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# Effects of a TTM-based Stratified Intervention on VAP Prevention Behaviors among Multi-professional ICU Staff

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**Abstract:** *Objective*: To evaluate VAP prevention behavioral characteristics and barriers among ICU physicians, nurses, and cleaners based on the Transtheoretical Model (TTM), and to verify the application effects of a stratified intervention model. *Methods*: A quasi-experimental study was conducted. In June 2025, a convenience sample of 205 ICU staff from 7 ICUs of a tertiary hospital was recruited. A self-designed questionnaire was used to construct the model, which was implemented for 6 months to compare behavioral stages and VAP incidence. *Results*: Before the intervention, significant differences were observed in behavioral stages among the groups ($p < 0.05$). The maintenance stage proportions for physicians, nurses, and cleaners were 71.87%, 41.14%, and 13.33%. After intervention, they increased to 84.38%, 58.23%, and 33.33%, respectively ($p < 0.05$). Subglottic secretion drainage compliance among nurses increased from 41.77% to 89.24%, and environmental cleaning compliance among cleaners increased from 26.67% to 86.67% ($p < 0.05$). VAP incidence decreased from 3.14 to 1.21 per 1,000 ventilator-days ($p < 0.05$). *Conclusions*: The model precisely matches occupational needs, promotes positive behavioral shifts, improves compliance, and significantly reduces VAP incidence.

**Keywords:** Transtheoretical model; ICU; Ventilator-associated pneumonia; Stratified intervention

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## 1. Introduction

Ventilator-Associated Pneumonia (VAP) is one of the most common and severe complications associated with mechanical ventilation therapy, leading to prolonged hospital stays and increased mortality rates [1,2]. Ladbrook et al. confirmed that while bundled interventions are cost-effective, inadequate compliance remains a key barrier [3]. The SHEA/IDSA 2022 updated guidelines outline comprehensive strategies for preventing

VAP, Ventilator-Associated Events (VAE), and non-ventilator hospital-acquired pneumonia, emphasizing the importance of cognitive and behavioral compliance across the entire ICU team, including nurses, physicians, and cleaning staff [4]. However, existing research and intervention practices exhibit notable limitations: studies predominantly focus on nurses, neglecting the roles of physician decision-making and environmental control by cleaning staff; moreover, intervention methods are often uniform, relying on "one-size-fits-all" knowledge dissemination without considering the psychological patterns of individual behavior change [5]. The Transtheoretical Model (TTM), proposed by Prochaska et al., divides individual behavior change into five stages and has been widely validated in the field of health behavior modification [6,7]. This study innovatively introduces TTM into ICU team-based prevention and control, incorporating physicians, nurses, and cleaning staff for the first time to construct a stratified intervention model and evaluate its effectiveness.

## 2. Objects and methods

### 2.1. Research objects

A convenience sampling method and a pre-post control design were employed. All currently employed medical staff from seven intensive care units (ICUs) in a tertiary grade A general hospital in Central China were selected as the research objects. Prior to the survey, approval was obtained from the Ethics Committee of Xiangyang No.1 People's Hospital Affiliated to Hubei Medical College (Approval No.: 2026KY023).

#### 2.1.1. Inclusion criteria

Continuous work in the target ICU for ≥ 3 months; direct involvement in patient care, diagnosis and treatment, or environmental cleaning; informed consent and voluntary participation in the study.

#### 2.1.2. Exclusion criteria

Long-term leave (> 1 month), further education, or rotation out of the department during the study period. Ultimately, 32 physicians, 158 nurses, and 15 cleaning staff (totaling 205 individuals) were included.

### 2.2. Research tools

#### 2.2.1. General information questionnaire

This included professional title, years of work experience, and the type of ICU.

#### 2.2.2. VAP prevention and control knowledge scale

Comprising 15 questions covering the definition, risk factors, and core prevention and control measures of VAP, each correct answer was scored 1 point, with a total score ranging from 0 to 15. The Cronbach's α coefficient was 0.82.

#### 2.2.3. VAP prevention and control behavior and self-efficacy scale

Using a Likert 5-point rating scale, this assessed the self-reported frequency of compliance (1 = never, 5 = always) and confidence in executing eight key prevention and control measures. The Cronbach's α coefficient was 0.88.

#### 2.2.4. TTM behavioral stage assessment scale

Based on the Transtheoretical Model, this scale determined an individual's stage in "overall VAP prevention

and control behavior" (pre-contemplation, contemplation, preparation, action, maintenance) through five items.

