9-13-2023

Implementation of Endotracheal Tube Cuff Manometry in the Operating Room: A Quality Improvement Project

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Date of Submission: November 29, 2022

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Abstract

Background and Review of Literature: Endotracheal tube cuff pressure should be maintained between 20 to 30 cmH2O to prevent adverse airway outcomes. Standardized practice is not endorsed by any major anesthesia organization nor by Washington University School of Medicine's Department of Anesthesia. The common practice of manual palpation is unreliable. Use of a manometer is effective to measure and achieve appropriate cuff pressure.

Purpose: Implement a quality improvement project to increase the proportion of anesthesia providers using syringe manometers.

Methods: The facility's EHR was used to obtain data reports on AG Cuffill syringe manometer use and documentation at specific time points. The independent variable was staff educational in-services; the dependent variable was the proportion of documented ETT cuff pressures in the EHR.

Implementation Plan/Procedure: This quality improvement project consisted of pre-intervention, implementation, and post-intervention phases. Educational in-services were provided two days a week for two weeks at the start of the intervention phase. The in-services aimed to improve provider knowledge and familiarity with syringe manometer use as well as appropriate documentation.

Implications/Conclusion: Educational in-services increased the proportion of providers who used and documented syringe cuff manometry. Improved provider adherence may eventually lead to implementation of an established departmental practice for all anesthetics delivered with a cuffed ETT to improve patient outcomes.

Keywords: Endotracheal Tube, Endotracheal Tube Cuff, Endotracheal Tube Cuff Pressure, Endotracheal Tube Manometer, Endotracheal Tube Cuff Manometer

Implementation of Endotracheal Tube Cuff Manometry in the Operating Room: A Quality Improvement Project

Patients undergoing general anesthesia with an endotracheal tube at Barnes Jewish Hospital do not routinely have their endotracheal tube cuff pressures measured or recorded. There is a lack of departmental policy regarding appropriate inflation technique, however, common practice is to use manual palpation of the pilot balloon with fixed volume inflation which is unreliable in achieving appropriate cuff pressure. Inflation of endotracheal tube cuffs to a pressure range of 20 to 30 cmH2O is critical to prevent airway complications and improve patient outcomes and experiences. Given the lack of standardized procedure and the importance of this metric, a quality improvement project aimed at addressing this identified gap was indicated to educate anesthesia providers on evidence-based practice and documentation thereof.

Background

Endotracheal intubation is necessary when providing general anesthesia to surgical patients, as it provides ventilatory support and airway protection intraoperatively. Endotracheal tubes (ETTs) are plastic medical devices that are placed in the trachea by an anesthesia professional. Once in place, they act as a conduit for gas exchange and positive pressure ventilation. The medical intervention in question poses potential threats to the patient. ETTs contain high-volume, low-pressure cuffs which, once inflated, secure the tube in the patient's airway distal to the vocal cords (Kumar et al., 2021). When endotracheal tube cuffs are inflated properly, they prevent aspiration of gastric contents and oral secretions as well as allow for positive pressure mechanical ventilation (Ahmed & Boyer, 2021).

Unfortunately, ETT cuffs are not always inflated to the appropriate pressure range, resulting in adverse outcomes. When underinflated, oral and gastric secretions can be aspirated into the lungs, leading to potential pneumonia and tissue damage, both of which increase patient morbidity and mortality. Overinflation can lead to hoarseness or sore throat as well as tracheal ischemia, stenosis, ulceration, and rupture (Kumar et al., 2021).

Cuff manometry provides a quantitative way for clinicians to quickly assess these pressures and intervene accordingly (Kumar et al., 2021). Currently, standardized practices regarding ETT cuff inflation and/or monitoring do not exist. The most common practice is fixed volume syringe inflation and manual pilot balloon palpation; however, this is not supported according to a review of literature.

Problem Statement

Despite recommendations for use of manometry when placing laryngeal mask airways, there is a lack of guidance at any level when placing ETTs (Kumar et al., 2021; Turner et al., 2020; Seet et al., 2010). Assessing for adequate cuff pressure is paramount in ensuring positive outcomes for intraoperative patients. Given the established risks of improper inflation of endotracheal tube cuffs discussed above, it is important to work towards improving the proportion of ETT cuff pressures measured to the appropriate pressure range with the use of a quantitative tool such as a manometer.

