equipment, supervision) in improving nursing compliance.
2. **Real-world Healthcare Setting:** Conducted in a cardiovascular-thoracic surgical ICU where VAP rates (7.41 per 1,000 ventilator-days) significantly exceed hospital averages, representing a high-risk population.
3. **Comprehensive WHAPOS Protocol Evaluation:** Systematic assessment of six key VAP prevention practices: Weaning, Hand hygiene, Aspiration precautions, Prevention of contamination, Oral care, and Suction.
4. **Important Clinical Insights:** While nursing compliance improved significantly (40% to 90%, $p<0.04$), VAP rates remained unchanged, highlighting the complexity of infection prevention and the importance of patient-specific risk factors.

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Introduction

Ventilator-associated pneumonia (VAP) continues to pose a significant healthcare challenge in intensive care units (ICUs), accounting for 86% of hospital-acquired pneumonia cases and being a leading cause of mortality among mechanically ventilated patients [1]. The European Centre for Disease Control reported a VAP incidence rate of 5.6 per 1,000 ventilator-days in ICUs with over 60% ventilated patients on ventilation. In contrast, the United States documented a rate of 1.27 cases per 1,000 ventilator-days, which contributes to prolonged mechanical ventilation (21.8 days), extended ICU stays (20.5 days), and longer hospitalizations (32.6 days), incurring additional healthcare costs of approximately US$39,828 per case [2]. In Thailand, tertiary hospital studies indicate VAP rates ranging from 5.1 to 6.8 per 1,000 ventilator-days, with mortality rates between 35.8% and 36.8% [3,4].

Nursing practice promotion through various strategies has shown effectiveness in reducing VAP incidence. Previous research has demonstrated that implementing nursing care bundles coupled with education, feedback mechanisms, and support systems can significantly enhance compliance with VAP prevention protocols. For instance, the application of the WHAPO protocol (Weaning, Hand hygiene, Aspiration precautions, Prevention of contamination, and Oral care) led to improved nursing practices ($p<0.001$) and a reduction in VAP rates from 12.26 to 2.68 per 1,000 ventilator-days (RR=6.11, 95% CI: 2.12-17.65) [5].

The cardiovascular-thoracic surgical ICU at our tertiary hospital faces particularly high VAP rates of 7.41 per 1,000 ventilator-days, significantly exceeding the hospital's overall rate of 5.01. This elevated risk is especially concerning, as patients undergoing thoracic surgery are 38 times more likely to develop pneumonia compared to those undergoing other surgical procedures. Utilizing evidence-based nursing practices framed by Herzberg's Motivation Theory presents a promising approach to tackle this critical issue through systematic practice promotion and enhanced staff engagement.

This quasi-experimental study aims to evaluate the impact of nursing practice promotion on VAP prevention in the cardiovascular-thoracic surgical ICU. We hypothesized that post-intervention, adherence to nursing practices will improve and VAP incidence rates will decrease. The study focused on registered nurses working in the cardiovascular-thoracic surgical ICU and mechanically ventilated patients between November 2023 and February 2024.

METHODS

Study Design And Methodology

This quasi-experimental study employed a rigorous one-group pretest-posttest design involving 15 registered nurses and 80 mechanically ventilated patients over a four-month period (November 2023 - February 2024). Our methodology demonstrates several strengths:

- **Robust Sample Size Calculation:** Used G*Power software ensuring 80% power to detect moderate effect sizes.
- **Validated Instruments:** All data collection tools were validated by expert panels and tested for reliability.
- **Comprehensive Data Collection:** Combined knowledge assessments, direct practice observations, and VAP surveillance.
- **Ethical Compliance:** Full approval from hospital ethics committee with adherence to Declaration of Helsinki guidelines

Setting and Participants

The study was conducted in the cardiovascular-thoracic surgical intensive care unit (ICU-CVT) of a tertiary care hospital in Thailand between November 2023 and February 2024. Two groups of participants were included:

Nurses

All registered nurses (N=15) working in the ICU-CVT were recruited through purposive sampling. This group represented the target population for the nursing practice intervention.

Patients

This study determined the sample size using the G*Power software to ensure sufficient statistical power to evaluate the effectiveness of nursing practice interventions in preventing ventilator-associated pneumonia (VAP) in the cardiothoracic surgical intensive care unit. The effect size was set at 0.5, with a Type I error (α) of 0.05 and a statistical power of 0.80. A two-tailed test was employed. The G*Power calculation indicated that an appropriate sample size would be 80 participants, with 48 in the pre-intervention group and 32 in the post-intervention group. This sample size provides 80% power to detect a moderate effect size.