### 2.3. Data collection

The first phase of this study was the model construction phase (March–June 2025), aimed at developing a stratified intervention model based on baseline surveys and theoretical frameworks; the second phase was the model application and effectiveness evaluation phase (June-November 2025), implementing the intervention and assessing its effects.

### 2.4. Statistical methods

Data analysis was performed using SPSS 25.0 software. Continuous data were expressed as mean ± standard deviation, with paired sample *t*-tests used for comparisons before and after the intervention; categorical data were expressed as frequencies and percentages, with chi-square tests or non-parametric tests used for comparisons before and after the intervention. A $p$-value < 0.05 was considered statistically significant.

## 3. Results

### 3.1. Baseline data of research objects

This study ultimately included 205 ICU medical staff, with their demographic characteristics detailed in **Table 1**.

**Table 1.** Baseline demographic characteristics of research objects

| Characteristics | Doctors | Nurses | Cleaning staff | Total |
|---|---|---|---|---|
| Gender | | | | |
| Male | 18 (56.3%) | 12 (7.6%) | 3 (20.0%) | 33 (16.1%) |
| Female | 14 (43.8%) | 146 (92.4%) | 12 (80.0%) | 172 (83.9%) |
| Age (years) | 35.6 ± 5.2 | 28.4 ± 4.8 | 48.3 ± 6.1 | - |
| ICU working experience (years) | 8.2 ± 4.5 | 5.1 ± 3.6 | 3.5 ± 2.2 | - |
| Professional title | | | | |
| Junior | 2 (6.3%) | 102 (64.6%) | 15 (100.0%) | 119 (58.0%) |
| Intermediate | 18 (56.3%) | 52 (32.9%) | 0 (0.0) | 70 (34.1%) |
| Senior or above | 12 (37.5%) | 4 (2.5%) | 0 (0.0) | 16 (7.9%) |
| Total | 32 (15.6%) | 158 (77.1%) | 15 (7.3%) | 205 (100.0%) |

### 3.2. Baseline assessment results before intervention

#### 3.2.1. Distribution of VAP prevention and control behavioral stages

Before the intervention, there were significant differences in the distribution of VAP prevention and control behavioral stages among the three categories of medical staff ($\chi^2 = 45.732$, $p < 0.001$). The proportion of physicians in the "action/maintenance stage" was the highest (65.6%), while it was relatively lower for nurses (41.8%) and cleaning staff (6.7%). More than half of the cleaning staff (53.3%) were in the "pre-contemplation stage."

### 3.2.2. Levels of VAP prevention and control knowledge and behavior

The baseline survey revealed statistical differences in VAP prevention and control knowledge scores among the three categories of personnel ($F = 89.347$, $p < 0.001$). The physician group had the highest score (12.45 ± 1.82), followed by the nurse group (9.23 ± 2.15), and the cleaning staff had the lowest score (4.80 ± 1.67). In terms of key behavioral compliance, direct observation revealed that nurses had a compliance rate of 58.2% for "daily assessment of sedation and ventilator weaning indications", and only 41.8% for "standardized subglottic secretion drainage." The compliance rate of cleaning staff for "cleaning and disinfecting high-touch surfaces at least twice daily" was only 26.7%.

## 3.3. Construction of a stratified intervention model

Based on the "stage-matching" principle of the TTM and combined with the results of baseline needs analysis, the "Stratified Intervention Model for VAP Prevention and Control Behaviors among ICU Medical Staff" was constructed. The model framework is shown in **Table 2**.

**Table 2.** Framework of the stratified intervention model for VAP prevention and control behaviors among ICU medical staff

| Behavior stage | Stage goal | Physician intervention strategy | Nurse intervention strategy | Environmental services (EVS) intervention strategy |
|---|---|---|---|---|
| Precontemplation / Contemplation | Enhance awareness, stimulate motivation for change | 1. Conduct special academic lectures emphasizing the latest research evidence on VAP and outcomes.<br>2. Report VAP incidence data during departmental morning meetings to raise attention. | 1. Share "One Minute on VAP Prevention" case studies during shift handovers.<br>2. Show warning case videos of adverse outcomes due to prevention gaps. | 1. Use illustrated "easy-read fact sheets" to explain the chain of microbial contamination and its relation to VAP.<br>2. Provide simplified, plain-language micro-video training. |
| Preparation | Remove practical barriers, provide start-up support | 1. Distribute an electronic "VAP Prevention Clinical Decision Support" manual.<br>2. Organize multidisciplinary rounds to discuss weaning indications from mechanical ventilation on-site. | 1. Conduct "VAP Prevention Standard Workshops" with hands-on training and assessment of oral care, subglottic suctioning, etc.<br>2. Provide pocket cards with Standard Operating Procedures (SOPs). | 1. Provide one-on-one bedside coaching to demonstrate proper procedures and frequency for cleaning and disinfecting environmental surfaces in the ICU.<br>2. Clearly define the use of cleaning tools by zone and color-coding. |
| Action / Maintenance | Reinforce positive behaviors, establish feedback mechanisms, prevent relapse | 1. Regularly (monthly) provide process quality control data on VAP prevention (e.g., head-of-bed elevation compliance) in departmental groups.<br>2. Integrate VAP prevention into the quality evaluation of attending physician rounds. | 1. Launch an "Electronic VAP Prevention Checklist" embedded in the mobile nursing system for daily reminders and documentation.<br>2. Establish a "peer supervision" system where senior nurses guide junior nurses.<br>3. Link prevention compliance with monthly performance and awards. | 1. Have infection control nurses or head nurses conduct daily spot checks of environmental cleaning quality, using ATP fluorescence testing for objective feedback.<br>2. Establish a rotating "Monthly Environmental Safety Champion" flag with material and non-material rewards. |

