**Research Article**

**Ventilator Associated Pneumonia: Reducing the Risk during Covid-19 Pandemic**

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**Abstract**

Novel coronavirus, known as COVID-19, was identified in the United States (U.S.) in January 2020. Within two months, patients testing positive for COVID-19 were overwhelming U.S. hospitals in major cities. Many of these patients were presenting with Severe Acute Respiratory Syndrome (SARS) requiring critical care and mechanical ventilation to support respiratory function. A complication of mechanical ventilation is Ventilator Associated Pneumonia (VAP). Orem’s, theories and the American Association of Critical-Care Nurses (AACN) Synergy Model for Patient Care, 2000, provide information that explain the need for and how to individualize nursing care to achieve quality outcomes. Evidence of effective strategies to prevent VAP are available. Planning and executing implementation must include the interprofessional team led by an expert nurse familiar with critical care and VAP prevention. Bedside nurses are the change agents who will be most affected by this planned change, thus should be proportionally involved in the process. Change theory and evidence suggest that a process be mapped out including thorough assessment, goal setting, planning, implementation, and evaluation to facilitate quality improvement. Education, policy and protocol development, incorporation of the VAP bundle (a combination of care techniques demonstrated to prevent or reduce the incidence of VAP), “Ventilator care kit”, monitoring, and evaluation are key to successful sustainability of this initiative. Implementation of a VAP prevention program has never been more important than during the current COVID-19 pandemic when patients assaulted with this viral infection fight for their lives.

**Keywords:** AACN Synergy Model for Patient Care; Change theory; COVID-19; Critical Care Quality; Optimal Patient Outcomes; Orem; Root-cause-analysis; Severe Acute Respiratory Syndrome (SARS); VAP Bundle; Ventilator Associated Pneumonia (VAP)

**Background**

The novel coronavirus was transported to the United States via human hosts began shedding and spreading virus to people in cities where this unwanted visitor arrived. The exact date of arrival is not known. The first confirmed case was identified in an individual in Washington State at the end of January 2020 [1]. By September 4, 2020 over six million cases had been confirmed with more than 189,000 American deaths reported. “A novel coronavirus is a new coronavirus that has not been previously identified. The virus causing Coronavirus disease 2019 (COVID-19) … Coronavirus disease 2019 (COVID-19) is a respiratory illness that can spread from person to person. …COVID-19 is a new disease, caused by a novel (or new) coronavirus that has not previously been seen in humans” [2].

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), was “Identified as the source of a pneumonia outbreak in Wuhan, China,” and in the United States in late 2019 [3].” “Severe Acute Respiratory Syndrome (SARS) is a viral respiratory illness caused by a coronavirus …SARS was first reported in Asia in February 2003 and spread…to countries in North America, South America, Europe, and Asia before the SARS global outbreak of 2003 was contained” [2]. Since 2004, there have been no known cases of SARS reported anywhere in the world until the pneumonia reported in China in 2019 [2]. “Given how common the disease is becoming, as in prior major severe acute respiratory infection outbreaks-SARS…, MERS (Middle East Respiratory Syndrome), Avian Influenza A(H7N9), and H influenza A (H1N1) …-critical care will be an integral component of the global response to this emerging infection” [4]. Severe Acute Respiratory Syndrome associated with the novel coronavirus, known as Covid-19 has resulted in extreme rates of hospitalizations and admissions to critical care units in every country experiencing an outbreak. Those Covid-19 patients with SARS often require mechanical ventilation to support respiratory function as a life-saving treatment. A serious complication of mechanical ventilation is known as ventilator associated pneumonia or VAP.