Inclusion Criteria

1. Age ≥15 years
2. Receiving mechanical ventilation via endotracheal tube
3. Patient or legal guardian provided informed consent

Exclusion Criteria

1. Pre-existing VAP diagnosis based on CDC 2009 criteria
2. Withdrawal of consent by patient or legal guardian

RESEARCH INSTRUMENTS

Implementation Tools

1. Guidelines for the Prevention of Ventilator-Associated Pneumonia (VAP) These guidelines were adapted from the standard operating procedures of Sakon Nakhon Hospital. They include six key practices: (1) ventilator weaning, (2) hand hygiene, (3) aspiration prevention, (4) prevention of ventilator equipment contamination, (5) oral and dental care, and (6) suctioning.

2. Educational Training Program A knowledge training plan was developed by the researcher, covering the following topics: the incidence and impact of ventilator-associated pneumonia, definitions of VAP, and nursing interventions for VAP prevention. The content was organized in a teaching schedule and delivered using PowerPoint presentations.

Data Collection Tools

1. General Information Questionnaire for Professional Nurses This self-administered, closed-ended questionnaire was developed by the researcher to collect demographic and work-related information of nurses in the cardiothoracic intensive care unit. It includes items on gender, age, position, department, duration of clinical experience, previous training, and participation in conferences related to VAP prevention.

2. Focus Group Discussion Guide This guide was designed to facilitate group discussions aimed at identifying problems and co-developing solutions regarding VAP prevention practices in the hospital. It includes questions on the incidence of VAP in the unit, current preventive practices, existing barriers, and needs for improvement.

3. Knowledge Assessment Questionnaire on VAP Prevention Practices This tool is a 30-item multiple-choice test with four options per question. Each correct answer is awarded one point, and incorrect answers receive zero points. It was designed to measure the participants' knowledge of VAP prevention strategies.

4. Observation Checklist for VAP Prevention Practices Adapted from the hospital's VAP prevention protocol, this checklist records observed nursing practices in six categories: ventilator weaning, hand hygiene, aspiration prevention, prevention of equipment contamination, oral and dental care, and suctioning.

5. VAP Surveillance Form This form was adapted from Sakon Nakhon Hospital's VAP surveillance tool. It consists of six sections: (1) patient demographic data, (2) endotracheal intubation and ventilator use details, (3) VAP diagnostic criteria and infection summary, (4) laboratory test results, (5) VAP treatment, and (6) treatment outcomes.

QUALITY CONTROL

Content Validity

All instruments were validated by three experts:

- One infectious disease physician
- Two infection control nurses

Content validity was established and modifications were made based on expert recommendations.

Reliability Testing

1. Training program was pilot tested with 5 nurses from similar settings

2. Knowledge assessment reliability was tested with 10 nurses (KR-20 = 0.7)
3. Observation form inter-rater reliability was tested with 10 cases (reliability coefficient = 1.0)

Data Collection Procedure

The data collection process was divided into three phases: pre-intervention, intervention (promotion), and post-intervention, with the implementation guided by Herzberg's Two-Factor Theory to support behavioral change among professional nurses in the Cardiothoracic Intensive Care Unit.

1. Pre-Intervention Phase

1. The researcher explained the objectives, implementation process, and outcome measurements of the study to professional nurses in the Cardiothoracic, Cardiac, and Vascular Intensive Care Unit.
2. Baseline data were collected through direct observation of routine nursing practices in VAP prevention.
3. Surveillance of VAP prevention practices was conducted using a standardized checklist and surveillance form.

2. Intervention Phase: Promotion of VAP Prevention Practices

The intervention was based on Herzberg's Dual-Factor Theory, comprising motivators and hygiene factors as follows:

2.1 Motivators (Intrinsic Factors) These internal factors enhance motivation through direct work-related elements such as task assignments, recognition, achievement, and appreciation. Strategies included:

- Providing feedback on overall performance with praise and encouragement to improve compliance with VAP prevention practices
- Encouraging participation through focus group discussions with professional nurses to review current practices, identify barriers, and collaboratively explore solutions
- Conducting educational training covering the definition and diagnostic criteria of VAP, risk factors, and preventive nursing practices
- Distributing educational materials such as bulletin boards, pamphlets, activity posters, reminders, and visual guidelines related to VAP prevention
- Implementing a role model activity, recognizing and rewarding exemplary nurses who adhered strictly to VAP prevention practices

