2024

A PLAN-DO-STUDY-ACT TO DECREASE TIME SPENT ON BILEVEL POSITIVE AIRWAY PRESSURE

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A thesis submitted in partial fulfillment
of the requirements for the degree of

MASTER OF ARTS

to the faculty of the

DEPARTMENT OF PSYCHOLOGY

of

ST. JOHN'S COLLEGE OF LIBERAL ARTS AND SCIENCES

at

ST. JOHN'S UNIVERSITY
New York
by
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Date Submitted 9/11/2024 Date Approved 9/18/24

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ABSTRACT

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Bilevel Positive Airway Pressure (BiPAP) is a form of noninvasive ventilation (NIV) typically employed as a bridging treatment in hospital settings. Research shows that prolonged BIPAP use can be associated with reduced patient satisfaction and adverse consequences. The purpose of this study was to reduce days spent on BiPAP to improve the quality of patient care. To address the issue of the length of time (LOT) patients spend on BiPAP at New York Presbyterian-Queens (NYP-Q), a Plan-Do-Study-Act (PDSA) intervention was implemented. The intervention involved repeated PDSA cycles with modifications from 2015 to 2019. The results of the intervention indicated that interprofessional empowerment interventions led to a notable decline in LOT on BiPAP from an average of 5.5 days to the goal of 3.54 days. Achieving the goals of 3.5 days or less on BiPAP required 4 different PDSA cycles: education-based intervention, adoption and dissemination of guidelines as policy, consultation, and interprofessional empowerment. Future research should evaluate the sustainability of the implementation of these interventions.

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INTRODUCTION

Bilevel Positive Airway Pressure (BiPAP) is a noninvasive ventilation (NIV) technique that involves the use of a tight-fitting mask to deliver alternating high and low air pressures during the inhalation and exhalation phases of the breathing cycle (Sprowls et al., 2022). Research has found BiPAP to be an effective bridging treatment before intubation and extubation for patients with acute exacerbation of chronic obstructive pulmonary disease (COPD) (Osadnik et al., 2017), congestive heart failure (CHF) (Vital et al., 2013), and acute hypoxic respiratory failure, among other conditions (Xu et al., 2017). BiPAP can increase survival rates and functioning (Kotanen et al., 2022) and prevent the need for intubation (Ameen et al., 2013), palliating symptoms, and/or discharging the patient home (Chatwin et al., 2015). NIV is popular in the emergency department and intensive care unit, and it is often used for pediatric patients (Masip, 2007).

In 2015, the leadership, physicians, and staff of New York Presbyterian-Queens (NYP-Q) became concerned about potential patient harms associated with prolonged BiPAP use. NYPQ put in place a Mortality Review System and discovered that BIPAP harm included discomfort and increased mortality rates. Further investigation revealed that a large number of patients harmed did not fit one of the generally recognized medical criteria for acute use (CHF exacerbation, COPD exacerbation, or acute hypoxic respiratory failure). These harms included use not consistent with patient-centered care, pressure injuries, delayed recognition of clinical deterioration, and mortality. To address these concerns, a formal multidisciplinary team of pulmonologists, palliative care physicians, internists, and respiratory therapists employed a Plan-Do-Study-Act (PDSA)

intervention to decrease the length of time patients spent on BiPAP. At the time, NYPQ lacked the tools necessary to quickly collect and analyze hospital mortality data. So, during their PDSA intervention, they opted to track BIPAP days as a surrogate.

Prevalence of NIV/BiPAP Use

BiPAP is used for patients experiencing respiratory failure or other illnesses that may make it difficult for an individual to breathe on their own but do not fit requirements to be intubated yet as it is intended to be used acutely. These illnesses include COPD (Wilson et. al, 2020), chest wall deformities and obesity (Baker & Sovani, 2020), neuromuscular disorders like amyotrophic lateral sclerosis (ALS) (Carlucci et. al., 2023), and sleep apnea (Selim & Ramar, 2021) as well as many others. There are certain contraindications that would deem a patient unfit for BiPAP use like the inability to protect the lower airways, a weak cough, gastroesophageal reflux disease (GERD) and/or vomiting, lack of cooperation from the patient, and facial abnormalities that prevent the mask to be fitted to the face (Praud, 2020). It is important to understand how prevalent BiPAP use is across hospital settings in order to understand if the concerns of prolonged use is hospital specific or general among all hospital settings. In a retrospective study in the Helsinki University Hospital Area of Finland, the 3-year prevalence of NIV and long-term oxygen (LTOT) for chronic respiratory failure (CRF) was analyzed where a total of 815 patients were treated with NIV and/or LTOT (Kotanen et al., 2022). The prevalence of NIV was 35.4 per 100,000 (44.5%) and prevalence of LTOT was 24.6 per 100,000 (41%). 14.4% of patients underwent both treatments (Kotanen et al., 2022). The three-year mortality in all patients was 45.2% and treatment duration and survival vary greatly depending on the underlying diagnosis (Kotanen et al., 2022).