**Ventilator Associate Pneumonia and COVID-19**

Ventilator Associated Pneumonia (VAP) is a hospital acquired lung infection noted in patients who require mechanical ventilation to support respiratory function [5,6]. VAP can develop after intubation, insertion of a tracheostomy or endotracheal tube, creating a direct connection to major airways which facilitates effective mechanical ventilation [7]. Intubation interferes with normal anatomical function by placement of a foreign object, tube, into the oropharynx and/or trachea. Direct impact of endotracheal tube placement results in a reduction “in local host defenses … mucosal injury can reduce mucociliary function, while upper airway defenses are bypassed, and the effectiveness of cough is reduced” [8]. Indirect impact may result in “an enhanced capacity of tracheobronchial cells binding to gram-negative bacteria, an effect that favors airway colonization and pneumonia”. Airway injury “can create binding sites for bacteria in the basement membrane of the bronchial tree and the stimulation of the secretion of mucus, which then stagnates and can create potential sites for bacterial adherence”. Devices such as endotracheal tubes and tracheostomy tubes provide sanctuary for bacteria which can multiply. COVID-19 patients have “disease-associated impairments” which impede normal human defense mechanisms and compounds the risk when using an artificial airway [8]. The insertion of the endotracheal tube or tracheostomy tube also provides a means for oral and gastric secretions to enter the lower airways [7].

VAP results from the invasion of microorganisms into the lower airways. Critically ill patients experiencing VAP are known to have a greater length of hospital stay, increased risk of mortality, and increased hospital costs [9]. VAP rates range from one to four cases per 1000 ventilator days [9,10]. There is a ≥30% attributed mortality rate in VAP treatment failures and an average increase of seven to 11 days in critical care units with an increased cost of approximately $39,000 per patient [9-12]. Covid-19 patients admitted to hospitals with severe respiratory distress syndrome require mechanical ventilation. Mechanical ventilation requires the insertion of an endotracheal or tracheostomy tube increasing the risk for VAP as a complication for COVID-19 patients. Nurses and other critical care healthcare providers must deliver effective, evidence-based quality care to assure survival of this high-risk population. Quality evidence-based practice includes theory, modeling, and planned change with successful use of prevention strategies.

**Theory-based Evidence for Care of COVID-19 Patients Experiencing VAP**

Theory is often over-looked and ignored when considering care of the critically ill. Technique, skills, and treatment are often the focus of nurses and healthcare practitioners. However, nursing care continues to be the performance of reasoned actions which mandate a professional duty to advocate for effective quality care. Theory and theoretical models are beneficial for improving effective techniques to decrease incidence of VAP and improve quality care. Orem’s [13], self-care deficit theory describes requirements of holistic human functioning known as requisites and basic conditioning factors, that are synonymous with determinants and social determinants of health. These requisites and basic conditioning factors are essentials that nurses must consider if they are to provide quality care. Universal self-care requisites (air, food, water, elimination, activity/rest, social/solitude, normalcy, and hazards) and developmental self-care requisites (having abilities to support life and development from birth through stages of adulthood and provide needed self-care to prevent and/or manage challenges that threaten normal development) provide an essential list of factors the people must successfully address to maintain health and well-being [13].

Maintaining the health and well-being of the critically ill is a challenge. Nurses are responsible for assisting critically ill patients in meeting their self-care requisites through use of their nursing knowledge and skill which Orem, identified as nurse agency. Patients relying on mechanical ventilation are unable to perform requisite behaviors on their own. This inability to address universal and developmental requisites requires nurses to provide wholly compensatory care, care to maintain function and support life. Nurses must provide care to compensate for all self-care activities a person normally does for self. This is especially true for those COVID-19 patients who are provided sedation or paralytic drugs during mechanical ventilation. “The American Association of Critical-care Nurses (AACN) Synergy Model for Patient Care is a patient-centered model that focuses on optimizing patient care by matching the characteristics of the patient with the competencies of the nurse” [14]. This model is in perfect alignment with Orem’s nursing theories.

AACN’s Synergy Model for Patient Care, developed in 1996, is a conceptual framework that aligns patient needs with nurse competencies [14]. This framework promotes a shift in nursing assessment skills from a medical model to a nurse competency framework. Like Orem’s, [13], theories, the principal idea is that patient need, or self-care deficits, drive the competencies required for care delivery. Orem’s [13], theories posit that knowledge of patient need or self-care deficits aligned to nurse agency or ability creates synergy for achievement of optimal care outcomes. (Table 1) presents the eight patient characteristics and eight nurse competencies identified in AACN’s Synergy Model for Patient Care. All competencies and characteristics are essential, but importance varies depending on patient need. “Synergy results when the needs and characteristics of a patient, clinical unit or system are matched with a nurse’s competencies” [14].

