TELE INTENSIVE CARE UNIT NURSE-DIRECTED LOW TIDAL VOLUME VENTILATOR ROUNDS: A QUALITY IMPROVEMENT PROJECT

by

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DEDICATION

This Doctor of Nursing Practice Capstone project is dedicated to my wife Charo Bautista and my son Xavier Bautista. Without their support and patience this would have never happened.

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ABSTRACT

Background: Mechanically ventilated critical ill patients are at an increased risk of developing ventilator induced lung injury. The use of high tidal volume (Vt) (12 to 15 ml/kg predicted body weight (PBW)) ventilation causes the alveoli to overstretch, which causes often irreversible injury to the lungs. A Meta-analysis found that about 4.22% of patients assigned to low Vt ventilation developed lung injury while 12.66% of patients developed lung injury with high Vt ventilation. The Acute Respiratory Distress Syndrome Network have recommended the use of low Vt (<8ml/kg PBW) ventilation for patients with Acute Respiratory Distress Syndrome (ARDS). Low Vt ventilation decreases mortality rate for ARDS patients. Low Vt ventilation also benefits critically ill patients without ARDS. Despite known benefits of low Vt ventilation, adherence is low. Adherence of low Vt ventilation in a major academic medical center was reported at 31.2%. An innovative way to increase adherence is the use of Tele-Intensive Care Unit (TeleICU) nurse-directed daily ventilator rounds. TeleICU ventilator rounds have been shown to increase adherence to low Vt ventilation for ARDS and non-ARDS patients.

Methods: This DNP quality improvement project will use the descriptive study design to evaluate the use of the TeleICU nurse-directed ventilator rounds checklist for critically ill mechanically ventilated patients on: 1) usability, 2) effectiveness, and 3) adherence to low Vt ventilation protocol. The participants will be the TeleICU nurses who will be gathering data from ICU adult patients that require mechanical ventilator support for more than 24 hours. The total target number of TeleICU nurses would be about six and total number of patients would be 20. The DNP QI project will be done for two weeks. The setting will be the TeleICU department in Mesa, Arizona. Another setting is a rural hospital’s ICU unit, located in the state of Arizona.

Results: The TeleICU low Vt ventilator rounds checklist was scored by the TeleICU nurses to be useful (Mean 80 points, Range 58 to 100). The TeleICU nurses also found the TeleICU low Vt ventilator rounds checklist to be easy to use (Mean 75.94 points, Range 45 – 100). The QI project also found that the TeleICU nurses are open to integrating the low Vt ventilator rounds checklist into their daily workflow (Mean 87.5%). The low Vt ventilator rounds checklist was successful at identifying patients not on low Vt ventilation protocol and that TeleICU intensivist made the necessary changes to the patients ventilator settings. Lastly, the QI project was able to make an improvement in the adherence of low Vt ventilation at Banner Casa Grande ICU.

Conclusion: Low Vt ventilation benefits patients with ARDS and non-ARDS patients. The TeleICU low Vt ventilator rounds checklist is usable, effective and increased adherence to low Vt ventilation for ARDS and non-ARDS patients. The TeleICU are open to integrating the TeleICU low Vt ventilator rounds checklist on their daily workflow.

INTRODUCTION

Critically ill patients receiving mechanical ventilation are at an increased risk of developing ventilator associated lung injury (Neto et al., 2012). Neto et al. (2012) reports that morbidity and mortality increases when ventilator associated lung injury develops. Patients with acute respiratory distress syndrome (ARDS) have traditionally been ventilated using high tidal volumes (Vt) of 12 to 15 ml/kg predicted body weight (PBW) (Yadam, Bihler, & Balaan, 2016). ARDS is an acute inflammatory lung process, that leads to pulmonary edema, causing hypoxemia, lung “stiffness” and impairment of carbon dioxide elimination (Rezoagli, Fumagalli, & Bellani, 2017). Studies have found that the use of high Vt causes the alveoli to overstretch contributing to ventilator associated lung injury (Neto et al., 2012). A large randomized control study by the Acute Respiratory Distress Syndrome Network (Brower et al., 2000) concluded that the survival of patients in the intensive care unit (ICU) with ARDS improved with low Vt ventilation. Low Vt (<8 ml/kg PBW) has become the standard of care for ARDS patients (Neto et al., 2015). Mortality rate from ARDS is between 40% to 46%, and mortality from high Vt is about 40% while the mortality rate for low Vt decreased to 31%.(Tang, Wang, Liu, & Zhu, 2015; Yadam et al., 2016). Studies have demonstrated that the use of low Vt ventilation also benefits ICU mechanically ventilated patients without ARDS (Kalb et al., 2014; Neto et al., 2012; Neto et al., 2015; Tang et al., 2015). Pulmonary complications (i.e., ARDS or pneumonia) occurred more in high Vt ventilated patients (220, 31%) compared to low Vt ventilated patients (166, 23%) (adjusted OR, 0.72; 95% CI, 0.52-0.98; $p = 0.042$) (Neto et al., 2015). The development of pulmonary complications increases the length of stay (LOS) in the ICU and the hospital (Neto et al. (2015). Even though studies have shown many benefits of low Vt vs high Vt ventilation, adherence of its use is low (Kalb et al., 2014) An innovative way to increase adherence is the use of Tele-Intensive Care Unit (TeleICU). The use of TeleICU technology have been show to improve adherence of low Vt ventilation, decrease ventilator days, and decrease mortality rates (Kalb et al., 2014).

In this Doctorate of Nursing Practice (DNP) quality improvement (QI) project, TeleICU nurses will be conducting ventilator rounds using the low Vt ventilator rounds checklist to enhance the assessment of the ICU intubated and mechanically ventilated patients. The usability of the low Vt ventilator rounds checklist, total number of TeleICU intensivist interventions (ventilator settings changes), and percent adherence to low Vt ventilation will be examined.

Background

Even though medical providers are aware of the benefits of low Vt ventilation, adherence is low and at one major academic medical center adherence was reported to be 31.2% (Kalb et al., 2014). Limitations of adherence are based on diagnostic uncertainty for ARDS, and a poor estimate or calculation of the PaO_2/fraction of inspired oxygen (P/F) ratio and predicted body weight (PBW) (Kalb et al., 2014). Organizational and management challenges to implementation are the other limitations (Kalb et al., 2014). These challenges include the “absence of an effective protocol to target and monitor adherence and a lack of time or structure to bring together dedicated staff” (Kalb et al., 2014, p. 697.e7). Practitioner bias is another limitation, stating that low Vt ventilation will cause physiologic worsening, symptom burden, and increased sedative need, even though evidence has proven those assumptions to be wrong (Kalb et al., 2014). The TeleICU technology can address those limitations and can increase adherence of low Vt ventilation by automatically calculating and displaying P/F ratios, PBW-based tidal volumes, and providing additional monitoring staff who are focused on process improvement (Kalb et al., 2014). The use of TeleICU technology to perform ventilator rounds increased adherence to low Vt ventilation for non-ARDS patients from 29.5% to 44.9% ($p < 0.003$), while adherence to low Vt ventilation for ARDS patients increased from 23.3% to 37% ($P < 0.005$) (Kalb et al., 2014).

Acute Respiratory Distress Syndrome

Acute respiratory distress syndrome (ARDS) is an acute inflammatory lung process that has been defined earlier in this paper. ARDS creates pulmonary edema, that results in hypoxemia, increased lung "stiffness" and impaired carbon dioxide elimination (Rezoagli et al., 2017). In 2012, the European Society of Intensive Care Medicine published the Berlin Definition of ARDS. The panelists that developed the revised definition of ARDS were from both Europe and North America (Ranieri et al., 2012). Table 1 is the Berlin Definition of ARDS and it describes the four components of ARDS: timing, chest imaging, origin of edema, and oxygenation. By using the Berlin Definition of ARDS the predictive validity for mortality has significantly improved (Rezoagli et al., 2017).