In a retrospective chart review spanning 2 years (2014-2016) within a single Korean hospital with 2,700 beds, 239 adult patients received BiPAP (Suh et al., 2016). The most common causes of BiPAP were acute respiratory failure, acute exacerbation of chronic respiratory failure, and neuromuscular disease. Mortality was 20.5% and the patients requiring home BiPAP at discharge were 25.1% (Suh et al., 2016). The overall weaning rate from BiPAP was 52.3% (Suh et al., 2016). The total duration on BiPAP and certain underlying conditions were significantly and negatively associated with successful BiPAP weaning (Suh et al., 2016). The weaning success group had a higher heart failure and a lower total duration of BiPAP compared to the weaning failure group. The total duration of BiPAP less than 5 days, chronic lung disease, and heart failure were independently associated with successfully weaning off of BiPAP.

BiPAP is often compared to other treatments like oxygen therapy or the use of Continuous Positive Airway Pressure (CPAP). Research supports the use of BiPAP over oxygen therapy with a High Flow Nasal Cannula (HFNC) (Nava et. al., 2013). Compared to HFNC, patients using BiPAP are more likely to discontinue treatment successfully and have a more rapid significant decrease in dyspnea (or difficult, labored breathing) (Nava et al., 2013). But because HFNC does not use the mask apparatus of BiPAP, it avoids creating facial pressure soreness that is a common complaint of BiPAP, which leads to a lower dropout rate of HFNC treatment. When compared to CPAP machines, the literature suggests CPAP is non-inferior to BiPAP (Ferrari et. al., 2010). They were found to have similar intubation rates as well as similar reductions in mortality rates and length of hospital stay. Studies also suggest BiPAP may be the more effective option between the two. Researchers found significant differences when it came to preterm infants with

Respiratory Distress syndrome (RDS) as BiPAP decreased the number of days spent on oxygen more than the CPAP machine (Pan et. al., 2021).

BiPAP use is well supported in the literature and across various studies NIV is significantly associated with a lower risk of mortality and shorter lengths of stays relative to invasive mechanical ventilations (IMV) (Chandra et al., 2012; Stefan et al., 2016; Taha et al., 2019). BiPAP is often chosen as a mode of intervention before intubation because of its advantages which lead providers to continuing using it acutely. It has been found that using forms of NIV like BiPAP were able to avoid usual complications found with invasive ventilation like airway problems (Patel et. al., 2021). Successful NIV use and low mortality rates has been found in high performing hospitals for COPD patients. Fisher et al. (2017) conducted interviews with 32 participants from 7 hospitals to understand the high success rates. Researchers found three interrelated domains that characterized effective NIV use: processes, structural elements & contextual factors. Respondents also stated that system-level approaches played a supporting role in successful NIV implementation. The themes identified compare to those of NYPQ's intervention. However, there is large variability across hospitals that suggests improper use that is inconsistent with BiPAP/NIV guidelines.

Inappropriate placement on BiPAP and/or delayed transition off BiPAP to intubation can impact patient outcomes and likelihood of mortality so it is important to understand the trends of how often BiPAP is used as a treatment because at times, it may be underutilized. For example, from a survey of respiratory therapists at VA Hospitals, they reported that 2/3rds of respondents stated NIV was used less than half the time it was clinically indicated (Bierer & Hoo, 2009). Because BiPAP is widely accepted as a

successful treatment compared to intubation in some cases, there is possible overuse of it as well. In two 10-year retrospective studies of over 11.5 million patients experiencing acute respiratory failure across all US hospitals, NIV failure (i.e., intubation or deterioration, death, etc.) was associated with significantly increased mortality (53%-61% greater risk) relative to immediate IMV (Chandra et al., 2012; Walkey et al., 2013). In these cases, BiPAP use was inappropriately used.

Adverse Consequences associated with BiPAP

Prolonged BiPAP use is associated with several adverse consequences including poor patient satisfaction, frequent early discontinuation by patients, facial pressure injuries, sepsis, and mortality (Abubacker et. al., 2021; Chu et al., 2004; Sprowls et. al., 2022; Wei et al., 2022). Across the literature, patients often report disliking BiPAP machines for various reasons. In a study using fixed and flexible BiPAP machines for 10 cancer patients undergoing radiation, patients reported feeling "restricted" and "uncomfortable" (Sprowls et. al., 2022).

As mentioned before, the constricting nature of the mask may result in facial pressure injuries. Although BiPAP is "noninvasive," the apparatus of the device itself is very confining and uncomfortable for patients who use it. In a meta-analysis of 12 NIV equipment studies and 2,689 patients, the prevalence of facial pressure injuries was 25% (Wei et al., 2022). In a cross-sectional study of 694 adult ICU patients across 30 hospitals in China, medical device related pressure injuries occurred for 13.1% of patients and of those, CPAP/BiPAP masks caused 25% of those injuries (Dang et al., 2022).

BiPAP use has also been associated with high readmission rates. High readmission rates and life-threatening events in some conditions in a study of 187

patients with COPD had 79.9% of patients readmitted, while 63.3% had another life-threatening event, and 49.1% patients had passed away. Those who survived spent a median of 12% of the subsequent year in hospital (Chu et al., 2004). In a retrospective study of 750 patients with COPD admitted to the hospital, the one-year mortality rate was 26.2% (García-Sanz et al., 2017).