Orem’s [13], theories and AACN’s Synergy Model for Patient Care affirm the idea that quality nursing care provision by competent nurses who assess and meet patient needs will achieve quality outcomes [15]. This notion is crucial when making a case for changing bedside care delivery. Frontline nurses, those working at the bedside delivering care, drive change and innovation in healthcare because they are the critical decision makers caring for the critically ill, 24 hours a day, seven days a week.

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| Eight Patient Characteristics | Eight Nurse Competencies |
| Resiliency | Clinical Judgement |
| Vulnerability | Advocacy and Moral Agency |
| Stability | Caring Practices |
| Complexity | Collaboration |
| Resource availability | Systems Thinking |
| Participation in care | Response to Diversity |
| Participation in decision making | Facilitation of Learning |
| Predictability | Clinical Inquiry |

**Table 1:** Patient Characteristics and Nurse Characteristics of AACN’s Synergy Model for Patient Care. Note. Patient Characteristics and Nurse Competencies are those identified in AACNs, Appendix C [14].

**Making the Case for Change**

Nursing care provided to critically ill COVID-19 patients requires highly competent nurses to prevent complications that can further limit a patient’s ability to meet their self-care requisites [13]. Competent care provision requires nurses to continually assess and incorporate best research evidence into practice. This dynamic state of professional nursing is often unappreciated but has been recognized during the COVID-19 pandemic. Front-line care givers worked feverishly to save the lives of their patients while adapting practice as new information regarding the deadly virus became known. Nurses working in critical care units across the world take care of the very ill and delivery of the best care is required to prevent hospital-acquired infection or injuries, such as VAP.

Patients that do experience VAP or other hospital-acquired conditions experience escalation in critical status, extended length of hospital stay, and associated increases in morbidity and mortality risk rates with proportional financial ramifications [12]. Multiple studies have analyzed interventions to prevent VAP. Pérez-Granda, et al. [15], found interventions that included care techniques and skills known as the VAP bundle, protocol for use of this bundle, and policies developed to incorporate the bundle into care delivery were shown to prevent patient infections. Effective educational interventions must include staff involvement in decision-making, in development and delivery of education, and in evaluation of the plan. When frontline nurses are involved in decision-making regarding changes at the bedside these nurses become change agents who drive improved patient and fiscal outcomes. Consistent compliance and adherence to policy, protocols, or guidelines is facilitated by nurses’ positive attitudes toward the specified interventions [17]. Nurse change agents can facilitate change or create barriers to a change in practice.

Frontline nurses who are change agents are using process tools to determine causative factors of issues in care delivery. One such tool, Root Cause Analysis (RCA), has been utilized to determine potential causes of hospital acquired conditions [18]. Examination of components associated with the issue or phenomena of interest reveals findings that guides teams to determine strategies which improve care and enhance prevention [19]. Root cause analysis is part of the continuous quality improvement process. This problem-solving tool is intended to identify all contributing factors that when addressed with acceptable practice change can eliminate threats [19]. Once completed, RCA results are used to identify the essentials elements that need improvement including the need for learning and the development of focused educational information for staff working in critical care [19].

Root cause analysis includes fishbone diagraming to visually depict or categorize the cause-and-effect aspects of the issue which may include personnel, policies, equipment, and other associated components [19]. The 5 Why technique, asking why each identified aspect causes or contributes to an issue or problem, is a process continued until all potential causes or contributing factors are identified and diagramed [20]. This technique, used in RCA and in the analysis phase of “Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) methodology, is a way to determine details about causes of issues or problems [20]. The tool “does not involve data segmentation, hypothesis testing, regression or other advanced statistical tools, and in many cases can be completed without a data collection plan” [20]. Continually asking why the issue occurs and recording all relational aspects can reveal preference for information transmission and form which is critical to assure necessary action is taken in proper sequence to address or prevent the issue or problem [19]. Research demonstrated that “accurate, easily accessed information at the bedside is needed for providing safe patient-centered care” [21]. A checklist in patient rooms or immediately accessible act as a visual reminder to complete interventions such as the VAP bundle thus increasing compliance and decreasing incidence of this complication. Orem [13] was a proponent of using tools like checklists to reinforce learning and guide care while providing nurse education. Provisional support increases the availability of resources and enhances health care system factors, environmental factors, and health states detailed in Orem’s theory [13]. Ongoing analysis and evaluation of these resources leads to protocol refinement and policy revision, which ensures quality care and improved health outcomes when caring for the critically ill.