TABLE 1. *The Berlin definition of acute respiratory distress syndrome.*

	Acute Respiratory Distress Syndrome
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging[a]	Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mm Hg $<$ $PaO_2/FIO_2 \leq$ 300 mm Hg with PEEP or CPAP $\geq$5 cm H_2O[c]
Moderate	100 mm Hg $<$ $PaO_2/FIO_2 \leq$ 200 mm Hg with PEEP $\geq$5 cm H_2O
Severe	$PaO_2/FIO_2 \leq$ 100 mm Hg with PEEP $\geq$5 cm H_2O

Abbreviations: CPAP, continuous positive airway pressure; FIO_2, fraction of inspired oxygen; PaO_2, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.
[a] Chest radiograph or computed tomography scan.
[b] If altitude is higher than 1000 m, the correction factor should be calculated as follows: [$PaO_2/FIO_2 \times$ (barometric pressure/760)].
[c] This may be delivered noninvasively in the mild acute respiratory distress syndrome group.

Note. Reprinted from "Acute respiratory distress syndrome: the Berlin Definition", by Ranier et al., 2012, *Journal of the American Medical Association,* 307, 23, p. 2530.

Mechanical Ventilation

Mechanical ventilation is the use of a special device to assist or replace a person's spontaneous breathing (Celli, 2015). Mechanical ventilation is indicated for acute respiratory failure with hypoxemia (arterial oxygen saturation SaO_2 < 90%) and/or hypercarbia (elevated arterial carbon dioxide partial pressure - $PaCO_2$ > 50 mm Hg) (Celli, 2015). By using mechanical ventilation the work of breathing is decreased therefore avoiding respiratory muscle fatigue and reverses life-threatening hypoxemia and progressive respiratory acidosis (Celli, 2015).

Methods of Mechanical Ventilation

Here are two methods of mechanical ventilation: noninvasive ventilation (NIV) and invasive ventilation.

Noninvasive ventilation. NIV involves the use of tight-fitting face mask or nasal mask (Celli, 2015). NIV applies a present positive pressure during inspiration and a lower pressure during expiration (Celli, 2015). NIV is contraindicated for cardiac or respiratory arrest, severe encephalopathy, severe gastrointestinal bleeding, hemodynamic instability, unstable angina and myocardial infarction, facial surgery or trauma, upper airway obstruction, high-risk aspiration and/or inability to protect airways, and inability to clear secretions (Celli, 2015).

Invasive ventilation. Invasive ventilation involves the insertion of an endotracheal tube to deliver oxygen to the airways and lungs (Celli, 2015). The goals of invasive ventilation are to “optimize oxygenation while avoiding ventilator-induced lung injury due to overstretch and collapse/recruitment” (Celli, 2015). The focus of this QI project is invasive ventilations.

Modes of invasive mechanical ventilation**.** Mode is defined as the way ventilator breaths are triggered, cycled, and limited (Celli, 2015). Trigger is what the ventilator senses to start the assisted breath (inspiratory effort or time signal), while cycle is the factor that ends the inspiration (Celli, 2015). Cycle could be volume-cycle ventilation, where the inspiration ends when a set Vt has been delivered, or pressure cycle, or time cycle (Celli, 2015). Limiting factors are values set by the operator that terminates the inspiratory flow when exceeded (volume, pressure, or flow) (Fessler, Fessler, Welsh, & Welsh, 2003). Low Vt ventilation is a parameter of the cycle and limiting factor of invasive mechanical ventilation. The most common modes of ventilation used for ICU mechanically ventilated patients are assist-control ventilation, intermittent mandatory ventilation, pressure-control ventilation, and airway pressure release ventilation (APRV).

Assist-control ventilation (AC). In AC, the trigger could be the inspiratory effort of the patient or time signal (Celli, 2015). The operator specifies a Vt and respiratory rate, thus a consistent Vt is delivered during the set rate or during the inspiratory effort of the patient (Dmello & Matuschak, 2015).

Intermittent mandatory ventilation (IMV). In IMV, the operator specifies a Vt and respiratory rate just like the AC mode, but the difference is that the Vt delivered during spontaneous breath depends on the inspiratory effort of the patient (different from the set Vt) (Dmello & Matuschak, 2015). IMV is used when the patients respiratory drive is intact and to exercise lung muscles between assisted breaths (Celli, 2015).

Pressure-control ventilation (PCV). In PCV, the trigger is time (rate), cycle is time (rate), and limitation factor is pressure (Celli, 2015). Vt delivered is different between breaths and is based on the patient's dynamic lung and chest wall compliance (Dmello & Matuschak, 2015). Ventilation can be initiated by the set rate (controlled breath) or can be initiated by the patient (assisted) (Dmello & Matuschak, 2015).

Airway pressure release ventilation (APRV). In APRV mode, the limit is pressure and the cycle is time (Esan, Khusid, & Raoof, 2016). APRV uses high continuous airway pressure level (P_{high}) with periodic release to a low continuous airway pressure level (P_{low}) (Esan et al., 2016). APRV allows the patient the spontaneously breathe during P_{high} and P_{low} (Esan et al., 2016). The provider sets the time spent at P_{high} (T_{high}) and P_{low} (T_{low}), T_{high} is usually longer than T_{low} (Esan et al., 2016). APRV promotes adequate alveolar recruitment, oxygenation, and ventilation (Esan et al., 2016). The Vt generated depends on lung compliance, airway resistance, periodicity, and duration of the release phase (Esan et al., 2016).

Low and High Tidal Volume Ventilation

Low Vt ventilation is defined as Vt between 4 – 8 ml/kg predicted body weight (PBW) with a plateau pressure (static pressure in the airway at the end of inspiration) less than 30 cm H2) (Celli, 2015; Simonis et al., 2015). Low Vt ventilation, however, may result in increased partial pressure of carbon dioxide (permissive hypercapnia) (Yadam et al., 2016). The results of permissive hypercapnia are hypoventilation, carbon dioxide retention, and acidosis (Rogovik & Goldman, 2008). Permissive hypercapnia results in decreased alveolar oxygen tension and alveolar collapse (Rogovik & Goldman, 2008). To offset alveolar collapse and to increase alveolar recruitment, the positive end-expiratory pressure (PEEP) is adjusted to maintain the patency of the alveoli while preventing overdistention and closure (Celli, 2015; Rogovik & Goldman, 2008). High Vt ventilation is defined as Vt greater than 8 ml/kg PBW (Simonis et al., 2015). PBW is calculated by 50 + 0.91 x (centimeters of height – 152.4) for males and 45.5 + 0.91 x (centimeters of height – 152.4) for females (Simonis et al., 2015).

Tele-Intensive Care Unit

The American Telemedicine Association, defines TeleICU as the use of audio/visual communication, and computer systems technology to provide critical care services to critically ill patients (Davis et al., 2016). TeleICU uses networking technology to monitor critically ill patients remotely from an offsite central monitoring facility, where the patient's electronic medical records can be accessed (Davis et al., 2016; Kohl et al., 2012). TeleICU is staffed by board-certified intensivist, board-certified acute care nurse practitioners, and board-certified nurses (Kalb et al., 2014). The TeleICU team follows a structured process and workflow which focuses on best practice compliance (Kalb et al., 2014). TeleICU team evaluates between 40 – 50 patients per shift using three monitors with large amounts of information such as patient diagnosis, temperature, electrocardiogram (ECG), oxygen saturation, lab works, radiology images, etc. TeleICU has access to electronic health records (EHR). TeleICU has teleconference capabilities to be able to communicate with the ICU bedside team (Kalb et al., 2014).

Problem Identification

I currently am employed in the Banner TeleICU department where, quarterly and yearly reports of best practice compliance are provided. As of quarter three of 2016, the average compliance to low Vt ventilation for ARDS patients is 85% for all hospitals that the TeleICU provide services. Data from individual hospitals are also provided. From that report, Banner Casa Grande has been chosen for this quality improvement project. Compared to all the hospitals TeleICU services are provided, Banner Casa Grande has been identified to be the least complaint to low Vt ventilation. Quarter 3 2016 report for patients with P/F ratio less than 300 without ARDS, Banner Casa Grande's adherence to low Vt ventilation (< 9 ml/kg PBW) was 51.3%, and for patients with P/F ratio less than 300 with ARDS, Banner Casa Grande's adherence to low Vt ventilation (< 8ml/kg PBW) was 48.9%. The target goal for Banner TeleICU is to be greater than 90% complaint with low Vt ventilation for both non-ARDS and ARDS patients.