Understanding the consequences that come with BiPAP failure is imperative because the decision to be removed from BiPAP is clinician dependent and BiPAP is most effective when used as a temporary, bridging treatment. Consequences of BiPAP failure include prolonged ICU stay, increased rates of ventilator associated pneumonia and septic complications, and increased ICU mortality as well as delayed intubation for patients who are failing BIPAP which is associated with harm (Im et. al., 2022). Children intubated after BiPAP failure have higher rates of complications during intubation which include desaturation, prolonged hypoxemia, and cardiac arrest (Im et. al., 2022). A study aimed at identifying those likely to fail BiPAP, hypothesized it could prevent the need for future invasive ventilation and other complications (Im et. al., 2022). They compared three machine learning models of predicting BiPAP failure: two logistic regression models and one deep learning model which resulted in the deep learning model yielding the best results for predicting BiPAP failure because of using readily available data from the EMR. The faster the data is acquired, the faster the model will be able to predict failure allowing for better judgment on the clinicians' end. Researchers found that within 6 hours of BiPAP initiation, the deep learning model predicted which patients were likely to fail BiPAP superior to all models, and identified nearly 80% of BiPAP failures, with a 50% false alarm rate (Im et. al., 2022). Clinical judgment dictates assignment to and

removal from BiPAP which emphasized the importance of efficiently predicting BiPAP failure. Since this judgment is a primary determinant, using a machine learning model to predict BiPAP failure is highly beneficial (Im et. al., 2022).

BiPAP & Anxiety

Anxiety is common when it comes to BiPAP use on both the patient and provider side. Some patients discontinue treatment due to mask intolerance and anxiety (Nava et al., 2013). For patients, anxiety may stem from having to be strapped into the apparatus of the BiPAP machine which is uncomfortable and can exacerbate dyspnea leading to increased distress (Nava et al., 2013). High failure rates, which has been seen to be up to 40%, can be attributed to patient discomfort as fear is highly reported when it comes to be placed on an NIV apparatus (Cammarota et. al., 2022). The mask prevents patients from easily communicating with their hospital care team (Wong et.al., 2020). The lack of communication creates anxiety because patients feel that they are unable to communicate effectively or at all what they are feeling which is a major risk when in the hospital. This anxiety was also found to be increased when they could see that their relatives saw them being misunderstood (Wong et. al., 2020). A study found that after the first initial NIV session, the intensity of dyspnea was associated with anxiety (Dangers et. al., 2018). The causal relationship between anxiety and dyspnea in both directions highlights a complex issue when it comes to using NIV because while the relief of anxiety can decrease the severity of dyspnea experienced, increased anxiety negatively affects the severity of dyspnea (Dangers et. al., 2018). Patients on NIV also experience anxiety when they have to be left alone and express the need to have bedside support (Schmidt et. al., 2016). Anxiety may be a factor that is overlooked by providers because it is expected that

patients feel anxious about using NIV but should be addressed because of its detrimental effect on failure rates. Anxiety in patients may increase as length of time on NIV increases, which ties into the larger problem of not using NIV acutely. Proper use of NIV, specifically taking patients off when symptoms ameliorate, can alleviate anxiety.

Providers have also been found to express anxiety and discomfort with administering NIV to their patients (Schmidt et. al., 2016). In a study assessing provider perceptions of NIV use, researchers found that some ICU doctors and nurses had negative perceptions of NIV (Schmidt et. al., 2016). Specifically, nurses reported feeling regretful when they administer NIV to their patients because the experience is traumatic and stressful for patients (Schmidt et. al., 2016). Additionally, providers expressed that their willingness to provide NIV for their patients was dependent on length of their shift as well as feeling that NIV is excessively time consuming (Schmidt et. al., 2016).

BiPAP Management

From the perspective of nurses, managing patients on BiPAP and other NIV machines raises concerns about their ability to manage their workload, as NIV use requires significant staff time, as successful NIV use is dependent on continuous monitoring (Yaman et. al., 2021). Because nurses work long 12-hour shifts caring for multitudes of people depending on the medical setting, anxiety can arise when they feel like they are unable to devote enough time to patients on NIV. They may also feel underprepared or lacking the competence to help patients who are on NIV. A study assessing NIV with a nursing perspective found that NIV increased the workload of nurses per patient within the first six hours (Yaman et. al, 2021). This is because with NIV, nurses are frequently called into patient rooms to assist with providing mask safety,

helping patients maintain the proper position for NIV, as well as preparation and assistance for other procedures (Yaman et. al., 2021). When the patient to nurse ratio is low, this is manageable but with increasing numbers of patients and problems with the limited number of nurses, this becomes difficult to balance (Cabrini et. al., 2015). A global study found that many medical sites report not using NIV at all because of the lack of resources available (Cabrini et. al., 2015).