## 3.4. Implementation of intervention

An interdisciplinary intervention team was established, comprising the director of the Hospital Infection

Control Department, the head nurse of the ICU, respiratory therapists, and key nursing staff. Starting from June 2025, a precise, six-month intervention tailored to the individual behavioral stages of 205 study participants was conducted, following the model outlined in **Table 1**. The intervention process was dynamically managed, with rapid reassessments of stages conducted every two months, allowing for adjustments in individual strategies as stages changed.

## 3.5. Effect evaluation

### 3.5.1. Behavioral stage transition

After six months of stratified intervention, significant positive shifts were observed in the behavioral stages of all three categories of medical personnel. Overall, the proportion of individuals in the "Action/Maintenance Stage" increased from 40.5% before the intervention to 78.0% ($Z$ = -8.924, $p < 0.001$). Among them, cleaning staff showed the most remarkable improvement, with the proportion in the "Action/Maintenance Stage" rising from 6.7% to 60.0%; nurses increased from 41.8% to 82.3%; and doctors increased from 65.6% to 90.6% (**Table 3**).

**Table 3.** Comparison of VAP prevention and control behavioral stages among three categories of medical personnel before and after intervention

| Group | Time | Precontemplation | Contemplation | Preparation | Action | Maintenance | Action/Maintenance total |
|---|---|---|---|---|---|---|---|
| Physician (n = 32) | Pre-intervention | 2 (6.3%) | 4 (12.5%) | 5 (15.6%) | 10 (31.3%) | 11 (34.4%) | 21 (65.6%) |
| | Post-intervention | 0 (0.0%) | 1 (3.1%) | 2 (6.3%) | 12 (37.5%) | 17 (53.1%) | 29 (90.6%) |
| Nurse (n = 158) | Pre-intervention | 18 (11.4%) | 32 (20.3%) | 42 (26.6%) | 45 (28.5%) | 21 (13.3%) | 66 (41.8%) |
| | Post-intervention | 2 (1.3%) | 8 (5.1%) | 18 (11.4%) | 75 (47.5%) | 55 (34.8%) | 130 (82.3%) |
| Cleaning staff (n = 15) | Pre-intervention | 8 (53.3%) | 4 (26.7%) | 2 (13.3%) | 1 (6.7%) | 0 (0.0%) | 1 (6.7%) |
| | Post-intervention | 1 (6.7%) | 2 (13.3%) | 3 (20.0%) | 6 (40.0%) | 3 (20.0%) | 9 (60.0%) |

### 3.5.2. Improvements in knowledge and behavior

After the intervention, the scores for VAP prevention and control knowledge and the compliance rates for key behaviors among the three types of personnel significantly increased compared to those before the intervention (all $p < 0.05$). Among them, nurses showed the most significant improvement, with the compliance rate for "subglottic secretion drainage" increasing from 41.8% to 89.2%. For cleaning staff, the compliance rate for implementing environmental cleaning and disinfection protocols rose from 26.7% to 86.7% (**Table 4**).