Significance

Kalb et al. (2014) reported that adherence to low Vt ventilation increased, ventilator duration ratio decreased, and ICU mortality ratio decreased when TeleICU-directed ventilator rounding was implemented. Neto et al. (2015) reported that the use of low Vt ventilation decreased ICU LOS. Coustasse, Deslich, Bailey, Hairston, and Paul (2014) reported that because of better patient outcomes from implementing TeleICU, ICU cost decreased, thus improving the hospitals financial performance. In one health care organization that implemented TeleICU, during the first 6 months, a cost savings of $3 million was reported (Coustasse et al., 2014). ICU LOS, reception of mechanical ventilation, and ICU mortality has been identified as the major ICU cost factors (Kramer, Dasta, & Kane-Gill, 2017). For non-ventilated patients, the ICU cost was $11.470 vs $34,183 for patients receiving mechanical ventilation (Kramer et al., 2017). By using TeleICU to improve adherence to low Vt ventilation there will be improved patient outcomes (i.e. decreased ventilator duration, ICU LOS, & ICU mortality) and improved hospital financial benefits (decreased ICU cost).

Purpose

The purpose of this Doctorate of Nursing Practice (DNP) QI project is to evaluate the use of the TeleICU nurse-directed low Vt ventilator rounds checklist for ICU intubated and mechanically ventilated patients. The aims of the QI project are to: 1) measure the usability of the low Vt ventilator rounds checklist; 2) measure the number of TeleICU intensivist interventions based on the use of the low VT ventilator rounds checklist; and 3) increase adherence to low tidal volume (Vt) ventilation. The QI project will be conducted for 2 weeks, in the TeleICU department.

Question

The DNP QI project will answer the following questions: 1) What is the usability of the TeleICU nurse directed ventilator rounds checklist? 2) Did the TeleICU nurse directed ventilator rounds checklist result in TeleICU intensivist intervention (change in the ventilator settings)?; and 3) What is the influence of the TeleICU nurse-directed ventilator rounds checklist on the adherence to low Vt ventilation on all ICU ventilated patients?

SYNTHESIS OF EVIDENCE

I searched PubMed and CINAHL for terms “low tidal volume ventilation,” “teleintensive care unit,” “lung-protective ventilation,” “acute respiratory distress syndrome,” “acute lung injury,” and “intensive care unit.” I further filtered the results to “clinical trials,” publication dates “5 years,” and species “human.” I also looked at the reference page of a meta-analysis and a systematic review article. After reading the titles and abstracts of the results I included 10 articles to review. There are six randomized clinical trials (RCT) (Futier et al., 2013; Memtsoudis, Bombardieri, Ma, & Girardi, 2012; Natalini et al., 2013; Pinheiro de Oliveira, Hetzel, dos Anjos Silva, Dallegrave, & Friedman, 2010; Sundar et al., 2011; Yang et al., 2011), one observational sub study of an RCT (Mehta et al., 2014), two prospective observational cohort study(Chen et al., 2014; Needham et al., 2015), and one retrospective observational longitudinal study (Kalb et al., 2014).

The standard for care for adult patients with ARDS is the use of low Vt ventilation (Mehta et al., 2014). Low Vt ventilation has shown to have many benefits including: decrease mortality ratio, ICU LOS, hospital LOS, development of pulmonary and extrapulmonary complications, reduce ventilation days, and increase in cardiac index (Chen et al., 2014; Futier et al., 2013; Kalb et al., 2014; Memtsoudis et al., 2012; Needham et al., 2015; Pinheiro de Oliveira et al., 2010; Sundar et al., 2011; Yang et al., 2011). Even though studies have shown many benefits of low Vt vs high Vt ventilation, adherence of its use is low (Kalb et al., 2014). The use of TeleICU technology for ventilator rounds have been shown to improve adherence to low Vt ventilation protocol (Kalb et al., 2014). After reviewing the literature, there is evidence that ICU intubated and mechanically ventilated patients will benefit from low Vt ventilation and that the use of TeleICU will increase its adherence.

TeleICU Ventilator Rounds

TeleICU is an off-site electronic monitoring facility that is capable of data acquisition, and interventional services using audio/visual technology (Kalb et al., 2014). One of the focus of TeleICU is to monitor and enhance best practice adherence (Kalb et al., 2014). A retrospective, population-based, cross sectional, and longitudinal analysis study found that adherence to low Vt ventilation for non-ARDS patients significantly improved from 34% to 47.5% ($P<0.0001$), and adherence to low Vt ventilation for ARDS/ALI patients significantly improved from 23.3% to 37% ($P <0.005$) after the implementation of the teleICU-directed daily bedside ventilator rounds (Kalb et al., 2014). Ventilation duration ratio and ICU mortality significantly decreased as well (Kalb et al., 2014).

Low Vt Benefits – Evidence

Pulmonary and Extrapulmonary Complications

In surgical patients, Low Vt has shown a decrease pulmonary and extrapulmonary complications (Futier et al., 2013; Yang et al., 2011). Futier et al. (2013), reported that 21 patients (10.5% in the low Vt ventilation group and 55 (27.5%) in the high Vt ventilation group developed pulmonary (pneumonia) and extrapulmonary complications (systemic inflammatory response syndrome, sepsis, severe sepsis and septic shock, and surgical complications) within seven days after surgery. Yang et al. (2011) studied the use of low Vt ventilation of lung cancer surgical patient for risk of pulmonary complications. Yang et al. (2011) found that fewer pulmonary complications occurred in the use of low Vt ventilation. Sundar et al. (2011) reported that cardiac surgical patients that used high Vt during surgery and subsequent ICU stay were reintubated at a significantly higher rate compared to low Vt ventilation (9.5% to 1.3%, P = 0.03).

Cardiac Index

Natalini et al. (2013) conducted a study that measures the cardiac index and oxygen delivery between low Vt ventilation and high Vt ventilation in patients with ARDS. They found that low Vt ventilations increased cardiac index and oxygen delivery (Natalini et al., 2013).

Ventilation Days, ICU LOS, Hospital LOS and Mortality Rate

Kalb et al. (2014) showed that the mean ventilator duration ratio significantly improved ($p<0.04$) with the use of TeleICU-directed ventilator rounding for the use of low Vt. For cardiac surgical patients, Sundar et al. (2011), reported that by the sixth and eighth hours from ICU admission, the patients in low Vt ventilation were extubated compared with the control group (6 hours: 37.3% vs 20.3%, P = 0.02; 8 hours: 53.3% vs 31.1%, p = 0.006). Yang et al. (2011) showed that the ICU LOS and hospital LOS decreased with the use of low Vt ventilation, but did not show statistical significance (p = 0.13, and p = 0.16, respectively). Studies did not show statistical significance in ICU mortality ratio (Futier et al., 2013; Memtsoudis et al., 2012), but when TeleICU was used to make sure that low Vt ventilation is used, ICU mortality ratio improved and showed statistical significance (Kalb et al., 2014). In patients in ARDS, the use of higher Vt ventilation immediately after ARDS identification was associated with a greater risk of ICU mortality (Needham et al., 2015). Meaning, improved survival of ARDS patients depends on timely adherence to low Vt ventilation (Needham et al., 2015). Furthermore, the 28-day and

1-year survival of severe ARDS patients are better on low Vt ventilation compared to high Vt ventilation (Chen et al., 2014).

Inflammation

Decrease in inflammatory markers with the use of low Vt ventilation has been inconsistent. Inflammatory markers desmosine and interleukin-6 did not show any difference for intraoperative patients that received low Vt and high Vt ventilation (Memtsoudis et al., 2012). On the other hand, a different study found that BALF interleukin-8 and BALF-tumor necrosis factor-α decreased for patients that received low Vt ventilation after lung resection surgery ($p = 0.042$) (Pinheiro de Oliveira et al., 2010). Even though evidence of decreased inflammatory markers is inconsistent during the use of low Vt ventilation, there are inflammatory markers that did decrease, so low Vt can show benefits in preventing additional injury (Pinheiro de Oliveira et al., 2010).

Sedation

Increased sedation and increased discomfort are barriers to low Vt ventilation use (Mehta et al., 2014). Mehta et al. (2014) concluded that there was no change in the dosing or duration of sedatives, opioids, or neuromuscular blockers (NMBs) during the use of low Vt ventilation.

Strengths

The major strength of the literature review is that there are six RCTs that addressed the importance of low Vt ventilation. Another strength is that there was one study that involved the effectiveness of teleICU unit-directed ventilator rounds (Kalb et al., 2014). Kalb et al. (2014) demonstrated that the use of teleICU-directed ventilator rounds significantly improved adherence to low Vt ventilation, ventilator duration ratio, and ICU mortality ratios. Another strength is that the literature review involved non-ARDS and ARDS patients.

