

# The Effects of a Nursing Care Plan Incorporated with a Decision Support System on Ventilator Associated Pneumonia: A Case Study

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**Abstract:** The risk of pneumonia is high in patients who are ventilated in intensive care units (ICUs). Without proper and adequate care, this risk and the mortality rate increases. In a study conducted by the infection committee of our hospital (Izmir Tire State Hospital, the first digital (Stage 7) hospital in Turkey in 2016), it was found that the rate of ventilator-associated pneumonia (VAP) cases increased had increased over three years (2015-17) and was well above the national average. In this study, VAP prevalence in our ICU and the associated extra medication costs were calculated. Furthermore, nursing care plans related to VAP were reviewed and improvements were made according to international standards. The care plan was triggered by criteria defined in a clinical decision support system (CDSS) on the hospital information management system (HIS), and monitorization was conducted to ensure that nurses implement the care plan in a comprehensive and timely manner. As a result of the change, the rate of VAP cases, which had risen to 4.5% in 2017, was reduced to 0.5% in 2018. Similarly, we achieved cost reductions of 90.87% for VAP-based extra medications. Based on these results, it can be suggested that CDSS-supported nursing care can significantly reduce the risk of VAP and increase patient safety in the ICU.

## 1 INTRODUCTION

Ventilator-associated pneumonia (VAP), defined as pneumonia between 48 and 72 hours following endotracheal aspiration, is the most common infection among intensive care unit patients receiving mechanical ventilatory support (Kapucu & Ozden, 2014). In a study conducted at the national level in the USA, it was estimated that a significant 10% of patients who are connected to mechanical ventilators are diagnosed with VAP (Wang et al., 2014). Other studies found that mortality rates of 20-50% in patients connected to ventilators in intensive care units may be reduced by 13% (Klompas & Li, 2013; Melsen et al., 2013; Sara, Phillips, Kaur, & Isaac, 2015).

According to a recently published systematic review of VAP, the aims of several studies to identify, prevent, and treat VAP epidemiology were related to the prevention of associated mortality and morbidity, to reduce costs, and to improve the quality of care (Gutiérrez et al., 2019). Studies in different countries indicate that the development of VAP in patients increases the duration of ventilator utilization and hospital stay and increases patient care and treatment costs (Kalil et al., 2016), (Başyigit, 2017; Hayashi et al., 2013; Luckraz et al., 2018; S et al., 2017).

There are many approaches to preventing the development of VAP, such as infection control measures, minimum possible intubation, re-training of health personnel, and using care guidelines (Gutiérrez et al., 2019). Alternative VAP care management plans are prepared and recommended by

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recognized organizations, such as the European Respiratory Society (ERS), the European Society of Intensive Care Medicine (ESICM), and the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) (Torres et al., 2018). The use of care plans has consistently been found to decrease the duration of VAP-related length of stay, reduce complications, decrease antibiotic usage, and decrease antibiotic resistance; all of which reduce the amount of time and money lost due to VAP. The move from handwritten care plans to digital plans is effective in improving VAP control and reducing VAP-associated length of stay, useful in decreasing antibiotic use, and effective in reducing loss of time and money (Kalil et al., 2016), (Wang et al., 2014), (Klouwenberg et al., 2014), (Liao et al., 2019). Digital care plans have been shown to have an impact on decreasing VAP-related complications and the number of ventilator-associated tracheobronchitis (VAT) events (Neuville, Mourvillier, Bouadma, & Timsit, 2017).

Completing VAP checklists on paper is not efficient due to errors and omissions. Missing data in manually generated records may cause insufficient evaluations. Studies have shown that the transfer of checklists to digital media helps to reduce these problems (Liao et al., 2019), (De Bie et al., 2017), (Klompas, Kleinman, & Platt, 2008).

Although it is controversial whether the development of VAP and VAP-related complications should be used to measure the quality of patient care (Kalil et al., 2016), (Klompas & Berra, 2016), particularly in developing countries, there are significant costs associated with VAP (Alp et al., 2012). The results of studies conducted in Turkey are consistent with other studies in the literature. According to 2017 data from the business intelligence application of the Ministry of Health, the average rate of VAP in Level 2 ICUs in Turkey was 3.8%, while İzmir Tire State Hospital had a VAP rate of 4.5%, which is 18.42% higher than the national average (Kapucu & Ozden, 2014), (Alp et al., 2012; Grassie & Gevrek, 2016; Karaoglan et al., 2010; Torres et al., 2017).