Purpose, Aims & Objectives

Currently, the Washington University School of Medicine (WUSM) Department of Anesthesia does not have a standard practice for ETT cuff measurement or inflation implemented at Barnes Jewish Hospital. Although there is research to support multimodal approaches to reduce the incidence of postoperative sore throat and hoarseness, the full extent of the problem at Barnes Jewish Hospital (BJH) is unknown at this time; ETT cuff pressures are not routinely measured on surgical patients undergoing general anesthesia with an endotracheal tube at this academic facility. Currently, there are manometry syringes present in Pod 5 operating rooms (ORs) at the institution. ORs are separated by surgical specialty at BJH into “pods”; Pod 5 specialties include neurosurgery, ortho-spine surgery, ear/nose/throat (ENT) surgery, hepatobiliary surgery, vascular surgery, transplant surgery, and general surgery. Current practices may vary between clinicians, but fixed volume inflation with manual palpation is common yet has been proven to be unreliable in achieving appropriate ETT cuff pressure.

The goal of this quality improvement project was to increase the proportion of ETT cuff measurement and documentation with the use of syringe manometers in Pod 5. Educational in-services regarding the use of syringe manometers and appropriate documentation were conducted to improve staff knowledge and adherence to replace current standard practice of manual palpation and fixed volume inflation. Success was analyzed by review of documented ETT cuff pressures in the electronic health record (EHR). It is expected that an increase in manometry use by Pod 5 anesthesia providers was observed as demonstrated by documentation of ETT cuff pressures in the EHR , and therefore, patient outcomes will also be improved.

PICOT Question

In anesthesia healthcare professionals working in Pod 5 at Barnes Jewish Hospital (P), does providing an educational in-service about the use and documentation of an ETT cuff syringe manometry (I) result in a greater proportion of documented ETT cuffs pressures within the appropriate pressure range of 20 to 30 cmH2O (O) when compared to the current pre-educational intervention practice of fixed volume inflation with manual pilot balloon palpation (C) over a two-month period (T)?

Significance

Improper inflation of ETT cuffs leads to adverse patient outcomes. The current practice has not been shown to reliably produce appropriate cuff pressures, with between 50 to 80 percent of ETT cuff pressures measured outside the acceptable range of 20 to 30 cmH2O (Holyszko et al., 2021; Turner et al., 2020). Although underinflation can lead to pneumonia from aspiration, this complication is thought to be most relevant in the Intensive Care Unit and with longer-duration use of cuffed ETTs (Sole et al., 2012; Turner et al., 2020). Aspiration of gastric contents accounted for five percent of anesthetic complications from 2000-2009; although acute intra-abdominal processes independent of ETT cuff inflation were present in a majority of those cases (Warner et al., 2021). Duration of ETT placement strongly correlates to the potential adverse events of overinflation. In just 15 minutes, capillary perfusion impairment can lead to significant harm such as tracheal lesions, granulomas, and life-threatening tracheal stenosis (Turner et al., 2020). Beyond the risk for serious

harm, patient discomfort due to sore throat following ETT use is closely linked to high cuff pressures (Turner et al., 2020). This is one of the most common anesthetic complications as two in five patients will complain of sore throat after ETT placement (Royal College of Anesthetists, 2020). The use of manometers to maintain ETT cuff pressures in the proper range have been shown to reduce postprocedural airway complications even in short procedures (Liu et al., 2010).

Unfortunately, the total societal cost of improperly inflated ETT cuffs is difficult to quantify. Adverse outcomes such as tracheal stenosis can occur decades after application of an improperly inflated ETT (Dikkers, 2001). Due to the longitudinal nature of serious adverse effects, a lack of standardized practice and the minimization of less serious adverse effects, there exists a deficit in concrete data linking adverse outcomes to specify the societal burden. Despite the absence of quantifiable costs, even short-term improper ETT cuff inflation intraoperatively places patients at significant risk for harm.

Adverse outcomes from improper ETT inflation are preventable and place stress on the patient, healthcare organizations, and system as a whole. Elongated hospital stays and readmissions are costly. Beyond these seemingly larger complications, patients can be negatively impacted by milder symptoms such as hoarseness and sore throat for months after undergoing general anesthesia with endotracheal intubation. These complaints likely affect patient satisfaction regarding anesthetic experiences and quality of life if left unaddressed. Use of manometer syringes is a plausible means for anesthetists to maintain ETT cuff pressures in the admissible range.