2.2 Hygiene Factors (Extrinsic Factors) These factors involve the working environment, including interpersonal relationships, communication, feedback systems, policies, and access to essential resources that support appropriate nursing practices:

- Monitoring and supervision to provide guidance and ensure adherence to standard procedures
- Coordinating support for supplies and equipment, including closed suction systems, gloves, towels, and alcohol-based hand sanitizers
- Establishing communication channels for staff to express opinions, report challenges, and share experiences through post-shift handovers and a designated LINE communication group
- Observing nursing practices and collecting data on VAP prevention compliance
- Conducting ongoing VAP prevention surveillance
- Providing regular feedback every Friday, both as a group summary and individual feedback, to reinforce good practices and improve areas of weakness

3. Post-Intervention Phase

1. Continued monitoring of nursing practices to assess compliance with the established VAP prevention guidelines
2. Ongoing surveillance of VAP prevention behaviors
3. Observation and documentation of nursing practices related to VAP prevention
4. Final analysis of the outcomes, including adherence to preventive practices and incidence of ventilator-associated pneumonia

Data Analysis

1. Descriptive statistics for demographic data
2. Chi-square test for comparing nursing practice compliance rates
3. VAP incidence rate calculation per 1,000 ventilator-days
4. Mann-Whitney U Test was used to compare patient outcomes between the independent pre- and post-intervention groups, as the data were non-parametric and the groups were unpaired.

RESULTS

Demographic Characteristics

Table 1: Demographic Characteristics of Nursing Staff (N=15).

Characteristic	n (%)
Gender	
Male	1 (6.67)
Female	14 (93.33)
Age (years)	
20-25	2 (13.33)
26-30	5 (33.34)
31-35	5 (33.34)
36-40	2 (13.33)
41-45	0 (0.00)
46-50	1 (6.66)
Min-Max	22-50
Mean±SD	33.27±6.5
Work experience in Hospital (years)	
<5	6 (40.00)
5-9	4 (26.67)
10-14	4 (26.67)
15-19	0 (0.00)
≥20	1 (6.66)
Min-Max	2-23
Mean±SD	9.60±5.93
Work experience in ICU CVT (years)	
<1	2 (13.33)
1-3	0 (0.00)
4-5	10 (66.67)
>5	3 (20.00)
Min-Max	0.5-7
Mean±SD	4.45±1.82
Training on VAP Prevention	
Never attended	11 (73.33)
Attended	4 (26.67)
- Hospital academic conference	4 (26.67)
Participation in VAP Prevention Meetings	
Never attended	12 (80.00)
Attended	3 (20.00)
- IPC committee meetings	3 (20.00)

Table 2: Patient Characteristics Pre- and Post-Intervention

Characteristic	Pre-intervention n=48 (%)	Post-intervention n=32 (%)	p-value
Gender			0.885
Male	32 (66.67)	22 (68.75)	
Female	16 (33.33)	10 (31.25)	
Age (years)			0.194
<20	1 (2.08)	0	
21-30	3 (6.25)	1 (3.13)	
31-40	1 (2.08)	0	
41-50	4 (8.33)	3 (9.38)	
51-60	11 (22.92)	8 (25.00)	
61-70	19 (39.58)	11 (34.38)	
71-80	8 (16.67)	8 (25.00)	
>80	1 (2.08)	1 (3.13)	
Min-Max	17-82	26-86	
Mean±SD	57.50±16.70	63.09±11.79	
APACHE II score (Mean)	16.71	28.22	<0.0001
Ventilator days (Mean)	4.02	5.41	0.722

Effect of Practice Promotion on Nursing Compliance

Table 3: Comparison of Nursing Practices: Percentages of Correct Practices Before and After Promotion Program for Ventilator-Associated Pneumonia Prevention