In 2016, İzmir Tire State Hospital was designated as the first digital hospital (Stage 7) according to Healthcare Information and Management Systems Society (HIMSS) Electronic Medical Record Adoption Model (EMRAM) requirements (HIMSS Analytics, 2018). This study examines the effects of incorporating VAP care plans and patient monitoring with a clinical decision support system (CDSS) application within the hospital information management systems (HIS).

## 2 METHODS

In the first stage of the study, the incidence of VAP, the number of patients diagnosed with VAP, and the cost of extra medications associated with VAP were tracked between 1 January and 31 December, 2018. The Level 2 intensive care unit at İzmir Tire State Hospital has 15 ventilators and 17 beds. All nursing forms and nursing care plans related to VAP prevention and care that were used in the hospital were reviewed. The hospital's infection control committee reviewed patient monitoring charts and nursing care plans completed manually by nurses on paper. The committee then developed a single nursing care plan based on the recommendations of international guidelines (Torres et al., 2018). The new care plan and related forms were transferred to the hospital's HIS so that medical records related to VAP prevention and care would be digital instead of paper-based.

During our review of current practice, we found that some VAP prevention and care activities were not performed in the unit even though they were mentioned in the nursing care plan. As such, the following elements were added to the nursing care plan: correct hand washing and use of aseptic technique, continuous control of tracheal cuff pressure, postural drainage, and endotracheal tube direction change and level control. Then, the HIS vendor developed a CDSS application for the HIS system. The new CDSS was rule-based and triggered when relevant conditions are met, such as entering predefined diagnoses or interventions. Our CDSS was triggered when a nurse indicated on the respiratory system evaluation screen that a patient had an endotracheal tube (intubated) placed. The CDSS responds to this trigger by automatically adding the necessary care, follow-up, and nursing interventions to the care plan at appropriate frequencies. The HIS then prompts the nurses to follow the ventilator care plan scheduled by the CDSS. The CDSS generated plan includes the following tasks:

### Ventilator Care Plan

1. Deep venous thrombosis and peptic ulcer prophylaxis
2. Raising the head of the bed
3. Subglottic secretion drainage
4. Cleaning ventilator circuits and preventing fluid build-up
5. Oral care
6. Extubation readiness assessment
7. Aspiration with aseptic technique
8. Cuff pressure monitorization

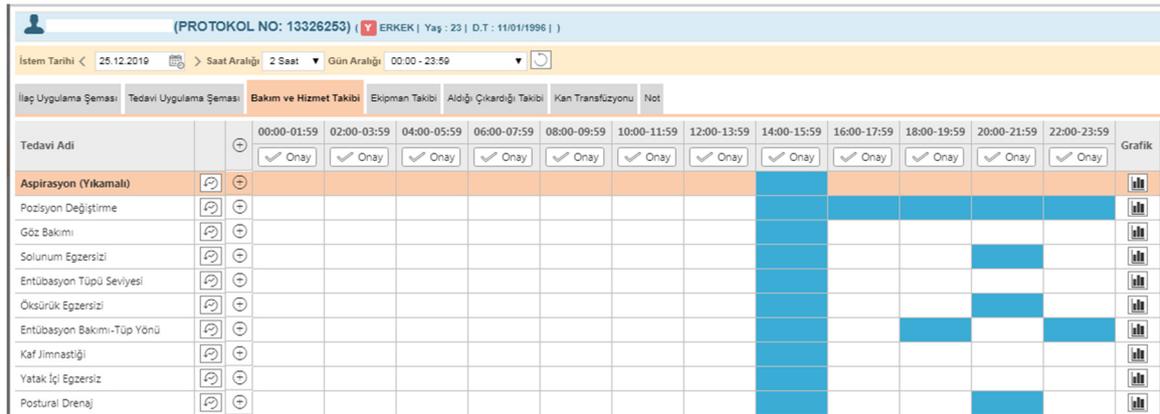


Figure 1: VAP Care scheduling screen on HIS.

Figure 1 shows these tasks added to the nursing care plan in the HIS work schedule.

In addition to the improvements in nursing care plans (Klompas et al., 2014), (Resetar et al., 2014), it is essential to train nurses on the new practices (Mogyoródi, Dunai, Gál, & Iványi, 2016), (Pneumonia, 2005). Once the improvement work was finalized on the HIS, 24 nurses working in the Level 2 ICU received training on the new care plan. After the nurses were trained and had used the new system for one complete year (2018), the incidence of VAP, the number of patients diagnosed with VAP, and the cost of extra medications related to VAP for 2018 were calculated and compared with the previous period (2015-17). When calculating the number of VAP cases, only patients who developed VAP after admission to the intensive care unit were taken into account (including the patients who were already on a ventilator when they arrived at the hospital (without pneumonia), and patients who were already diagnosed with pneumonia during hospitalization were excluded. In the calculation of medication costs, the costs of extra medications (antibiotics, etc.) administered to the patient due to a VAP diagnosis were taken into consideration. Costs were extracted from the hospital's HIS which is integrated with the claims submission portal of the national health insurance system.