Review of the Literature

Search Strategies

PubMed, Cumulative Index to Nursing & Allied Health Literature (CINAHL), and Google Scholar were the journal databases used. A search using MeSH terms with subheadings adverse effects, complications, and education was performed, in which only 11 of 77 articles were selected. An additional 4 articles were found on PubMed's database without using MeSH terms. Similar search terms were used on CINAHL and Google

Scholar, yielding another 11 studies of literature. A review of gray literature, including the National Institute of Health, Centers for Disease Control and Prevention, and World Health Organization, was also performed but none of the clinical trials about ETT cuff pressures were published, so these pieces were not included. Ultimately, the review of literature did lead to a recognition of the following themes: appropriate ETT cuff pressure, its clinical impact, and the use of manometry to measure ETT cuff pressure.

Appropriate ETT Cuff Pressure Range and Clinical Impact

Despite the lack of evidence-based practice guideline or best practice statement from either the American Society of Anesthesiology (ASA) or American Association of Nurse Anesthetists (AANA), the review of literature revealed a commonality in the agreed upon pressure range of 20 to 30 cmH2O for ETT cuffs. Of the 10 articles reviewed, all 10 articles utilized this figure in some form whether it being the goal inflation pressure range when evaluating ETT cuff inflation techniques or as a control variable when exploring additional factors for postoperative airway complication.

Five articles investigated postoperative airway complications following placement of an ETT defined as postoperative sore throat or hoarseness. An observational study by Levin et al. (2017) performed a multifactorial analysis of postoperative airway complications and found placement of a nasogastric tube, $p = 0.014$, and age, $p = 0.003$, to be the only statistically significant predictors for postoperative airway complications. Because the study by Levin et al. (2017) was observational in nature and examined several covariates rather than an experimental design with rigorous controls, the effect of ETT cuff pressure on postoperative airway complications cannot be ruled out. Christiansen et al. (2021) and Jaensson et al. (2010) both utilized randomized control trials to investigate the impact of ETT size on postoperative airway complications and found smaller ETTs to have a statistically significant lower incidence of postoperative airway complications, $p = 0.01$ and $p = 0.02$ per study, respectively, while controlling for ETT cuff pressure. Christiansen et al. (2021) utilized a manometer to set and adjust ETT cuff pressure between 20 and 30 cmH2O.

Conversely, a randomized controlled trial by Ganason et al. (2019) found maintaining ETT cuff pressures at 25 cmH2O resulted in a statistically significant reduction in postoperative airway complications: sore throat, $p < 0.001$, hoarseness, $p = 0.004$, and cough, $p = 0.002$. Similar findings resulted from a randomized controlled trial by Liu et al. (2010) wherein the experimental group had ETT cuff pressures adjusted intraoperatively to remain within the 20 to 30 cmH2O range and reported significantly lower rates of postoperative airway complications, $p < 0.001$. Lastly, a prospective randomized controlled trial by Park et al. (2018) investigated the impact on ETT cuff pressure changes on postoperative airway complications. Although Park et al. (2018) did not find a statistically significant difference between the control and intervention groups for postoperative airway complication, it is important to note that in their methodology, ETT cuff pressures were set to 30 cmH2O at the beginning of the case and intraoperative monitoring revealed that ETT cuff pressures never increased above 30 cmH20 for both the control and intervention group, which adjusted ETT cuff pressures. This review of literature demonstrates that ETT cuff pressures should be maintained within the range of 20 to 30 cmH2O and the failure to do so may increase a patient's risk for postoperative airway complications.

Use of Manometry to Manage ETT Cuff Pressure

Whereas the articles discussed above investigated the role of ETT cuff pressure on postoperative airway complications, the remaining articles examined the ideal method of measuring and maintaining the ETT cuff within the stated pressure range of 20 to 30 cmH2O. The findings from a study by Sole et al., (2011) indicated that continual cuff pressure monitoring is effective in maintaining ETT cuffs within the proper range, $p < 0.001$. Similarly, Athiraman et al., (2015) utilized manometers to measure intraoperative ETT cuff pressures and found significant changes in ETT cuff pressure outside the acceptable range during the intraoperative period, $p < 0.001$. The detection of ETT cuff pressures outside the acceptable range via manometer use highlights the importance of this assessment technique. Laksono et al. (2021) conducted a randomized control trial, and although there were issues related to the quality of the study, a key takeaway is that manual palpation is an

unreliable means of inflating and maintaining ETT cuff pressures within the appropriate pressure range, $p = 0.000$. Ganason et al. (2019) performed a randomized control trial comparing manometer use versus manual palpation and found manometer use to be significantly better at reducing postoperative airway complications by allowing for the ETT cuff pressure to be set to 25 cmH2O, $p < 0.001$.