The AACN declared that mortality with VAP (without the confluence of Covid-19) is significant and requires attention [22]. Ventilator associated pneumonia is a common, life-threatening nosocomial (hospital acquired), infection which is associated with a myriad of physiologic and economic consequences, not to mention demand and impact on nurses, other caregivers, and families [23]. The complication of VAP in the critically ill COVID-19 patient is the perfect storm, increasing the risk for significant disability including death. The study conducted by Nasiriani, et al. [23], looked at the incidence of VAP in patients supported by mechanical ventilation. One group of patients received routine care using standard precautions while another group of patients received comprehensive VAP prevention strategies, referred to as a VAP bundle. Significant decrease in VAP incidence was noted in the intervention group which received the VAP bundle. These results support previous findings regarding the effectiveness of the VAP bundle in decreasing or preventing VAP. Implementation of this effective strategy is required to assure Covid-19 patients have the best chance for recovery.

**The Planned Change**

Implementation science provides structure for planned change [24]. Change theories, in general, address fulfilling long-term goals using a series of planned steps while considering different perspectives of proposed change [24]. Consideration of perspective is key to effective change. Those personnel impacted by or responsible for the change must be included in the change process to a proportionate degree. Thus, goal setting must be a process that includes all stakeholders involved in or impacted by the change. This inclusion will help to focus efforts in creating common understanding of the need for change and required plan for implementation [24]. The use of SMART (specific, measurable, achievable, relevant, and time specific) goals and objectives by the interprofessional care team should concentrate on the reduction of people experiencing VAP, especially in mechanically ventilated Covid-19 patients. SMART goals and objectives should address standardizing practice, streamlining documentation, and evaluation of the efficacy of implementation and interventions within the VAP bundle. Delivering quality care should be the driver of change in healthcare, implementing the VAP prevention strategy is one such change. A VAP checklist can be utilized to standardize care delivery and documentation. The recommended bundle of nursing interventions for the prevention of ventilator-associated pneumonia are presented in (Table 2), Ventilator Associated Pneumonia Prevention Checklist.

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| Daily | Scheduled and Routine Care |
| Spontaneous wakening trial | Assess & document per policy |
| Spontaneous breathing trial (if tolerated) | Personal hand hygiene pre and post care |
| Cleanse ventilator | HCG bath for patient per policy |
| Ventilator circuits inspected (change only if needed) |   |
| Chlorhexidine (.12%) rinse with oral care | Oral care Q 4 hours |
| Fresh suction/oral care supplies (and as needed) | Manage oral secretions |
| Attempt mobilization | Repositioning Q 4 hours |
| Preform tube care (ET or Trach and as needed) | Manage oral secretions |
| Manage gastric reflux | Head of bed elevated 30-45 degrees (if tolerated) |
| Wear appropriate PPE for all care |   |

**Table 2:** Ventilator Associated Pneumonia Prevention Checklist. Note: Adapted from sources of the American Association of Critical-Care Nurses and Hellyer, et al. [25,26].

Havelock’s change theory, aptly applies to modern preventative protocol implementation efforts like the VAP bundle for preventing VAP in COVID-19 patients [27]. Havelock’s, theory proposed planned and purposeful change using a rational problem-solving process which considers the perspectives of involved stakeholders who are asked to change or facilitate the change [27], as well as others benefitting from the change. The six phases of change in Havelock’s change model include: 1) building a relationship, 2) identifying the problem, 3) acquiring relevant resources, 4) goal setting and choosing the best solution, 5) gaining acceptance, and 6) stabilizing the innovation and generating self-renewal for sustainability [18]. This model of change aligns well with implementation of a VAP prevention program which incorporates the use of VAP bundle strategies. This theory stresses the importance of successfully creating a healthy work environment while identifying problems, utilizing resources, and finding solutions by building trusting relationships and true collaboration within the interprofessional team [25].