Gaps

The major gap is the lack of randomized control trial studies with sufficient power that test the benefits of low Vt ventilation on non-surgical & non-ARDS patients. Although, there is a study underway that wants to answer this gap (Simonis et al., 2015).

Limitations

Even though there have been studies with the use of low Vt ventilation in patients without ARDS, most of them are focused on surgical patients. So, those data cannot be generalized to critically ill non-ARDS patients in the ICU setting.

Summary of Evidence

Findings from the appraisal of the literature support the benefits of low Vt ventilation for intubated and mechanically ventilated patients in the ICU, which are: 1) decreased occurrence of pulmonary and extrapulmonary complications; 2) increased cardiac index; 3) decreased in ventilator days, ICU LOS, hospital LOS, and mortality ratio; 4) decrease in inflammatory markers; & 5) sedation use is not increased. TeleICU-directed ventilator rounding is a way to increase the adherence to low Vt ventilation in ICU intubated and mechanically ventilated patients. This compilation of evidence validates my DNP QI project.

FRAMEWORK AND THEORETICAL UNDERPINNINGS

The DNP QI project will involve a change in the workflow of the TeleICU nurse. Change is difficult to achieve and to make it easier, a theory that supports the change process and a model of planned change is necessary (Zaccagnini, 2017). The theories that is used for this DNP

QI project are: 1) Data-Information-Knowledge-Wisdom (DIKW) framework (Matney, Brewster, Sward, Cloyes, & Staggers, 2011; Ronquillo, Currie, & Rodney, 2016; Topaz, 2013), and 2) Lippit's theory of planned change (Geraci, 1997; Mitchell, 2013).

Data-Information-Knowledge-Wisdom Framework

TeleICU is a relatively new way of health care delivery and is a part of the growing field of nursing informatics. Nursing informatics is the combination of information science, computer science, and nursing science (Topaz, 2013). The DIKW framework has been used in the field of nursing informatics. The application of the DIKW framework helps the TeleICU intensivist and TeleICU nurses in assessing the patient to provide better patient care.

Data

Data is defined as un-interpreted facts or observations (Matney et al., 2011). A single data has little or no meaning when isolated (Matney et al., 2011). The data the TeleICU nurse will be collecting during ventilator rounds are: predicted low Vt, ventilator settings (mode, FiO2, tidal volume, PEEP, rate, and minute ventilation), intubation date and time, and extubation date and time.

Information

Information is making meaning out of the all the data that has been collected (Matney et al., 2011). Information is data that has been interpreted (Ronquillo et al., 2016). For this DNP project, after the TeleICU nurse collects the data, he/she will now see a meaningful picture of the patient. For example, upon analysis of the data, patient X's predicted low Vt is 500 mL, but the current Vt is set at 600 mL.

Knowledge

Knowledge is the synthesis of the information (Matney et al., 2011). From the above example, the TeleICU nurse will use the information to draw conclusions about the data collected. The TeleICU nurse will identify that the patient is not on low Vt ventilation.

Wisdom

Wisdom is the appropriate use of the knowledge to manage and solve the problem (Matney et al., 2011). Wisdom is the use of patients' values, nurse experience, and healthcare knowledge to guide the nurse to recognize the issue (Topaz, 2013). Wisdom will help the TeleICU nurse decide what nursing intervention or action to take. For the DNP QI project, the TeleICU nurse, after recognizing that the patient is not on the low Vt ventilation protocol, will then inform the TeleICU intensivist so that he/she can investigate further and provide the appropriate medical intervention. Through wisdom, the work of the TeleICU nurse will be more visible (Ronquillo et al., 2016).

Lippit's Theory of Planned Change

Lippit's theory of planned change will be used in developing and implementing TeleICU nurse directed ventilator rounds. Lippit describes seven phases of planned change (Geraci, 1997).

Diagnosing the Problem

This is done by a member of the TeleICU department. From the quarterly and yearly best practice compliance reports the TeleICU department receives, leaders and/or staff can identify a problem that needs to be addressed/changed (Geraci, 1997). The problem could be a process or organizational (Geraci, 1997). Once the problem is identified, and a possible solution to the problem has been identified, the project team must discuss the strengths and weaknesses of the change (Geraci, 1997). For this DNP project, the problem (low adherence to low Vt ventilation) was identified using the quarterly and yearly best practice compliance reports. The inspiration for the possible solution came after reading Kalb et al. (2014), in which the researchers used TeleICU in improving adherence to low Vt ventilation.

Assess Motivation/Capacity for Change

This involves a "thorough appraisal of the organizational structure, the formal and informal power base, and an accurate assessment of the resources available for initiating a change" (Geraci, 1997, p. 201). Key stakeholders must be involved in this process to assure the success of the project (Geraci, 1997). Driving forces and restraining forces must be identified (Geraci, 1997). This also involves responding to stakeholders concerns about the change and, if necessary to justify the change (Mitchell, 2013). The key stakeholders for this DNP QI project are: TeleICU intensivist, TeleICU nurse, ICU intensivist, ICU nurse, ICU respiratory therapist, and the patient.

Identification of Change Agent

The next step involves the identification of the change agent/s that will act on the problem (Geraci, 1997). It could be the DNP project student or any member of the TeleICU nursing staff. For this QI project the DNP student is the change agent.

Objectives of the Change

The fourth step is to define the change process and the final plan to address the problem is developed (Mitchell, 2013). During this stage the specific and clear method of implementing TeleICU nurse-directed ventilator rounds is developed.

Choosing the Appropriate Role of the Change Agent

It is important to clearly identify the role of the change agent so that the plan can be successful (Geraci, 1997). Confusion and failure in communication can result if the role of the change agent is not defined (Geraci, 1997). For this DNP project, the DNP student is the change agent and the role could be that he/she oversee the education of the change in work flow of TeleICU nurses, incorporating the low Vt rounding checklist.

Implementation and Maintaining the Change

In this step the new plan to address the problems/issues will be implemented. Upon solving the possible problems/issues of the planned change, then it is necessary to maintain the change so that it can become a stable part of the system (Mitchell, 2013). Communication, feedback on progress, teamwork, and motivation is key in maintaining the change (Mitchell, 2013). When the methods of the planned change (TeleICU nurse-directed low Vt ventilator rounds) has been finalized then it is time to be implemented. Problems/issues to the planned change will come up, and solutions are identified to solve the problems/issues. The DNP project team must identify maintenance and sustaining strategies so the TeleICU nurse-directed low Vt ventilator rounding can be a part of the workflow of the TeleICU nurses.

Terminate the Helping Relationship

This step involves the evaluation and withdrawal of the change agent (Mitchell, 2013). A knowledgeable and committed individual must be identified to take over the role of the change agent (Geraci, 1997). Because the change agent is the DNP student, a new change agent needs to be identified in preparation to the DNP students’ graduation.

METHODOLOGY

Project Design

This DNP QI project will use a descriptive study design to evaluate the effectiveness of using the TeleICU nurse-directed low Vt ventilator rounds checklist for ICU intubated and mechanically ventilated patients on: 1) usability; 2) effectiveness; and 3) adherence to low Vt ventilation protocol.

Sample

The participants of the QI project are the TeleICU nurses who will be gathering data using the Low Vt ventilator rounds checklist. The TeleICU nurses have at least five years of critical care experience. The TeleICU nurses will gather the data from the electronic health records of ICU patients who meet the following inclusion criteria: 1) intubated and ventilated adult patients (>18 years old) that require mechanical ventilator support for more than 24 hours; & 2) patients using the AC and IMV modes of ventilation. Data for patients that received ventilation before ICU admission for example, in the emergency room or in the operating room, are also included (Simonis et al., 2015). Exclusion criteria: 1) Patients < 18 years old; 2) pregnant patients; 3) patients with increased and uncontrollable intracranial pressure (of ≥ 18 mmHg); & 4) patients on PCV and APRV mode of ventilation. The total target number of TeleICU nurses would be about six and total number of patients would be 20. The DNP QI project will be done for two weeks.

Setting

The setting is the Banner TeleICU department which consist of TeleICU intensivist (board certified medical doctors), TeleICU APRNs (board certified nurse practitioners), TeleICU nurses (board certified registered nurses), TeleICU clinical managers and health unit coordinators. The TeleICU department is in a remote facility in Mesa, Arizona. The TeleICU department uses Philips eCareManager™ data management platform which pulls data from the hospital's electronic medical record (EMR) (Kalb et al., 2014).