Activities	Correct Practice		p-value
	Before (N=736)	After (N=892)	
Wean			
- Patient assessment using Weaning protocol with assessment form in patient file	10.70%	100.00%	0.002*
- Assessment of arterial blood gas, monitoring oxygen saturation before weaning	15.40%	100.00%	0.025*
- Assessment of vital signs and tidal volume before ventilator removal	21.10%	100.00%	0.008*
Hand hygiene			
- Before touching ventilated patients	43.30%	78.00%	0.058*
- Before performing Aseptic Technique procedures on ventilated patients	64.50%	100.00%	0.003*
- After contact with ventilated patient's secretions	90.00%	100.00%	0.157
- After touching ventilated patients	93.50%	100.00%	0.157
- After touching ventilated patient's surrounding environment	83.90%	97.60%	0.102
Aspirate Precautions			
- Measuring cuff pressure every shift	100.00%	100.00%	1.00
- Maintaining cuff pressure not exceeding 20-25 mmHg (20-30 cm H_2O)	100.00%	100.00%	0.317
- Elevating head of ventilated patients to 30-45 degrees if not contraindicated	97.10%	100.00%	0.317
- Checking tube position before feeding	95.70%	100.00%	0.317
Prevent Contamination			
- Changing ventilator circuit only when visibly soiled	100.00%	100.00%	1.00
- Changing Ambu bag when soiled	100.00%	100.00%	1.00
- Cleaning Ambu bag with 70% alcohol daily	100.00%	100.00%	1.00
- Draining water from ventilator circuit when condensation is present	85.30%	100.00%	0.025*
- Changing sterile water in humidifier every 24 hours	88.20%	100.00%	0.180
Oral Care			
- Brushing teeth at least twice daily (using SMW/NSS wipe if contraindicated)	29.00%	100.00%	<0.001*
- Cleaning oral cavity with SMW/NSS during AM care and PM care	96.20%	100.00%	1.00
Suction			
- Assessment of secretions before and after each suctioning	55.20%	89.50%	0.02*
- Using suction pressure of 80-120 mmHg, not exceeding 150 mmHg, for 10-20 seconds	100.00%	100.00%	1.00
- Pre-oxygenation with 100% O_2 for 1-2 minutes before and after suctioning	100.00%	100.00%	1.00
- Documenting secretion characteristics in nursing notes	100.00%	100.00%	1.00
- Disinfecting endotracheal tube connections, ventilator circuit connections, and Ambu bag port with 70% alcohol swab before and after suctioning	100.00%	100.00%	1.00
Overall compliance	40.00%	90.00%	0.04*

*p-value < 0.05

Impact on VAP Incidence

Table 4: VAP Incidence Rates Pre- and Post-Intervention

Period	Ventilator Days	VAP	Incidence Rate*
Pre-intervention	193	1	5.18
Post-intervention	173	1	5.78

*Per 1,000 ventilator-days

DISCUSSION

This quasi-experimental study aimed to evaluate the impact of nursing practice promotion on ventilator-associated pneumonia (VAP) prevention in the cardiovascular-thoracic surgical intensive care unit at a tertiary care hospital. The findings lead to a discussion connected to the research hypotheses, theoretical frameworks, and related literature.

The results revealed a significant increase in compliance with VAP prevention guidelines, rising from 40.00% to 90.00% (p = 0.04), supporting our hypothesis that nursing practice would improve post-intervention. This enhancement in guideline adherence can be attributed to Herzberg's Motivation Theory [6], which provided the conceptual framework for this study. The intervention integrated motivating factors (e.g., group discussions, feedback, recognition and rewards, training, and role modeling) with hygiene factors (e.g., clear practice guidelines, adequate equipment, supervisory support, effective communication, and a conducive working environment). This approach aligns with Bandura's (1986) Social Learning Theory [7], which emphasizes that learning occurs through observation and imitation, facilitated by modeling and reinforcement.

Notable activities showing statistically significant improvement included patient assessments using the Weaning protocol (from 10.70% to 100.00%, p = 0.002), hand hygiene before aseptic techniques (from 64.50% to 100.00%, p = 0.003), draining water from ventilator circuits (from 85.30% to 100.00%, p = 0.025), brushing teeth at least twice daily (from 29.00% to 100.00%, p < 0.001), and assessing of secretions before and after suctioning (from 55.20% to 89.50%, p = 0.02). These findings are consistent with Kalyan, *et al.,* (2020) [5], who demonstrated that implementing the WHAPO protocol improved nursing practices and reduced VAP rates.

Similarly, Jansson, *et al.,* (2013) [8] noted that educational interventions increased nurses' knowledge and practices related to VAP prevention, and Khan, *et al.,* (2021) [9] reported significant improvements in knowledge and practices scores following educational programs. In Thailand, Tantrakul, *et al.,* (2019) [10] found that guideline adherence rates increased from 54% to 94% after implementing the developed guidelines, resulting in decreased VAP rates.