Plan-Do-Study-Act

PDSA interventions offer a framework to test modifications that can improve system quality and create sustainable change in healthcare (Moen, 2009). The key features of PDSA-based quality improvement projects consist of iterative cycles, continuous data collection, small-scale testing, and explicit description of intervention activities (Knudsen et al., 2019). The PDSA cycle consists of four stages: Plan, Do, Study, and Act. In the 'plan' stage, a measurable and specific change aimed at improvement is identified. It is during the plan stage that takes up the most time and resources because it sets up the intervention and ultimately determines the success of the intervention (Hill et. al., 2020). General ideas become more specific and streamlined in order to narrow down what problems will be addressed and ultimately solved with the intervention. A multidisciplinary team can be formed because it is supported across the literature that engaging members from other disciplines is effective when implementing interventions within a healthcare setting (Saint-Pierre et. al., 2018). In the 'do' stage, the change is implemented (Taylor et. al., 2014). Aspects of the 'do' stage include initial data collection, piloting improvements and collecting follow up data (Hill et. al., 2020). It is imperative for initial data to be collected in order for comparisons to be made in future

cycle interventions to understand if there is a change being made from cycle to cycle as well as pre- and post-implementation. In the 'study' stage, the change's impact is examined using statistical methods of analyses (Taylor et al., 2014). Visualizing collected data allows for conclusions to be drawn as well as identifying any patterns and trends within the data which will shape future interventions in the next cycle (Hill et. al., 2020). Finally, in the 'act' stage, adaptations and next steps are identified to inform a new cycle (Taylor et al., 2014). Within the final stage of a PDSA is when future actions will be discussed and made for the next cycle. If initial interventions were successful, next steps may look into finding out how to expand into a larger scale as well as discussing sustainability of the interventions (Hill et al. 2020). Prior interventions may yield unsuccessful results leading to another modified cycle to be initiated with a new intervention which is continued until deemed successful.

Across the literature, PDSA interventions are applied in quality improvement projects because of their effectiveness within specific projects. Originally, PDSA was created as a way for quality control check within businesses but has now been integrated into healthcare settings as well as other areas (Moen, 2009). A meta-analysis looking at the effectiveness of continuous quality improvement within healthcare settings found PDSA to be more effective when improving clinical process outcomes compared to other models like Model of Improvement (MoI) (Hill et. al., 2020). MoI is another type of continuous quality improvement which was adapted from PDSA that uses PDSA cycles as the last step in the process. MoI also requires more time than a traditional PDSA.

A significant aspect of a successful PDSA intervention is when there is an explicit prediction in each cycle and specific tests of change which address previously stated

predictions (Leis & Shojania, 2017). Without clearly defining the problem in each step, there are gaps for initial goals to become lost due to the scope of the intervention becoming too large. When enacting PDSA cycles, it is important to keep targeted goals clear and concise throughout each step. Researchers found that using the acronym "SMART" which stands for specific, measurable, attainable, relevant, and time-bound during PDSA interventions allows for feasibility of an initiative to be built because it reiterates qualities that should be represented within a PDSA cycle (Chen et. al., 2021).

In a study done employing PDSA in a palliative care setting, a multidisciplinary team was able to decrease length of stay in order to combat bed overcapacity problems which support the employment of a PSDA intervention in a healthcare setting similarly to the present study (Alshammary et. al., 2021). A PDSA intervention at another facility showed a significant decrease in pressure ulcer incidence by changing mask characteristics, improving skin protection, increasing collaboration, and adding skin assessment every 4 hours (Acorda, 2015). The quality improvement initiative results are theorized to be a direct result of teamwork and collaboration of nursing and respiratory teams from this study because the management of the BiPAP patient is no longer the responsibility of one discipline but rather a family-centered, interdisciplinary approach to care.

PDSA Cycles

PDSA interventions help identify and implement changes to improve patient outcomes and quality of care through iterative cycles, data collection, and explicit interventions, leading to sustainable change in healthcare systems. To determine

appropriate PDSA phases for hospital-wide improvement, it is important to consider research on long-term, behavioral change approaches in healthcare.

Provider Education

Phase 1 of the present PDSA cycle included provider education on BiPAP use. Educational programs are often easy and low-cost to implement (Farrell et. al., 2001; Baile et. al., 1999). Some indicate they can lead to long-term, hospital-wide change, although others suggest the benefits are minimal, short-lived, and/or unsustainable (Kasper et. al., 2017; Wyer et al., 2015). In a study aimed at evaluating the efficacy of simulation-based skills training, results indicated that participants reported higher levels of confidence, perceived skill, and perceived knowledge after the training program (Clemens, 2022).

A study done by Naran et al. (2022) found that junior doctors felt inadequately prepared regarding the delivery of NIV. Using a pedagogical approach, researchers used peer-to-peer interactive stimulation and scenarios were created to practice proper NIV delivery. They found that after provider education, participants felt more confident in discussing the use of NIV to patients and their families, as well as the other healthcare professionals involved. Participants had also indicated that they felt more prepared to teach other healthcare providers about proper NIV care and management (Naran et. al., 2022). However, there is a gap in the literature specifically testing the effectiveness of provider education on initiation and BiPAP use in general.

Dissemination of Hospital Policy

Phase 2 of the PDSA consisted of creating and disseminating new hospital policies. Although some studies state hospital staff perceive a change in policy to be

helpful in increasing their knowledge, the sole effectiveness of disseminating hospital guidelines has not been explicitly tested in the literature (Issac et. al, 2022). However, there are key characteristics associated with successful changes.

Shields et. al (2015) found that implementing and adopting a new hospital protocol for maternal hemorrhaging within a system of hospitals with more than 60,000 annual births resulted in a significant decrease in the number of blood products needed per 1000 births. After integration of hospital protocol, there was an increase in overall protocol compliance which highlights that when readily available, guidelines and protocols are effectively utilized (Shields et. al., 2015).