Another setting is Banner Casa Grande's medical-surgical ICU which consist of the intensivist/pulmonologist, nurses, respiratory therapist, and patients. Banner Casa Grande is a rural hospital located in the state of Arizona that typically cares for critically ill patients. The ICU is a 20-bed unit. Ventilator management is shared with consulting pulmonologist, and intensivists.

Tools for Data Collection

To organize the data collection and facilitate ventilator rounding, a low Vt ventilator rounds checklist was developed (Appendix A). The checklist was developed by myself which was revised and adopted from the ventilator rounding template used by Kalb et al. (2014). This checklist includes pre-calculated Vt, ventilator settings (mode, FiO2, tidal volume, PEEP, rate, and minute ventilation), and whether the TeleICU intensivist made any ventilator setting changes. This data will be collected from the electronic medical record, Cerner: Powerchart (as detailed below).

To test the usability of the low Vt ventilator rounds checklist, a Usability Evaluation Scales survey (Appendix B) was adopted from Sauro & Lewis (2012). The survey consists of three categories: 1) a 10-item Technology Usefulness Scale (TUS) questionnaire with 7-point Likert Scale response options (1 – strongly disagree to 7 – strongly agree); 2) a 10-item Ease of Use Scale (EUS) questionnaire with five-point Likert Scale response options (1 – strongly disagree to 5 – strongly agree); & 3) two dichotomous Acceptability ratings that will measure attitude and intention (Sauro & Lewis, 2012). The TUS measures usefulness and is 1.5 times more accurate compared to other usability scores in predicting actual use (Sauro & Lewis, 2012). EUS is a tool that measures ease of use (Sauro & Lewis, 2012). The Acceptability scales examines the feasibility of an intervention (Sauro & Lewis, 2012).

Intervention

The intervention that was implemented for this QI project was the use of the Low Vt ventilator rounds checklist by the TeleICU nurse to identify patients who are not being mechanically ventilated with the low Vt ventilation protocol. For patients that meet the inclusion criteria, the TeleICU nurse checked Cerner: Powerchart for the pre-calculated low Vt, which was written on the low Vt ventilator rounds checklist. Then, the TeleICU nurse wrote the current ventilator settings and then compared the current Vt with the pre-calculated low Vt. If the current Vt was not within the pre-calculated low Vt setting, the TeleICU nurse notified the TeleICU intensivist that the patient was not on low Vt ventilation and provided the current ventilator settings. The TeleICU intensivist reviewed the patients chart and analyzed if low Vt was appropriate for the patient. If low Vt ventilation was appropriate for the patient, then the TeleICU intensivist called the ICU unit and made changes to the ventilator settings. After giving time for the TeleICU intensivist to review the chart (around 5 to 10 minutes), the TeleICU nurse then asked the TeleICU intensivist if the ventilator settings were changed to reflect low Vt ventilation and marked either “yes” or “no” on the low Vt ventilator rounds checklist.

Data Collection

The low Vt ventilator rounds checklist was done every day, for 2 weeks, by the day shift and night shift TeleICU nurses. The completed checklist was collected at the end of each shift by the clinical manager and kept in a secure location in the TeleICU clinical manager's office.

After two weeks of using the low Vt ventilator rounds checklist, the TeleICU nurses that participated in the QI project was given the Usability Evaluation Scales survey. The Usability Evaluation Scales survey has been shown to be reliable and valid tool that measures the ease of use of technology (Sauro & Lewis. 2012). The completed survey was returned to the clinical manager and kept in a secure location in the TeleICU clinical manager's office.

Data Analysis

Aim 1

The usability of the low Vt ventilator rounds checklist was measured by conducting the Usability Evaluation Scale survey that was given to the TeleICU nurses, at the end of the QI project. Descriptive statistical analysis (mean, median, mode, and range) was measured for each of the subscales in the survey. The total scores for each scale was collected and descriptively analyzed. This data will show if the checklist could be integrated to the current work flow of TeleICU nurses. The TUS overall usefulness score of each TeleICU nurse was calculated by adding all the scores (per RN) divided by 70, times 100. For the EUS, the odd numbered questions were worded positively, and the even numbered questions were worded negatively. For the odd numbered questions, the score was calculated as the scale position minus 1 (X – 1) (Sauro and Lewis, 2012). For the even numbered questions the score was calculated as 5 minus the scale position (5 – X) (Sauro and Lewis, 2012). The overall EUS raw score was calculated by adding the adjusted scores and multiplying it by 2.5, thus the overall EUS scores ranged from 0 to 100 (Sauro & Lewis, 2012). On the EUS questionnaire, the lower the rating on the “even” numbered questions the better, and the higher the rating on the “odd” numbered questions the better.

Aim 2

The total number of patients that were not on low Vt ventilation was collected. From this, the total number of TeleICU intensivist interventions (mechanical ventilator settings changes) was collected. This data measured the total number of TeleICU intensivist interventions that resulted from the use of the low Vt ventilator rounds checklist. This data will show the value of TeleICU and how TeleICU is making a difference in patient care.

Aim 3

Adherence to low Vt ventilation was based on percentage of arterial blood gas analysis (ABG) drawn at Vt of less than 8 mL/kg PBW on patients with P/F ratios less than 300 for non-ARDS and ARDS patients. Adherence was calculated by the Clinical Performance Analyst Associate (CPAA) of the TeleICU department who extracted the data from eCareManager database, a propriety database managed by Philips. Adherence to low Vt (<8 mL/kg PBW) ventilation was calculated as:

$$\frac{No.of\ ABG\ drawn\ with\ Tidal\ Volume\ ventilator\ setting\ of < 8\ \frac{mL}{kg}/PBW}{Total\ no.of\ ABGs\ drawn\ for\ patients\ with\ P/F\ ratio\ of < \ 300\ with\ or\ with\ out\ ARDS}\ x\ 100$$

TABLE 2. *Adherence to low Vt ventilation calculation.*

Vt data was collected at the time of ABG to allow for a more accurate assessment of the adjustments that were made on individual patients, in part, as a result of TeleICU nurse-directed low Vt ventilator rounds (Kalb et al., 2014).

The two-week adherence to low Vt ventilation will be compared to the target bench mark of 90%.

Ethical Considerations

Protection of Patient Health Information

The low Vt ventilator rounds checklist does not contain any protected health information (PHI) (i.e. Name and MR#) as defined by the Health Insurance Portability and Accountability Act of 1996 (HIPAA), but it is best practice to ensure and maintain confidentiality, integrity, and availability of the data collected (U.S. Department of Health & Human Services, 2013). The low Vt ventilator rounds checklist will be returned by the TeleICU nurse to the TeleICU clinical manager. The TeleICU clinical manager will then place the low Vt ventilator rounds checklist in a folder inside a locked drawer at their locked office. The low Vt ventilator rounds checklist will remain in the TeleICU facility throughout the QI project. The data analysis will be conducted in the TeleICU department. The Usability Evaluation Scales survey does not contain any PHI but anonymity is ensured. Completion of the Usability Evaluation Scales survey is voluntary but is strongly encouraged. After the completion of the QI project, the low Vt ventilator rounds checklist and the Usability Evaluation Scales survey will be available and kept at the TeleICU department, but will be kept in a secure area.

Respect for Persons

When the TeleICU nurse determines that the patient is not on low Vt ventilation and have notified the TeleICU intensivist, the TeleICU intensivist has the authority and autonomy to decide what intervention to take with all the data provided and from his further investigation.

The TeleICU intensivist must consider all the information to determine if low Vt ventilation is appropriate for this patient.

Beneficence

The synthesis of evidence (above) shows that low Vt ventilation has minimal risk and maximum benefit for the patient. If low Vt ventilation is harming the patient, bedside intensivist or TeleICU intensivist are free to make changes that would benefit the patient.

Justice

With the inclusion and exclusion criteria, every intubated patient is treated equally. The exclusion criteria have shown that low Vt is not beneficial to them or can do them harm.

RESULTS

The QI project was conducted on February 25, 2018 to March 10, 2018. There were a total of nine TeleICU nurses that participated out of 41 TeleICU nurses. Out of the nine TeleICU nurses that participated, five were from the day shift and four were from night shift. There were a total of 16 low Vt ventilator rounds checklist that was filled out. The day shift filled out the low Vt ventilator rounds checklist ten times, while, the night shift filled out six. At the end of the QI study, the nine TeleICU nurses were given the Usability Evaluation Scales survey, but only eight of the nine TeleICU nurses returned the survey before the week deadline.