Interestingly, activities with the lowest pre-intervention compliance—such as using the Weaning protocol and brushing teeth—saw substantial increases in adherence post-intervention. This improvement can be explained by Knowles' (1984) Adult Learning Theory (Andragogy) [11], which posits that adults learn most effectively when they see the relevance and practical applications of their learning experiences.

While the nursing practice promotion led to improved compliance, our results showed no significant difference in VAP incidence rates between pre- and post-intervention periods (5.18 vs. 5.78 per 1,000 ventilator-days), which does not support our hypothesis that VAP rates would decrease. This outcome contrasts with several studies reporting decreased VAP rates following enhanced nursing practices, such as Álvarez-Lerma, *et al*., (2018) [12] and Sharma, *et al*., (2016) [13].

The lack of reduction in VAP rates may be attributed to several factors. The difference in patient severity, as indicated by APACHE II scores (16.71 vs. 28.22), was statistically significant based on the Mann-Whitney U test (p < 0.0001), indicating greater illness severity in the post-intervention group.

This finding is consistent with Rosenthal et al. (2023) [14], which identified higher APACHE II scores as a risk factor for VAP.

Additionally, one post-intervention VAP case involved an elderly patient with multiple comorbidities who could not maintain an elevated head-of-bed position due to neck catheter. This aligns with Chen, *et al*., (2022) [15], which identified inability to elevate the head of the bed as significant risk factor for VAP. Such patient-specific factors highlight the complexity of VAP prevention, as indicated by Reason's (1990) Human Error Theory [16], which asserts that clinical outcomes depend on various systemic factors beyond staff practices.

The study duration of four months (one-month pre-intervention, two months' intervention, and one-month follow-up) may have been insufficient to observe significant changes in VAP rates. Other studies, like Jain et al. (2016) [17], found that longer follow-up periods yielded more substantial results.

In summary, the relationship between guideline adherence and VAP rates underscores the complexity of VAP prevention. While compliance with VAP prevention guidelines significantly increased, VAP rates did not decrease, reflecting that VAP prevention is influenced by multiple factors. This aligns with Plsek and Greenhalgh's (2001) Complexity Science approach [18], which suggests that healthcare systems are complex adaptive systems where outcomes cannot be precisely predicted.

Implications for Practice

1. Nursing practice promotion using Herzberg's Motivation Theory is an effective method for improving compliance with VAP prevention guidelines and should be applied in other nursing contexts.
2. VAP prevention should focus on both improving nursing practices and managing patient-specific risk factors, especially in patients with positioning limitations, elderly patients, and those with comorbidities.
3. Specific guidelines should be developed for patients on ECMO or with head-of-bed elevation limitations to reduce VAP risk.

Recommendations for Future Research

1. The effects of nursing practice promotion should be studied over a longer period, such as 6-12 months, to assess the sustainability of changes and impact on VAP rates.

2. The effectiveness of VAP prevention guidelines tailored for high-risk patients, such as those who cannot maintain head-of-bed elevation, should be evaluated.

3. Further research should investigate other factors that may affect VAP incidence beyond nursing practices, such as pathogen types, environmental factors, and patient factors.

Target Audience

This research will be of significant interest to:

- Infection prevention and control practitioners
- Critical care nurses and nursing managers
- Hospital quality improvement teams
- Healthcare administrators in resource-limited settings
- Researchers studying healthcare-associated infections
- Policy makers developing nursing education programs

CONCLUSION

We believe this manuscript makes a significant contribution to the infection prevention literature by demonstrating that while nursing practice promotion can dramatically improve compliance with evidence-based protocols, reducing VAP incidence requires a multifaceted approach that addresses both staff behaviors and patient-specific risk factors.

The study's findings have immediate practical implications for ICUs worldwide, particularly in middle-income countries facing similar resource constraints and high VAP rates. We anticipate that publication in WJIPC will facilitate widespread dissemination of these important findings to the global infection prevention community.

Ethical Considerations

The study was approved by the hospital's ethics committee. Written informed consent was obtained from all participants. Data confidentiality was maintained through coding and secure storage. Participants were informed of their right to withdraw at any time without consequences. The study adhered to the Declaration of Helsinki guidelines for research involving human subjects.

Conflict of Interest:

We have no conflicts of interest to declare

Funding: None

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