### 3 RESULTS

Following a full year of implementation of the new nursing care plans triggered by the CDSS, the rate of new cases diagnosed with VAP decreased from 4.5% in 2017 to 0.5% in 2018 (Figure 2).

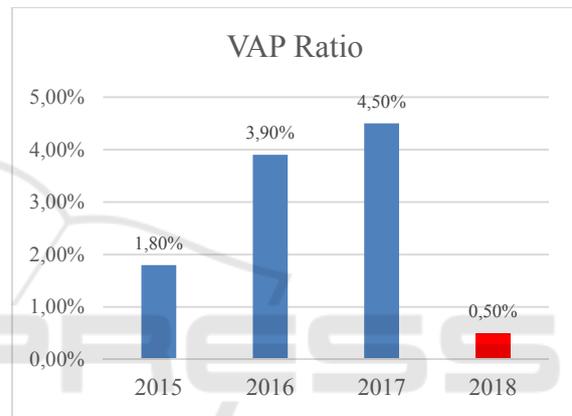


Figure 2: Comparison of VAP Ratio in ICU.

Similarly, the total number of patients diagnosed with VAP, dropped from 17 in 2017 to 2 in 2018 (Figure 3).

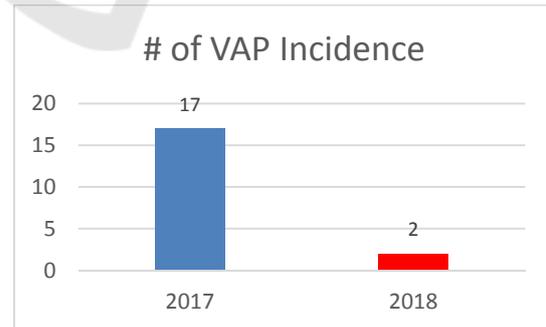


Figure 3: Comparison of the number of VAP incidence.

In our hospital, the cost of extra medication (antibiotics, etc.) administered to the patient due to VAP decreased significantly (90.87%). Accordingly, the cost of extra medications, which was 855,412 Turkish Lira ( $\approx 189,250\text{€}$ ) in 2017, decreased to only 78,044 TL ( $\approx 12,900\text{€}$ ) in 2018 (Figure 4).

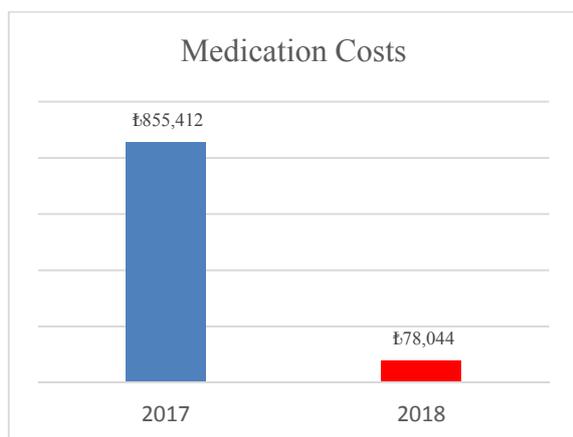


Figure 4: Comparison of extra medication costs related to VAP.

## 4 CONCLUSIONS

VAP is associated with high mortality and morbidity rates and high treatment costs. Managers of intensive care units can improve the quality and cost of care through prevention of VAP. This study produced results consistent with previous studies showing that the implementation of a comprehensive, evidence-based, and safe care plan to prevent VAP can significantly reduce the cost of care. This study also confirmed that findings of other research showing the economic benefits of using electronic systems in patient monitoring and evaluation, early diagnosis, and documentation are also valid for VAP (Prgomet, Li, Niazkhani, Georgiou, & Westbrook, 2017), (Schurink et al., 2007). Many studies reporting the benefits of CDSSs on improving performance on healthcare quality indicators (Johnston, Langton, Haynes, & Mathieu, 1994; Kawamoto, Houlihan, Balas, & Lobach, 2005). It can be suggested that instead of implementing nursing interventions individually, even if they are scientifically proven, incorporating comprehensive care plans with CDSS and following the activity plan can contribute to preventing or reducing infections more efficiently. Following this study, hospital managers decided to develop new care plan packages using CDSS for other care processes.

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