In another policy-based intervention, formal dissemination articulation of policies and policy reminders led to significant reductions in potentially harmful resident and attending surgical communication breakdowns during inpatient care (Arriaga et al., 2011). This led to critical events not conveyed to an attending decreased from 33% to 2%, gaps in the frequency of attending notification of patient status on weekends were virtually eliminated, and the proportion of weekend patients not visited by an attending for greater than 24 hours significantly decreased by half (Arriaga et al., 2011). Reducing communication breakdowns between residents and doctors successfully increased communication and attending-led changes in patient management increased, reduced gaps in attending notification of patient status, and decreased avoidable surgical adverse events (Arriaga et al., 2011).

A public health study found that community readiness for change and effective implementation & design are often associated with the effectiveness or ineffectiveness of an intervention (Paltzer et al., 2013). In healthcare, provider-initiated and clearly

communicated changes are more likely to be successful and less likely to be resisted (Nilsen et al., 2020). The analysis yielded three categories concerning characteristics of successful changes: having the opportunity to influence the change, being prepared for the change, and valuing the change. The interviewees emphasized the importance of having the opportunity to influence the organizational changes that are implemented. Changes that were initiated by the professionals themselves were considered the easiest and were rarely resisted and changes that were clearly communicated to allow for preparation increased the chances for success (Nilsen et al., 2020). Overall professional involvement is associated with successful change; specifically, provider opportunity to influence the change, provider preparation for the change, and a provider's appraised value of the change. Both phase 1 and phase 2 of the intervention, the initial provider education and dissemination of policy, was a way for community preparedness to be established. Community preparedness is an important aspect because it allowed for providers to be aware and ready for the change that was meant to happen with implementation.

Consultation

Phase 3 of the PDSA consisted of consultation which is a more time-intensive procedure involving direct intervention by a specialized professional; in the literature, it has been shown to improve patient outcomes (Nelson et al., 2011). Research suggests palliative care consultation can decrease readmission rates, improve patient symptoms (i.e., pain, dyspnea, etc.), reduce the length of hospitalization, and decrease mortality rates (Isenberg et al., 2017; Nelson et al., 2011). In the study done by Nelson et al. (2011), results showed that the readmission probability to the hospital per patient per six

months after consultation dropped from 73% to 33%. Researchers concluded in Isenberg et al. (2017) that cancer patients should be directed to specialized interdisciplinary palliative care as opposed to receiving only treatment from their oncologists. Palliative care prevents avoidable healthcare utilization, reduces the length of hospitalizations, and decreases readmission and mortality rates. Findings from Hossri et al. (2022) demonstrate that involving a pulmonologist in the management of a patient with AECOPD dramatically improves patient outcomes, particularly the readmission rate. This is evident, even when there was a bias to consult pulmonologists for more severe exacerbations. Abbas et al. (2021) provides a different perspective. The addition of a pulmonary consult did not have additive improvement; however, only those with poorer baseline conditions received the consult. Nevertheless, what the study does demonstrate is that early disease treatment and exacerbation avoidance may be improved by pulmonary intervention.

Interprofessional Provider Empowerment

Phase 4 of the PDSA consisted of interprofessional provider empowerment which has been associated with improved clinical outcomes in the literature (Sibbald et. al., 2022). Respiratory therapists play a vital role in treating BiPAP patients, as they routinely assess the readiness of extubation, communicate pain or ventilator asynchrony to nurses, enable early mobilization, and educate families while patients receive respiratory support (Mart et. al., 2019).

In previous studies that included interprofessional empowerment of respiratory therapists as part of an intervention, quality of care improved (Gupta et. al., 2014). One study by Cherian et al. (2022) found that an interprofessional COPD care bundle

significantly reduced 60-day readmission rate and 90-day all-cause readmissions. In a team-based model called Best Care COPD (BCC), providers worked closely with the patient's care team and found that empowering providers enhanced the quality of care (Sibbald et. al, 2022). Their model included three phases: pre-implementation, implementation, and spread and sustainability (post implementation) and the success of each implementation stage were dependent on mechanisms the researchers categorized as foundational, transformative, and enabling. Respiratory therapists had increased responsibility within the leadership team as they were available throughout all steps of implementation and recruited patients they felt would benefit from the program (Sibbald et. al, 2022). Providers felt more confident because the model "facilitated peer-to-peer learning" and stated they "appreciated the proactive approach to patient recruitment as opposed to waiting for referrals" (Sibbald et. al, 2022). Although respiratory therapists were utilized in a different capacity in this study, empowering respiratory therapists can improve a program. A limitation to the study is there was not an outcome variable measuring the program's success which is addressed by this study by isolating just respiratory provider empowerment as the only intervention and measuring resulting outcomes (length of time spent on BiPAP) which significantly decreased.

There is an absence of studies specifically focused on empowering respiratory therapists specifically by increasing their involvement and responsibility for patient care. But one study did find support for empowering nurses that worked with using NIV for treatment of AECOPD (Farmer et. al., 2022). Before nurse empowerment and education, nurses stated feeling underprepared for caring for these sick patients as well as a concern for patient safety when placing them on NIV equipment and only 13% of nurses reported

their NIV training being adequate. Results indicated four main themes expressed by participants. These themes included needing a multi-system approach to patient assessment when determining candidacy for NIV, benefiting from real-time clinical support, team communication, and multiple opportunities for education and training about NIV. Overall, the study is important because it addresses the sentiment that healthcare providers feel underprepared when it comes to handling patients that need NIV which can be helped through interprofessional collaboration.