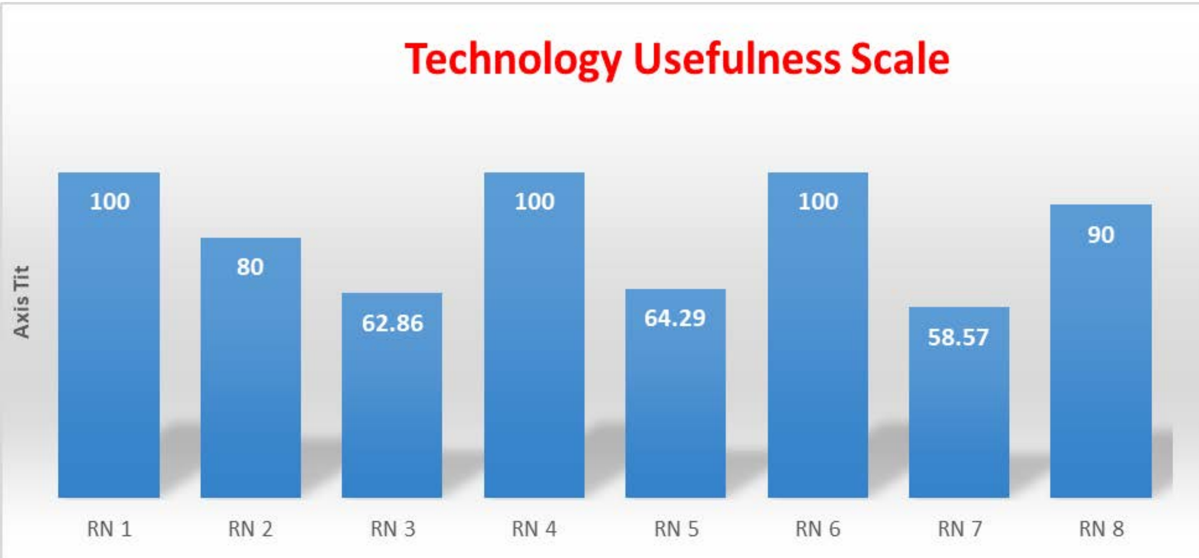
Aim 1

Aim 1 - *Measure the usability of the low Vt ventilator rounds checklist*:

The Usability Evaluation Scales survey was given to the TeleICU nurses at the conclusion of QI project and they were given a week to turn in the survey. Eight of the nine TeleICU nurses returned the survey before the week ended.

Technology Usefulness Scale

Figure 1, presents how the eight TeleICU nurses viewed the low Vt Ventilator rounds checklist's usefulness. Five out of the eight nurses scored the usefulness of the checklist above 80 points. The other three nurses scored the usefulness of the checklist between 58 - 64 points. Overall, the TeleICU nurses scored the usefulness of the checklist with a Mean of 81.96 points, with a Range of 58 to 100 points. For Question 1, which asked if the quality of assessing the patients improved by using the checklist the TeleICU nurses scored with a mean of 5.5, which showed that they agreed (Table 3). The quickness of assessing the patient was important to the TeleICU nurses surveyed. The TeleICU nurses scored the quickness of assessing the patient on mechanical ventilation with a mean of 5.38, which showed that they somewhat agreed that the low Vt ventilator round checklist was quick in assessing the patients on mechanical ventilator (Table 3: Question 3). The TeleICU nurses agreed (Table 3: Question 9; Mean 5.5) that the low Vt ventilator rounds checklist made it easier to assess patients on mechanical ventilation. For Question 4, the TeleICU nurses strongly agreed that low Vt ventilator rounds checklist supports the critical aspects of assessing patients on mechanical ventilation (Table 3; Mean 6.5). This means that the TeleICU nurses thought that the low Vt ventilator rounds checklist included what is important in assessing mechanically ventilated patient. The TeleICU nurses agreed that the low Vt ventilator rounds checklist to be an efficient way in assessing patients on mechanical ventilation (Table 3: Question 5; Mean 6.13). Looking at question 10 (Table 3; Mean 5.88), the TeleICU nurses agreed that the low Vt ventilator rounds checklist is useful.



Mean = 81.96, Median = 85, Mode = 100, Range = 58.57 to 100

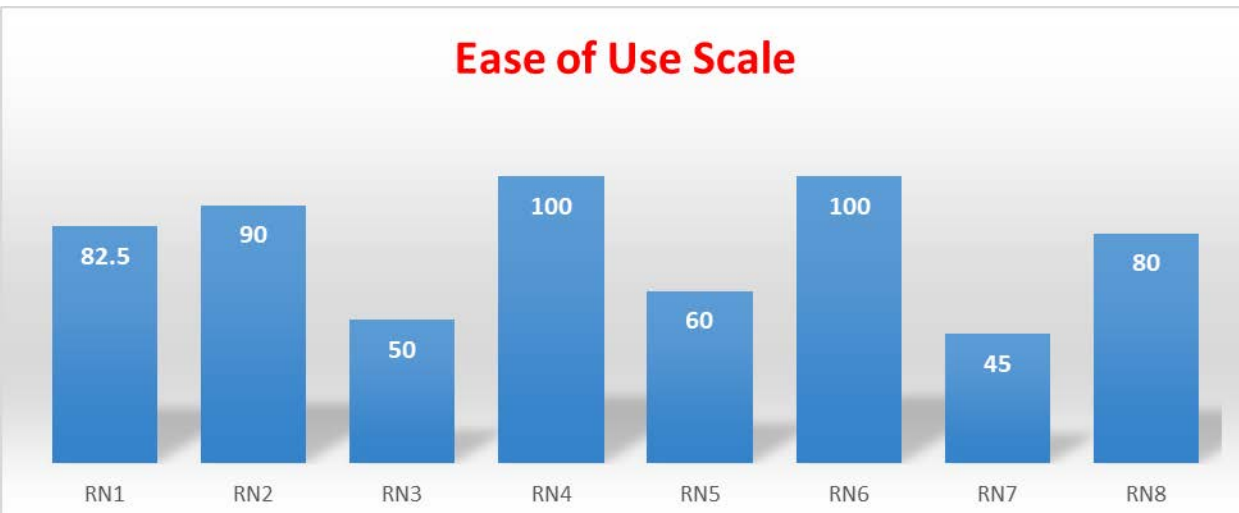
FIGURE 1. Technology usefulness scale.

TABLE 3. *Technology usefulness scale: Mean rating score per question*

	Mean Rating Score per Question
1. Using the TeleICU Low Vt ventilator rounds checklist improves the quality of assessing patients on mechanical ventilation	5.50
2. Using this TeleICU Low Vt ventilator rounds checklist gives me greater control over assessing patients on mechanical ventilation.	5.38
3. This TeleICU Low Vt ventilator rounds checklist enables me to assess patients on mechanical ventilation more quickly.	5.38
4. This TeleICU Low Vt ventilator rounds checklist supports critical aspects of assessing patients on mechanical ventilation.	6.5
5. This TeleICU Low Vt ventilator rounds checklist increases the efficiency of assessing patients on mechanical ventilation.	6.13
6. This TeleICU Low Vt ventilator rounds checklist improves the task of assessing patients on mechanical ventilation.	5.63
7. This TeleICU Low Vt ventilator rounds checklist allows me to accomplish more in-depth assessment of patients on mechanical ventilation than would otherwise be possible.	5.88
8. This TeleICU Low Vt ventilator rounds checklist enhances my effectiveness of assessing patients on mechanical ventilation.	5.63
9. This TeleICU Low Vt ventilator rounds checklist makes it easier to assess patients on mechanical ventilation.	5.5
10. Overall, I find this TeleICU Low Vt ventilator rounds checklist useful in assessing patients on mechanical ventilation.	5.88

The Ease of Use Scale

The eight TeleICU nurses that completed the survey found that the low Vt ventilator rounds checklist was easy to use (Mean of 75.94 points, Range 45 - 100, Figure 2). Looking at Appendix C, which shows the percentile ranks and the curved grading scale interpretation of the "Ease of Use" survey, a mean of 76 is graded as a "B" (Sauro & Lewis. 2012). While not finding an "A" level of support, some support was found for the low Vt ventilator rounds checklist's ease of use.