The AACN has compiled best evidence supporting the use of VAP prevention strategies contained in their helpful and effective resource the *Pulmonary Management Pocket-guide* which includes VAP bundle specifics [22]. Larsson, et al. [11], stated that implementation of an evidence-based practice (EBP) VAP prevention program should include seven steps. Implementation of this EBP program include forming an interprofessional task force to address VAP, education about hospital-acquired infections, presentation of evidence-based interventions in education and practice materials, ensuring development and implementation of policies and documentation standards, measurement of unit compliance with the VAP bundle, and incorporation of education into orientation of all new personnel [11]. The interprofessional teams should include members of the critical care unit nursing staff, physicians, respiratory therapists, and risk/quality management. Critical care staff nurses are the direct patient care professionals who must perform the interventions that prevent VAP. Interprofessional unit practice teams led by nursing staff ensure their sustained engagement in quality care process improvement over time. The interprofessional team commits to prioritizing peer review by performing regular compliance rounds, monitoring compliance with provision of VAP bundle, ensuring availability of resources, and ongoing investigation of VAP occurrences.

Boez, et al. [28], noted that nurses are on the front line in preventing hospital-acquired infections such as VAP through provision of oral care, supportive respiratory care with Respiratory Therapists, positioning, and initiating steps that lead to successful rapid extubation. Dental plaque buildup and oral bacteria reproduction occurs five times in each 24-hour period, contributing to the occurrence of VAP. Performance of meticulous oral hygiene for intubated patients is an essential component of the VAP bundle [29,30]. Compounding bacteria growth is the potential for aspiration as 50 percent of healthy adults’ aspirate in their sleep [29]. Endotracheal intubation provides a direct pathway into the lungs and if the mechanically ventilated patient is receiving sedation or paralytic medications, which many are, then VAP is almost sure to occur if not intentionally prevented [29].

Implementing VAP prevention strategies should include how to address barriers, limitations, and facilitating factors. Low quality work and a poor organizational culture have been identified as barriers to successful implementation of a VAP prevention program [31]. The intense nature of care required by medically complex patients, such as the critically ill COVID-19 patient, challenges the best critical care nurses. Those critical care nurses who receive little encouragement, have poor interprofessional relationships, lack educational resources and/or opportunities, and have insufficient skilled staff, identified these experiences as quality work life barriers [22,25,32]. Staff shortages, namely the number of nursing care hours and nurse skill level is correlational to patient safety [22]. It is crucial to evaluate the risks that insufficient nurse staffing pose to complicated patients [22]; Nogueira, et al. [33], shared that addressing barriers can be accomplished by providing VAP education to all nursing and other members of the interprofessional team, increasing nurse to patient ratios, developing schedules and assignments considering nurse competency and skill level, providing laminated checklists in patient rooms and a ventilator supply kit, which includes all necessary items for oral hygiene and essential VAP prevention care [22]; Nogueira, et al. [29,33], stated that the overall goal of these actions is to increase knowledge of and compliance with quality initiatives, standardize practice, improve nurses’ time management, improve the unit culture, and work life, and ultimately reduce the incidence VAP and other preventable complications.

Facilitating factors present in healthy work environments also noted in critical care units are positive, supportive attitudes, readiness to learn and change, knowledgeable and skilled personnel, readily available technology, and willing participation to improve outcomes [25]. Technology use to expedite training and support reliable protocol documentation is a facilitating factor promoting the prevention of and reduction in VAP incidence [34]. Technological availability varies in critical care, but most critical care units have greater technological capabilities than general medical/surgical patient care areas. Using the available technology aligned with staffs’ readiness to learn about the use of the equipment in the VAP prevention kit to complete the VAP bundle will increase staff satisfaction with the care they provide as well as improve health outcomes for their patients [22]. In the ideal critical care unit, there is an interprofessional team of nurses, physicians, and respiratory therapists available 24 hours a day, seven days a week to allow collaboration and provide care. Costa, et al. [35], noted a positive connection between the nurse work environment, critical care physician staffing, and VAP. When there is adequate skilled health professionals, there is an increased likelihood for optimal care to prevent VAP [35]. The study also noted that interprofessional collaboration between the nurses and physicians staffing the critical care units in the study played an important role in VAP rates.