The current study aims to decrease the length of time patients spend on BiPAP by testing the effectiveness of different interventions of the PDSA employed.

METHODS

Participants

Participants included 5,497 BiPAP patients across 5,475 hospital visits from the end of 2014 to 2019 during a 51-month period from 2015 to 2019. Common reasons for BIPAP use included COPD exacerbation, CHF exacerbation, and acute hypoxic respiratory failure.

Phases

The key features of our PDSA were iterative cycles, prediction-based test of change, use of data over time, and documentation.

Baseline data was collected across 30 months. PDSA cycle 1 lasted seven months and included physician education on appropriate and inappropriate BiPAP use. Cycle 2 spanned three months which was spent on the formal dissemination and adoption of the NIV guidelines as hospital policy. Cycle 3 spanned four months and focused on encouraging physicians to use pulmonary and/or palliative care consultations prior to starting BiPAP use. Cycle 4 spanned four months and implemented a stewardship model of interprofessional empowerment. This increased respiratory therapist responsibility for patient management, as they were empowered to ask questions or raise concerns about the appropriateness of BiPAP for the patient's clinical needs and the length of BiPAP use. If concerns of the respiratory therapist could not be adequately addressed by the ordering provider, the therapist could escalate their concerns to pulmonary clinical leadership. As mentioned, prior, the acronym "SMART" which stands for specific, measurable, attainable, relevant, and time-bound can be applied to the phases included in this intervention.

The initial aim is specific because it targets patients on BiPAP, and their LOT spent on it. The effects of the intervention were made to be measurable by tracking the number of days patients were on BiPAP in order to determine if there was a decrease because of the employed intervention. The scope of this study was attainable because the goals set had the ability to be reached with the available means to do so. This intervention was relevant and time-bound because of the increased concern for potential harm to patients that is associated with prolonged BiPAP use. Mixed models ANOVA (SAS Institute 9.4) were conducted to evaluate differences in length of time on BIPAP during a baseline period and across the four phases.

RESULTS

Demographic data was collected in order to have a better understanding of the type of patients who were on BiPAP during the time of the study. Overall, patient gender is almost evenly split as 50.59% of patients are male and 49.41% are female. The age of patients ranged from 0 to 104. But the majority of patients were children in the age range of 1 to 10 years of age or older adults in the range of 46 to 97. 37.13% of patients are White, 14.67% of patients are Black/African American, 20.37% are Asian, and 25.51% identified as other not included in the identified categories. 21.05% of patients identified as an ethnicity that is Hispanic or Latino The race of the remainder of patients was not specified. A majority of patients spoke English (61.98%) but a significant portion of patients did not (38.02%). When discharged, a majority of patients were discharged home/self-care (41.29%), to home health services within 3 days of discharge (31.99%), or to a skilled nursing facility (13.79%). There were 37 different diagnoses that patients on BiPAP had. The four most prevalent diagnoses are hypertensive heart disease with heart failure (27.44%), hypertensive heart disease with heart failure and stage 1-4 unspecified chronic kidney disease (19.52%), COPD with acute exacerbation (15.49%), and unspecified asthma with acute exacerbation (13.39%). We were also able to determine the most prevalent diagnoses according to race. The most prevalent diagnosis for the White and Black/African American population is hypertensive heart disease with heart failure. For patients who identified as Hispanic or Latino, unspecified asthma with acute exacerbation was the most prevalent diagnosis. For the Asian population of patients, hypertensive heart disease with heart failure and stage 1-4 unspecified chronic kidney disease was the most prevalent diagnosis.

Before PDSA cycle interventions were employed, data could be obtained on 3,192 patients on BiPAP during the baseline period which lasted from 2015 to 2019, over a period of 51 months. During the first phase, there were 892 patients on BiPAP. During the second cycle, there were 365 patients on BiPAP. During the third cycle, there were 573 patients on BiPAP and during the final phase there were 475 patients on BiPAP.

Mixed models ANOVA (SAS Institute 9.4) were conducted to evaluate differences in length of time across phases. Least squared means for each phase were as follows (Baseline: 5.50; Phase 1 = 5.33; Phase 2 = 4.82; Phase 3: 4.43; Phase 4: 3.54). Results yielded from chi-square indicated that the mean days spent on BiPAP was significantly different between the baseline and phase 4 (interprofessional empowerment) (estimate= -1.9622, SE = 0.3002, t = -6.54, $p<.001$). Phase 1 (education) was also significantly less effective than Phase 4 (interprofessional empowerment) (estimate = 1.7945, SE = 0.3454, t = 5.20, $p<.001$).

Discussion

In this study, we employed a PDSA cycle to evaluate interventions to reduce patients' length of time spent on BIPAP. Over a 51-month period of time, we compared 4 interventions given in sequence: provider education, dissemination of hospital policy, consultation, and interprofessional empowerment.