Mean = 75.94, Median = 81.25, Mode = 100, Range 45 – 100

FIGURE 2. The ease of use scale overall raw score.

Looking at the scores of each individual question (Table 4), the TeleICU nurses "Agree" that they would like to use the TeleICU low Vt ventilator rounds checklist daily (Question 1, Mean = 3.50). The TeleICU nurses "Strongly Agree" that the TeleICU low Vt ventilator rounds checklist is easy to use (Table 4, Question 3: Mean = 4.50). The TeleICU nurses "Agree" that they would learn to use the TeleICU low Vt ventilator rounds checklist quickly (Table 4, Question 7; Mean = 4). The TeleICU nurses did not find that the TeleICU low Vt ventilator rounds checklist to be complex (Table 4, Question 2: Mean – 2.25: "Disagree"). The TeleICU nurses did not find that they would need any technical support person to be able to use the TeleICU low Vt ventilator rounds checklist (Table 4. Question 4: Mean – 2.38: "Disagree"). The TeleICU nurses did not find that the TeleICU low Vt ventilator rounds checklist to be cumbersome to use (Table 4, Question 8: Mean = 1.75: "Disagree").

TABLE 4. *Ease of use scale mean rating score per question.*

	Mean Rating Score per Question. – Out of 5: 1 – Strongly Disagree; 2 – Disagree; 3 – Undecided; 4 – Agree; & 5 – Strongly Agree
1. I think that I would like to use the TeleICU Low Vt ventilator rounds checklist daily.	3.50
2. I found the TeleICU Low Vt ventilator rounds checklist unnecessarily complex.	2.25
3. I thought the TeleICU Low Vt ventilator rounds checklist was easy to use.	4.50
4. I think that I would need the support of a technical person to be able to use the TeleICU Low Vt ventilator rounds checklist.	2.38
5. I found the various functions in the TeleICU Low Vt ventilator rounds checklist were well integrated.	4.13
6. I thought there was too much inconsistency in the TeleICU Low Vt ventilator rounds checklist.	1.75
7. I would imagine that most people would learn to use the TeleICU Low Vt ventilator rounds checklist very quickly	4.00
8. I found the TeleICU Low Vt ventilator rounds checklist very cumbersome to use.	1.75
9. I felt very confident using the TeleICU Low Vt ventilator rounds checklist.	4.25
10. I needed to learn a lot of things before I could get going with the TeleICU Low Vt ventilator rounds checklist.	1.88

Attitude and Intention

Table 5 shows that the low Vt ventilator rounds checklist is successful in assessing patients that are mechanically ventilated (Mean 87.5%). Table 5 also shows that seven out of eight that completed the survey (Mean 87.5%) would use the checklist if it was a regular part of their daily workflow.

TABLE 5. *Attitude and intention.*

Successfulness

	RN1	RN2	RN3	RN4	RN5	RN6	RN7	RN8
Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass

Pass	7		87.50%
Fail	1		12.50%

Would you USE IT?

	RN1	RN2	RN3	RN4	RN5	RN6	RN7	RN8
Yes/No	YES	YES	YES	YES	YES	YES	NO	YES

Yes	7		87.50%
No	1		12.50%

Aim 2

Aim 2 - *Measure the number of TeleICU intensivist interventions based on the use of the low Vt ventilator rounds checklist*:

The QI project was conducted for two weeks. During the first three days of the QI project, I was present for a few hours during both day shift and night shift to educate and answer questions. The times when I was not at the TeleICU department, both shifts knew to contact me via phone if they have any questions. The TeleICU nurse-directed low Vt ventilator rounds checklist was filled out 16 times (10 Day shift & 6 Night shift). The low Vt ventilator rounds checklist identified four patients that were not on the low Vt ventilation, the TeleICU intensivist was notified of only two of those incidences (50%). The TeleICU intensivist made changes to the ventilator settings, to reflect adherence to low Vt ventilation protocol on those two patients (100%).

Aim 3

Aim 3 - *Increase adherence to low tidal volume (Vt) ventilation*:

On March 15, 2018, the Clinical Performance Analyst Associate (CPAA) of the TeleICU department was asked to run a percent adherence report for the Low Vt ventilation for Banner Casa Grande. To run the report, filters were set to only include mechanically ventilated adult patients (>18 years old) from February 25, 2018 to March 10, 2018; and patients using the AC and SIMV modes of ventilation. During the two weeks of the QI project the percent adherence to low Vt ventilation was calculated to be 58%, and 42% where mechanically ventilated with a Vt of > 8 ml/Kg. Compared to the bench mark of 90%, the percent adherence of the QI project was 32% off.

DISCUSSION

Improving adherence to Low Vt ventilation for adult ICU mechanically ventilated patients is complex. It requires the cooperation of the whole medical team. Belief in the improvement in patient and system outcomes from using Low Vt ventilation must start from the hospital administration down to the nurses and respiratory therapist. Despite known benefits, the adherence of low Vt ventilation remains low. This QI project was conducted at Banner Casa Grande Hospital to evaluate the use of a TeleICU nurse-directed low Vt ventilator rounds checklist for ICU intubated and mechanically ventilated patients.

Aim 1 examined the usefulness of the low Vt ventilator rounds checklist. Aim 1 also identified if the TeleICU nurses will use the checklist in their regular day to day work flow. After two weeks of the QI project, results in evaluating the low Vt ventilator rounds checklist were promising. The majority of TeleICU nurses found the checklist to be useful, easy to use, and intend to incorporate the low Vt ventilator rounds checklist in their daily workflow. Before incorporating the low Vt ventilator rounds checklist in the daily work flow of the TeleICU nurse, changes should be made to make it even more easier to use.

Aim 2 presents number of patients that were not on low Vt ventilation, if the TeleICU intensivist were notified and if the TeleICU intensivist made the necessary changes to the mechanical ventilator settings. The QI project identified four patients not on low Vt ventilation and the TeleICU intensivist was notified on only two patients. The TeleICU intensivist made the necessary mechanical ventilator changes to those two patients to comply with low Vt ventilation. Two patients identified did not receive ventilator changes. The TeleICU nurses stated their reasoning was that the instruction given to them in filling out the low Vt ventilator rounds checklist was not clear and that they thought that notifying the TeleICU intensivist was not necessary because the current tidal volume ventilator setting was close enough to the upper limit of the pre-calculated low Vt ventilator setting. Those two TeleICU nurses were re-educated on how to fill out the low Vt ventilator rounds checklist and on when to notify the TeleICU intensivist. Education on how to use the low Vt ventilator rounds checklist was not done ahead of time before the QI project started. This caused confusion for the first three to four days of the implementation. The education was done one-on-one during change of shift for both day shift and night shift. It was hard to do an education ahead of time because the TeleICU department monitors 44 hospitals and there are about 41 TeleICU nurses. The project leader tried to reduce the confusion by being present for a few hours during day shift and night shift for five days. The project leader also informed the TeleICU nurse to call for any questions or confusions. The project leader also called the TeleICU nurse if they have any questions. When the TeleICU department decides to continue this QI project it is highly suggested to do the education at least one to two weeks ahead of time.

The low Vt ventilator rounds checklist was completed for the newly intubated patients, resulting in not capturing any changes to the tidal volume setting after one or two days of being mechanically ventilated. The decision to only complete the low Vt ventilator rounds checklist for the newly intubated patients was done so that the TeleICU nurses would not feel overwhelmed because they already monitor 50 patients. Even though the QI project only involved one ICU unit with an average of only 5 – 8 intubated patients a day, some of the nine TeleICU nurses were still hesitant to participate in the QI project. This showed that the TeleICU nurses were not engaged in the QI project. The engagement of the TeleICU nurses must be improved when the QI project is implemented again. This could be done by re-education of the physiological effects of Low Vt ventilation and the presentation of its many benefits.