The most effective way to prevent VAP is to educate current and future nurses and the entire interprofessional team about the VAP prevention program, including policies, protocol, tools, VAP bundle, “Ventilator care kit”, and evaluation components [6,22,36]. Aloush [36], demonstrated significant improvement in nursing student VAP knowledge after completing an educational program. Provision of ongoing education is effective, both in school and in professional settings beyond licensure. When nursing schools implement VAP prevention education into the critical care courses of their respective programs, they prepare more effective graduate nurses who will provide benefit to the critical care patients in their care and to the units and organizations where they work. When organizations provide professional development for nursing staff and other members of the interprofessional team, competency and skill are reinforced, new practices are introduced and the risk of patient harm is mitigated, including the prevention of VAP development.

**Action Plan & Evaluation**

Nurses are expert process engineers, as process is included in every standard of practice. A comprehensive assessment needs to be completed by an interprofessional team led by an expert nurse. Nurses must be intimately involved in the process because they are the change agents who will be incorporating the care strategies into their day-to-day practice. Process requires that goal setting precede planning. Education efforts should create information regarding causes and ways to prevent VAP and be available to healthcare providers in accessible formats such as video, audio, hard copy, and other electronic modes. Annual competencies regarding VAP prevention should be included in programming to facilitate sustained improvement in addressing VAP.

Tools to facilitate VAP prevention include a laminated intervention checklist of the VAP bundle and “Ventilator care kit” in each patient care room where mechanical ventilators are used. This will provide a reminder for bedside nurses of the actions needed to reduce VAP while providing appropriate resources conveniently available in patient rooms to facilitate use. An online evidence-based education refresher should be available to all staff. The refresher should be a succinct professional presentation that provides key information, background and significance of VAP, current institutional and benchmark statistics, expected national target of no VAP, elements in the VAP bundle, documentation tools, and inter-unit/institutional resources readily available to reduce VAP risk. A laminated copy of the VAP bundle could be posted in each critical care patient room as a reminder to staff and to promote adherence. Lamination will permit reuse; nurses can use dry erase markers to check off completed bundle tasks each shift worked and allows for appropriate disinfecting after discharge and prior to admission of a new patient.

The “Ventilator care kit” saves nurses time by having everything needed to perform oral hygiene every four hours during each shift already assembled. Recommended hygiene routine includes: Chlorhexidine oral solution (used every 12 hours), mouth swabs, suction toothbrushes, suction supplies (both rigid and flexible suction catheters), normal saline, ambu bag, tube stabilizer of choice (twill tape, cath secure tube tamer, or other), and dressing supplies [22,30]. The supplies in the “Ventilator care kit” should be available in unit supplies but can be included in a “Ventilator care kit” when a patient is placed on mechanical ventilation. These supplies are to be used on all patients and would require no additional cost. Assembling the supplies for the “Ventilator care kit” and having them available in a supply or ventilator room should be included in the protocol and either supply staff or ancillary staff can be educated on maintaining supply stock levels. Supply levels in each kit should be maintained to provide care for a 24-hour period or the designated period between stocking and re-stocking.

Budgeting should include costs of developing and providing educational materials in video, audio, and electronic forms, printed educational materials, and laminated checklists. Costs will vary depending on the number of rooms in each unit. “Ventilator care kit” assembly will require a container that has compartments that can be stocked with supplies for providing the VAP bundle. Paid time for expert nurses to lead the interprofessional team, develop policies and protocols, and provide education should also be included in the budgeting process. Increasing safety, improving patient outcomes, and reducing hospital costs justifies the request to cover budgetary demands of implementing the VAP prevention program. Hospitals must absorb the costs related to cases of VAP since it is a nosocomial/hospital acquired infection not covered by Medicare and other third-party payors [37]. Implementation and maintenance costs for the VAP prevention program are offset by the reduction in uncompensated care associated with VAP cases. Policy development will be a work product of the interprofessional team. Policy should provide background and definitions, general statements about the VAP prevention program, and the goal of zero VAP cases. The policy or policies should address associated requirements, care requirements and standards, unit specification, supply specification, and associated responsibilities. Policy review should occur on a prescheduled basis to provide appropriate updates.