We found education alone was significantly less effective than interprofessional empowerment. Our study findings are consistent with studies which have found limited effects for education alone. A study done by Frank et al. (2020) found that although evidence-based practice training improved short-term provider satisfaction, it did not increase treatment adoption compared to self-study or no training at all. Similar to our

interventions, this study found that education was only successful when combined with other forms of interventions. They found that education was able to increase knowledge but not successfully increase utilization of learned practices which could be why our PDSA cycle for education did not yield significant results. Our results are not consistent with studies that have found significant effects for education as an intervention. In a study aimed at implementing an education program to reduce opioid prescriptions for pediatric patients found that provider education was able to sustain reduction of prescriptions post intervention (Slater et. al., 2022). Researchers also found that due to a reduction in opioid prescriptions, there was a reduction in readmissions and emergency department visits (Slater et. al., 2022). For patients who did receive opioid prescriptions, there was a significant decrease in the number of doses prescribed (Slater et. al., 2022). Through their education intervention, they were able to determine that pain management without opioids was feasible. Education was also given recurrently which could be why they yielded such significant results for education alone as an intervention. In our study, if provider education was implemented recurrently, it may have been able to produce better results in decreasing the length of time.

We found dissemination of hospital policy alone did not have a significant effect on the length of time patients spent on BiPAP. In general, there is a lack of studies specifically aimed at determining the effectiveness of disseminating hospital policy. But overall, our findings are inconsistent to studies done assessing the relationship dissemination of policy and hospital outcomes. A study aimed at assessing the use of a smartphone app as a way to disseminate information to healthcare workers during COVID-19 found that the app was able to successfully disseminate information quickly

and simply (Helou et. al., 2022). In this study, the utilization of an app made it possible for hospital policy to be accessed quickly as healthcare workers spent on average about 80 seconds per session (Helou et. al., 2022). The success of this policy intervention is based on the app being user friendly as well as healthcare workers having faith in the information being disseminated to them (Helou et. al., 2022). If our intervention had used a medium such as a phone app, the dissemination of hospital policy may have had a stronger impact on being able to decrease the length of time patients spent on BiPAP.

We found consultation alone to not have a significant effect on the length of time patients spent on BiPAP. Within the literature, there are mixed results of the effect of consultation on patient outcomes as an intervention. Our results are consistent with studies that have found consultation alone to not have a significant effect on patient outcomes as our intervention did not significantly affect the length of time patients spent on BiPAP. A systematic review aimed at evaluating the effectiveness of palliative care consultations for patients with COPD, concluded that the results were mixed and inconclusive (Broese et. al., 2021). Researchers found that the acceptability of the intervention was high but there were barriers that may have prevented the intervention from being significantly effective (Broese et. al., 2021). These barriers included the timing of referral and time availability of the providers themselves which could have been this case with our intervention (Broese et. al., 2021). Timing as a barrier could explain why consultation was not significantly effective because it is hard to predict when a provider may be available because of the number of patients they may have in their caseload. Our results are also inconsistent with literature that has found consultation to have positive effects on patient outcomes. A systematic review done assessing the

impact of palliative care consultation found that it did have a positive effect on patient outcomes (Janberidze et. al., 2021). They found that palliative care consultations were able to reduce the intensity of pain in patients as well as increased patient satisfaction (Janberidze et. al., 2021). A barrier they found was a lack of referral to the services which our intervention addressed because providers were encouraged to seek pulmonary and palliative care consults before starting a patient on BiPAP.

We found that from baseline to the final intervention cycle, phase 4 of interprofessional empowerment had the most significant reduction of time compared to the other cycles. This is consistent with the literature as there is a vast amount of support for interprofessional empowerment as a way for improving clinical outcomes. As mentioned previously, provider education is important when it comes to the successful use of BiPAP but without interprofessional provider empowerment, education alone has been found to be effective but with limited effects. Educational programs have benefits that when coupled with interprofessionalism can provide better hospital wide outcomes. A study found that healthcare providers felt optimistic that interprofessional education would be able to successfully improve the process of translating evidence into practice (Rak et. al., 2021). This further reiterates the importance of interprofessional care as an effective strategy because providers are able to rely on each other and bring together various perspectives on the decisions made for the treatment of patients. This may also be able to combat negative effects of implementing BiPAP. The psychological safety of those managing NIV must be taken into consideration. Nurses have been found to express regrets when managing patients on NIV because of distressing it is for their patients which causes their own distress (Schmidt et. al., 2016). Nurses may feel immense

pressure when having to balance taking care of patients on NIV because of how time consuming it can be, possibly taking away from other patients when there are not enough nurses available on a unit (Cabrini et. al., 2015). Because of these concerns, future research should be done in order to understand the full effects that come with administering BiPAP from the provider side. Healthcare providers may not be able to perform to the best of their abilities when dealing with such conflicting thoughts about NIV. Interprofessional provider empowerment may have been able to decrease the length of time patients spent on BiPAP because respiratory therapists were encouraged to incorporate providers from different disciplines when it came to BiPAP placement and management further solidifying the need for interprofessionalism within healthcare.