Similar support for manometer use in ETT cuff inflation and management was found by Unsal et al. (2018) in a prospective controlled study with significantly lower levels of postoperative sore throat, $p < 0.001$ at multiple time intervals being reported. Liu et al. (2010) utilized a randomized control trial wherein manual palpation was found to have a mean ETT cuff pressure of almost 60 cmH2O requiring adjustment via manometer to reach the target pressure range, $p < 0.001$. Another study employed by Christiansen et al. (2021) evaluated the use of manometry and controlled for ETT cuff pressure to investigate the role of ETT size on postoperative airway complication as discussed above. It is apparent that not only is the current common practice of manual palpation unreliable, but that use of a manometer is the most reliable and feasible means of ensuring proper ETT cuff inflation.

System Needs

Currently there is no department policy regarding ETT cuff pressure manometry. A lack of departmental policy and staff education has led to inconsistent and infrequent use of manometry for cuff pressure management, regardless of manometer availability. Without manometry, unreliable qualitative assessment methods are used which put patients at risk for airway complications during the peri-operative period due to improper ETT cuff inflation. Educating anesthesia providers and encouraging their use of manometers should increase adherence to best practices. Increased provider adherence may lead to a change in department culture and ultimately lead to development of a formalized department policy regarding ETT cuff pressure manometry.

Evidence for This DNP Project

Placement of an ETT is a common intervention during the maintenance of safe anesthesia. Despite the risk of adverse patient outcomes associated with over and underinflation of ETT cuffs, they are often inflated

outside the proper pressure range of 20 to 30 cmH2O more than 50 percent of the time (Sole et al., 2011). Overinflation of ETT cuffs is most likely to occur during the short-term intraoperative application of ETTs and is strongly associated with negative patient experiences such as pain, sore throat, and hoarseness (Christiansen et al., 2021; Ganason et al., 2019; Jaensson et al., 2010; Levin et al., 2017; Liu et al., 2010). Although there are a lack of standardized practice guidelines, fixed volume inflation with manual palpation is a commonly practiced technique clinically; however, it has not been shown to reliably achieve proper pressure ranges of ETT cuffs (Laksono et al., 2021; Liu et al., 2010; Sole et al., 2011; Unsal et al., 2018). Despite there being further research investigating how to address the issue of cuff pressures and its relation to postoperative sore throat and hoarseness, it is important to consider the recurring theme of controlling for ETT cuff inflation pressure as a key control utilized in these studies (Christiansen et al., 2021; Jaensson et al., 2010).

Manometry is supported as a means of ETT cuff pressure assessment by a variety of clinicians and studies (Athiraman et al., 2015; Ganason et al., 2020; Laksono et al., 2021; Liu et al., 2010; Unsal et al., 2018). After a quantitative measurement of pressure is achieved, anesthesia clinicians can correct the pressure by adding or removing air from the cuff to protect the patient's airway. This simple intervention could positively impact postoperative patient experience as well as reduce postoperative airway complications associated with improper ETT cuff filling. This unveiled gap in care emphasizes the importance of a quality improvement project on the topic with its goal being to increase the number of ETT cuffs inflated to the appropriate pressure range with the use of syringe manometers by anesthesia providers. Formulation of a standard practice for clinicians to follow when an endotracheal tube is in place was endorsed by articles to prevent patient airway complications and improve patient postoperative experience.

Further clinical research is still required to fully understand best practice for endotracheal tube cuff monitoring, given the lack of published standardized practice recommendations. Nevertheless, from a review of the literature, a key takeaway is support for the use of manometry to guide the inflation of ETT cuff pilot balloons to ensure the appropriate pressure range is achieved and maintained to reduce adverse outcomes in

patients undergoing endotracheal intubation. The use of manometry to measure ETT cuff pressure and guide cuff inflation to the appropriate pressure range could be efficacious. A quality improvement project aimed at implementing the use of manometers to properly inflate ETT cuffs to the desired pressure range was warranted as a good starting point to reduce the risk for adverse airway outcomes in patients undergoing general anesthesia with an ETT and improve patient outcomes and experiences postoperatively at Barnes Jewish Hospital.

Theoretical Framework

Nola J. Pender's health promotion model is a conceptual nursing theory that was developed to complement other models of health protection (Nursing Theory, 2020). The goal is to increase patients' levels of well-being, which applies to this project's aim: to decrease adverse events related to under or overinflation of ETT cuffs. This model focuses on behavior-specific cognitions and affect, individual characteristics and experiences, and behavioral outcomes (Nursing Theory, 2020). These variables are unique to each patient and can be controlled to change the desired outcome. Clinicians can modify variables with clinical interventions to make an impact on patients' interpersonal environment (Nursing Theory, 2020).