Aim 3 examined the adherence to low Vt ventilation of those patients that are mechanically ventilated during the two weeks of the QI project. The QI project calculated that during the two weeks of the QI project, 58% of the intubated patients were on the low Vt ventilation. Even though the QI project was 32% off the bench mark of 90%, there was still an increase of 13% compared to Quarter 4 2017 report (Quarter 4 2017 adherence = 45%, p value not calculated). The QI project was only done for two weeks so a longer QI project should be conducted to be able to longitudinally analyze the impact of TeleICU nurse-directed low Vt ventilator rounds. Kalb et al., (2015), reported that the use of TeleICU in assessing low Vt ventilation adherence showed an incremental and significant improvement by the third quarter of implementation. Adherence increased from 29.5% during preimplementation to 44.9% (p <

0.002) after a year of TeleICU ventilator rounds (Kalb et al., 2014). Clearly, two weeks is not enough to achieve the bench mark goal of 90% in the adherence of low Vt ventilation. Even though, the QI project did not reach the bench mark of 90%, the QI project showed an improvement in the adherence of low Vt ventilation protocol. With the improvement of adherence, the TeleICU management must be encouraged to continue with the QI project.

There are several limitations to this study. First, the bedside team were not notified of the TeleICU QI project. A similar study conducted by Kalb et al., (2014) involved both TeleICU team and the bedside team. The increase in adherence could have been affected by not involving the bedside team, which resulted in bedside intensivist not being engaged in the TeleICU QI project. After the TeleICU intensivist made the necessary changes to comply with low Vt ventilation the bedside intensivist might have discontinued the TeleICU intensivist order and reverted back to the original mechanical ventilation order. For the next implementation of this QI project the TeleICU department must involve and inform the bedside team of the QI project. Second, the QI project was only done for two weeks. The study done by Kalb et al., (2014), did not see a significant change until after quarter 3 of implementation. Clearly, to see significant change in the adherence of low Vt ventilation the QI project must be done for a longer period of time. This QI project was only done for two weeks due to time constraints so that the project leader can finish school. The TeleICU department has intentions to continue the work past the end of this project.

The QI project results will be disseminated during the bimonthly TeleICU nursing staff meeting. The project leader will create a power point presentation which will include the benefits of low Vt ventilation (physiological and patient outcome). The power point will also include the aims and results of the QI project. The lessons learned (education and engagement) during the implementation of the QI project will also be shared. The QI project results will also be presented to the chief executive officer, and chief medical officer of the TeleICU department. During both of this presentations, the project leader (due to the promising results) will encourage the TeleICU department to continue the QI project.

Conclusion

TeleICU is an innovative way in improving patient outcomes and hospital financial performance. TeleICU does this by looking at best practice protocols. One of this best practice protocols is the use of low Vt ventilation on mechanically ventilated patients. Low Vt ventilation has been shown to improve patient outcomes, but adherence is low. To improve adherence of low Vt ventilation, TeleICU can be utilized. This QI project was developed so that the TeleICU department can assist in improving the adherence of low Vt ventilation in mechanically ventilated patients. The QI project used a low Vt ventilator rounds checklist to assist the TeleICU team to identify and treat mechanically ventilated patients that are not being ventilated using the low Vt ventilation protocol. The ease of use of the checklist was also measured. After reviewing all the data, the QI project showed that the low Vt ventilator rounds checklist is useful, easy to use, and that the TeleICU nurses are open to using it in their daily work flow. The low Vt ventilator rounds checklist also correctly identified patients that were not in compliance to low Vt ventilation therefor ventilator settings were changed. The adherence to low Vt ventilation was calculated to be 58% during the QI project. Even though the benchmark of 90% was not reached, the QI project showed an increase.

Much was learned about the importance of training to use of the Low Vt Checklist, but the findings of this QI project is encouraging. By increasing the study length, making changes to the low Vt ventilator rounds checklist, and involving the bedside team, the use of TeleICU to increase adherence to low Vt ventilation protocol will show statistical significant improvement in patient outcomes and hospital financial performance.

APPENDIX A:

TELEICU NURSE-DIRECTED LOW TIDAL VOLUME VENTILATOR ROUNDS CHECKLIST

Today's Date: DAY or NIGHT shift (circle one)

Room #:

- Mode of Ventilation:
  STOP if patient is on PCV or APRV!

- Pre-calculated Low Vt ventilator setting:

  4 ml/kg PBW:
  6ml/kg PBW:
  8ml/kg PBW:

- Current Ventilator settings for Patients on AC or SIMV mode.

  FiO2:
  Tidal volume:
  PEEP:
  Rate:
  Minute ventilation:

- Is the tidal volume in the current ventilator settings with in the pre-calculated low Vt ventilation? **Yes**

- **NO**: notify teleICU intensivist – provide patients name, MR#, and ventilator settings.

- Did the teleintensivist change the ventilator setting to low Vt? Yes or No

Please RETURN to Charge Nurse at the end of the shift. Thank you!

APPENDIX B:

USABILITY EVALUATION SCALES

Technology Usefulness Scale

Please respond to the following statements where 1 indicates that you "Strongly Disagree" and 7 indicates that you "Strongly Agree"

Strongly Disagree 1	Disagree 2	Disagree Somewhat 3	Neither agree or disagree 4	Agree Somewhat 5	Agree 6	Strongly Agree 7
o	o	o	o	o	o	o

1. Using the TeleICU Low Vt Ventilator rounds checklist improves the quality of assessing patients on mechanical ventilation.
2. Using this TeleICU Low Vt Ventilator rounds checklist gives me greater control over assessing patients on mechanical ventilation.
3. This TeleICU Low Vt Ventilator rounds checklist enables me to assess patients on mechanical ventilation more quickly.
4. This TeleICU Low Vt Ventilator rounds checklist supports critical aspects of assessing patients on mechanical ventilation.
5. This TeleICU Low Vt Ventilator rounds checklist increases the efficiency of assessing patients on mechanical ventilation.
6. This TeleICU Low Vt Ventilator rounds checklist improves the task of assessing patients on mechanical ventilation.
7. This TeleICU Low Vt Ventilator rounds checklist allows me to accomplish more in-depth assessment of patients on mechanical ventilation than would otherwise be possible.
8. This TeleICU Low Vt Ventilator rounds checklist enhances my effectiveness of assessing patients on mechanical ventilation.
9. This TeleICU Low Vt Ventilator rounds checklist makes it easier to assess patients on mechanical ventilation.
10. Overall, I find this TeleICU Low Vt Ventilator rounds checklist useful in assessing patients on mechanical ventilation.

Appendix B - continued

The Ease of Use Scale

Please respond to the following statements where 1 indicates that you "Strongly Disagree" and 5 indicates that you "Strongly Agree"

Strongly Disagree 1	2	3	4	Strongly Agree 5
○	○	○	○	○

1. I think that I would like to use the TeleICU Low Vt Ventilator rounds checklist daily.
2. I found the TeleICU Low Vt Ventilator rounds checklist unnecessarily complex.
3. I thought the TeleICU Low Vt Ventilator rounds checklist was easy to use.
4. I think that I would need the support of a technical person to be able to use the TeleICU Low Vt Ventilator rounds checklist.
5. I found the various functions in the TeleICU Low Vt Ventilator rounds checklist were well integrated.
6. I thought there was too much inconsistency in the TeleICU Low Vt Ventilator rounds checklist.
7. I would imagine that most people would learn to use the TeleICU Low Vt Ventilator rounds checklist very quickly.
8. I found the TeleICU Low Vt Ventilator rounds checklist very cumbersome to use.
9. I felt very confident using the TeleICU Low Vt Ventilator rounds checklist.
10. I needed to learn a lot of things before I could get going with the TeleICU Low Vt Ventilator rounds checklist.

Attitude and Intention – Please circle one response for each statement.
Grade the successfulness of the TeleICU Low Vt Checklist as a tool for assessing patient ventilator settings and informing the teleICU Intensivists of the need to reconsider the current order for mechanical ventilation settings. Did it pass or fail?

Pass **Fail**

If the TeleICU Low Vt Checklist was a regular tool for assessing patient ventilator settings and informing TeleICU Intensivists would you use it?

Yes **No**

APPENDIX C:

CURVED GRADING SCALE INTERPRETATION OF THE EASE OF USE SCALE

SUS Score Range	Grade	Percentile Range
84.1–100	A+	96–100
80.8–84	A	90–95
78.9–80.7	A−	85–89
77.2–78.8	B+	80–84
74.1–77.1	B	70–79
72.6–74	B−	65–69
71.1–72.5	C+	60–64
65–71	C	41–59
62.7–64.9	C−	35–40
51.7–62.6	D	15–34
0–51.7	F	0–14

Note. Adapted from "Quantifying the User Experience," by J. Sauro, & J.R. Lewis, 2012, Waltham, MA: Morgan Kauffman.

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