Limitations

A PDSA design was employed for this study. A limitation to this study is that it is unclear if the effectiveness of the PDSA intervention was cumulative or due to a single cycle. Future research should take this into consideration as it would be beneficial to understand if all cycles are needed for a successful intervention. It would also be important to determine if interprofessional empowerment is a successful intervention on its own. As mentioned previously, the key features of PDSA's are iterative cycles, prediction-based test of change, small-scale testing, use of data over time, and documentation (Taylor et al., 2014). This study employs iterative cycles, prediction-based tests of change, use of data over time, and documentation. It did not include small-scale testing because NYPQ's current treatment of BiPAP was shown to have adverse consequences. The current literature suggested that change was needed and could improve patient outcomes; so, all patients were given the intervention cycles if on

BiPAP. Another limitation despite increased use of quality improvement methods, the evidence base for their effectiveness is poor and under-theorized (Taylor et. al., 2014). PDSA interventions within healthcare systems may be too specific and are at risk for biases, limiting the generalizability of interventions to other healthcare sites (Hill et. al., 2020). PDSA interventions are highly individualized and although there is support within the literature for its effectiveness on clinical process outcomes, there are not enough significant results on its effectiveness on patient outcomes (Hill et. al. 2020). Taylor et al. (2014) conducted a systematic review which revealed significant variability in PDSA quality in healthcare. The key features of PDSA's included were iterative cycles, prediction-based test of change, small-scale testing, use of data over time, and documentation but less than 3% of the articles showed criteria compliance across all five key features. Only 64% detailed their cycles and less than 20% of studies document a sequence of iterative cycles. Only 15% reported quantitative data at monthly or more frequent intervals (Taylor et. al., 2014). Future research should be done examining PSDA's role on patient outcomes specifically in order to determine its effectiveness. This could help form official standards for rating the implementation or reporting of PDSA cycles because there are currently none. Another limitation of the present study is that there is no follow up study. It would be beneficial to evaluate if previous interventions were sustained and continued to be effective from the initial implementation.

Conclusion

Inappropriate or prolonged BiPAP use has hospital-wide consequences. Interprofessional empowerment of respiratory therapists resulted in a significant reduction in days spent on BiPAP compared to no intervention or education alone. These

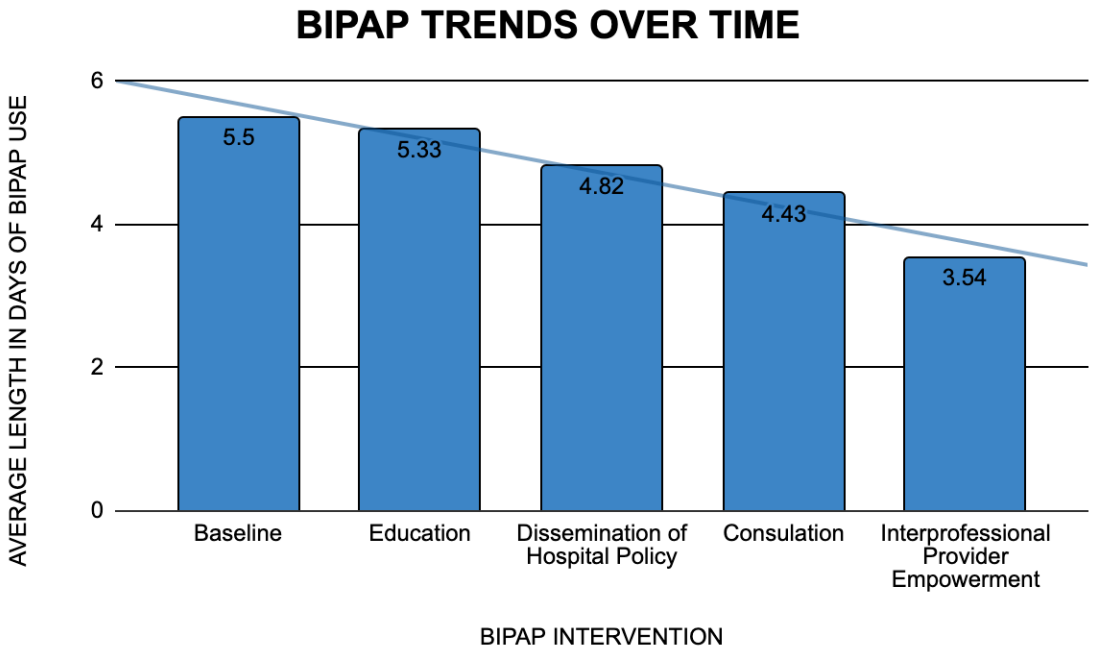
findings highlight that interprofessional empowerment can improve clinical outcomes and create sustainable change. The implications are that this may be useful at other hospitals that also have difficulties using BIPAP effectively but PDSAs are highly individualized which may limit generalizability to other sites.

Table 1
Least Squares Means

Effect	pdsanum	Estimate	Error	DF	t Value	Pr > |t|	Alpha	Lower
psdanum	1	5.3346	0.2042	5334	26.13	<.0001	0.05	4.9343
psdanum	2	4.822	0.318	5434	15.16	<.0001	0.05	4.1986
psdanum	3	4.4292	0.2551	5314	17.36	<.0001	0.05	3.9292
psdanum	4	3.5401	0.2801	5349	12.64	<.0001	0.05	2.9911

Figure 1

BiPAP trends over time



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