Evaluation is instrumental in any planned change and should begin with planning and include implementation strategies [18]. Base-line data should be collected prior to implementation. Different interventions included in the VAP prevention program can be evaluated in a variety of ways such as surveys, documented observation, and critical care unit data review and analysis. Timing of evaluation and duration between evaluation cycles must be included in the implementation plan, and in all program components which must be reviewed and revised as appropriate. The interprofessional team will determine evaluation type and interval for evaluating VAP prevention program components. Obtaining staff perceptions of the VAP prevention program is important including evaluation. These front-line workers are the professionals responsible for care delivery. Depending on interprofessional team recommendations, a survey could be sent to all critical care unit staff pre-implementation and six- to 12-months post-program implementation. Survey items should assess knowledge of VAP, VAP bundle, VAP “Ventilator care kit”, VAP protocol, policies, thoughts and feelings about the program, implementation, and evaluation. The survey instrument should also include an open-ended section for nurses to offer suggestions, comments, and voice concerns.

Compliance rounding is another form of evaluation and should be a component of unit policy regarding the VAP prevention program. Compliance rounding should be listed as a professional responsibility, for both nurses and respiratory therapists working in critical care units and should be conducted at regular intervals. Compliance rounding reinforces the VAP prevention program and leads to standard practice ensuring effective quality care delivery. Data about cases of VAP should be analyzed at six- and 12-month intervals. All VAP cases should be examined by the interprofessional team using RCA. Comparing the number of VAP cases to base-line data collected prior to implementation, will determine if the plan is effective in creating the desired change and achieving the SMART goal(s). Well planned evaluation components will help to determine if VAP cases decrease or are eliminated because of effective program planning and development. Evaluation strategies, critical interventions, are as important as the provision of the VAP care bundle to the critically ill COVID-19 mechanically ventilated patient. Planned evaluation is central for continuous quality improvement and elemental in implementation of a VAP prevention program.

Evidence and resources are readily available and a blueprint for implementing a VAP prevention program has been provided. The Institute for Healthcare Improvement (IHI) reminds us quality improvement is not simply a short-term limited fix, but rather a long-term commitment to those served by the organization [38]. It takes time, teamwork, resources, perseverance, vigilance, education, and ongoing evaluation which may require modification of processes, protocols, and policies.

**Conclusion**

Ventilator associated pneumonia (VAP) is a preventable, life-threatening nosocomial/hospital acquired infection. COVID-19 patients are high risk for contracting VAP because of severe acute respiratory syndrome (SARS) that triggers respiratory failure requiring intubation and mechanical ventilation to sustain life. Critical care nurses are pivotal in preventing VAP as they are the primary front-line care providers working to prevent these infections. Evidence has shown that specific interventions included in the VAP bundle can prevent a patient from developing VAP, but often this requires change [22,26]. To facilitate the change process an interprofessional team led by expert nurses should be brought together to act to prevent VAP within each organization where patients requiring mechanical ventilation are receiving care.

Nursing theory, change process and models, best evidence, and process components to implement an effective VAP prevention program have been presented to improve quality care, produce improved patient outcomes such as reducing morbidity, mortality, and potentially eliminating VAP. The collaborative plan presents implementation steps which include educational elements, tools for care provision such as the VAP bundle in-room checklist, and “Ventilator care kit” which contains equipment and cues for each nurse providing care. The interprofessional team working to implement a VAP prevention program requires collaboration and communication. This teamwork improves working relationships on critical care units and enhances organizational partnerships which are ingredients that contribute to development of a healthy work environment [22]. Implementation of a VAP prevention program must be an inclusive interprofessional process. When done correctly, it can have far reaching effects on patients, families, nurses, other interprofessional team members, as well as organizational culture.

The COVID-19 pandemic has presented challenges to healthcare professionals’ and organizations throughout the world. These challenges have forced us to revitalize collaborative efforts to prevent life-threatening complications such as VAP in COVID-19 ventilator dependent patients. Implementation of VAP prevention programs have saved lives through the hard work and commitment of front-line nurses, physicians, respiratory therapist, and countless other healthcare team members whose continued commitment shoulders this important work.

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