**Table 4.** Comparison of VAP prevention and control knowledge and compliance rates for key behaviors among three types of medical personnel before and after intervention

| Evaluation indicator | Group | Preintervention | Postintervention | Statistic | pvalue |
|---|---|---|---|---|---|
| Knowledge score | Doctor | 12.45 ± 1.82 | 13.81±1.12 | $t$ = 4.112 | < 0.001 |
| | Nurse | 9.23 ± 2.15 | 12.67±1.58 | $t$ = 16.843 | < 0.001 |
| | Cleaning staff | 4.80 ± 1.67 | 9.20±1.32 | $t$ = 8.905 | < 0.001 |

| | | | | | |
|---|---|---|---|---|---|
| Subglottic suctioning compliance rate | Nurse | 66/158 (41.8%) | 141/158 (89.2%) | $\chi^2 = 85.341$ | < 0.001 |
| Head of bed elevation ≥ 30° compliance rate | Nurse | 92/158 (58.2%) | 150/158 (94.9%) | $\chi^2 = 58.724$ | < 0.001 |
| Environmental cleaning and disinfection compliance rate | Cleaning staff | 4/15 (26.7%) | 13/15 (86.7%) | | < 0.001 |

### 3.5.3. Improvement in clinical outcomes

During the intervention period (June-November 2025), the incidence rate of ventilator-associated pneumonia (VAP) in the study ICU was 1.21 cases per 1,000 ventilator days, representing a significant decrease from 3.14 cases per 1,000 ventilator days in the six months prior to the intervention (December 2024–May 2025), with a statistically significant difference ($\chi^2 = 9.524$, $p = 0.002$).

## 4. Discussion

Based on the Transtheoretical Model (TTM), this study successfully constructed and validated a stratified intervention model for VAP prevention and control tailored to multiple professional groups in the ICU. This model significantly promoted positive transitions in prevention knowledge, behavioral compliance, and behavioral stages among three categories of personnel, achieving a clear clinical benefit in reducing the incidence of VAP.

The baseline survey revealed that physicians were predominantly in the action/maintenance stage, emphasizing the need for evidence-based decision support; nurses were mainly in the intention/preparation stage, facing a practical gap between knowledge and action; and cleaning staff were generally in the pre-intention stage, with extremely weak awareness of their role in VAP prevention and control. These differences stem from the fundamental distinctions in professional backgrounds, job responsibilities, and work patterns among the three groups. Traditional hospital infection training often adopts a “one-size-fits-all” approach to collective instruction, neglecting individual differences in psychological readiness and capacity for behavioral change, resulting in superficial and unsustainable intervention effects. This study, based on TTM, matched differentiated intervention strategies with the behavioral stages of different professional groups, achieving a transition from “universal education” to “precision behavioral intervention”, fully demonstrating the theoretical appropriateness and practical necessity of stratified intervention.

Given that cleaning staff were predominantly in the pre-intention/intention stage, this study employed strategies such as role-playing scenarios and visual consequence education to trigger their perception of VAP prevention risks and role identity through “consciousness arousal” and “emotional awakening”, enabling more than half of the cleaning staff to cross the threshold of behavioral change and enter the preparation stage. For nurses, who were mainly in the preparation/action stage, skill workshops and peer demonstrations were used to enhance “self-reevaluation” and operational competence. Additionally, checklists embedded in the mobile nursing system and immediate positive feedback facilitated “environmental reevaluation” and “reinforcement management”, effectively reducing the execution burden and strengthening behavioral confirmation. As a result, the compliance rate for key operations such as subglottic suctioning jumped from 41.8% to 89.2%, with behaviors becoming normalized. For individuals in the maintenance stage, such as senior healthcare professionals, evidence-based knowledge updates were provided to meet their

professional growth needs, while linking behavioral compliance with performance evaluations and team honors internalized external incentives into long-term behavioral maintenance drivers, effectively preventing behavioral regression.

In this study, the incidence of VAP decreased from 3.14‰ before the intervention to 1.21‰, a reduction of 61.5%, comparable to the reduction in VAP incidence achieved through the Plan-Do-Study-Act (PDSA) cycle in a tertiary hospital in India [8]. This verifies the applicability of our model in different healthcare resource settings and provides direct evidence for the clinical effectiveness of the stratified intervention model. The reason lies in the fact that our model not only improved the "paper compliance rate" of prevention measures but also constructed a sustainable "knowledge-belief-behavior" closed loop, ensuring patient outcome safety through behavioral reliability.

## 5. Conclusion

In conclusion, the stratified intervention model for VAP prevention and control among ICU healthcare personnel, constructed based on the Transtheoretical Model, is a scientific, effective, and practically valuable intervention strategy. By accurately identifying and addressing the individual needs of different roles and behavioral stages, it significantly enhances the compliance and effectiveness of prevention behaviors, ultimately translating into a reduction in the incidence of VAP. Future research could conduct multi-center, cluster-randomized controlled trials to provide higher-level evidence-based support and validate the model's universality. Additionally, qualitative interviews could be incorporated to deeply explore the core facilitating and hindering factors during transitions at different stages.

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## Disclosure statement

The authors declare no conflict of interest.

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