Methodology

Project Design

This project took place over approximately one year from start to finish. Each "Promoting Evidence-Based Practice" course in the DNP- Nurse Anesthesia (Doctor of Nursing Practice) program curriculum accounts for 100-150 hours of project time. The sum of three courses equals 350 hours total. Time was spent reviewing the literature, planning the implementation process, implementing the educational intervention, and collecting and analyzing data. Two days a week were spent educating the sample population for two weeks. Educational in-services were provided from 0630-1230 each day. This totaled approximately 24 hours.

The in-service education was provided via PowerPoint, printed handouts, and hands-on demonstration of proper use of the AG Cuffill syringe. Project managers conducted in-services two days a week for two weeks

with an aim to reach as many Pod 5 anesthesia clinicians as possible. Project managers spent 4 to 5 hours in the second floor WUSM anesthesia lounge and provided approximately 5 minute educational sessions to providers who attended. The goal was to provide in-services to at least 50 percent of the anesthesia providers who work in Pod 5. Regular reminders were sent to the department via WUSM email for the two weeks leading up to the intervention phase of the project. Fliers were placed in Pod 5 ORs as additional practice reminders during the intervention phase.

Health Promotion

The benefit of this project was improved outcomes in the pod 5 patient population as a result of establishing the use of syringe manometers to properly inflate ETT cuffs within the WUSM Anesthesia Department. Appropriate cuff pressures are associated with fewer postoperative airway complications such as hoarse voice, sore throat, and numerous other potential adverse events. The success of this QI project should lead to increased adoption of the evidenced-based practice for ETT cuff inflation using manometry.

Stakeholders

Key stakeholders included individuals employed by Washington University School of Medicine Department of Anesthesia, specifically CRNAs and MDs providing anesthetic services within Pod 5. Specific stakeholders included Emily Davenport, Jennifer Stephan, and Paul Winson, the SRNAs (student registered nurse anesthetists) and project managers of this quality improvement project. Other members of the project included chairman, Sarah Perez, DNP, CRNA and Beth Beyatte, DNP. Rainer Kentner, MD and Helga Komen, MD are both WUSM faculty as well as project members. David Eisenbath and Erin Herrera are nurse anesthetists and leaders/directors for CRNA activities at BJH. Lastly, buy-in from CRNA leaders, especially in Pod 5, was crucial as their support eased the spread and adoption of the project by other CRNAs within the department.

With proper education of the background of our project, buy-in from key stakeholders such as certified registered nurse anesthetist (CRNA) and MD (medical doctor) leadership was obtained. These leaders included

Pod 5 lead CRNAs and anesthesiologists, whose attitudes influence those of their peers and staff. The project chairman, Dr. Perez, CRNA; and members, Dr. Beyatte, ACNP; Dr. Kentner, MD and Dr. Komen, MD are all in support of the project and were resourceful throughout the duration of the process. Additionally, the commitment of the WUSM Department of Anesthesia to evidence-based practice and quality improvement aided in the success of this project as there was already a cultural paradigm centered around improving practices and outcomes.

Resources

Multiple resources were needed to conduct this project. The EPIC EHR was utilized throughout the data collection phase of the project. This did not pose a cost to the team because the setting, BJH, has already incurred the cost of the electronic documentation system. Surveys that the WUSM department of anesthesia completed following education was also not an expenditure. The educational in-services provided occurred during normal scheduled shifts, thus, there were no additional costs or overtime associated with providing this education to anesthesia providers. Breakfast and snacks were purchased by the project managers as a participation incentive during the educational intervention phase. Other monetary costs of this project were minimal. AG Cuffill syringes were already present in all pod 5 ORs with the exception of the MRI rooms. See Appendix A for specific costs.

Project Site

The quality improvement project was conducted within the WUSM Department of Anesthesia at Barnes Jewish Hospital, an academic hospital and level one urban trauma center with 1,273 staffed beds (BJC HealthCare, 2022).

Sample Population

The sample population was Pod 5 patients, consisting of neurosurgery, ENT, hepatobiliary, vascular, and transplant surgical patients receiving general anesthesia with an ETT as compared to patients in other Pods, all other surgical specialties, receiving general anesthesia with an ETT. The outcome of interest was to

determine if an educational intervention aimed at achieving buy-in from CRNAs and MDs to utilize syringe manometers to inflate and measure ETT cuff pressures will improve the proportion of ETT cuffs within the appropriate range as opposed to the current practice of manual palpation and fixed volume inflation.

Ethical Considerations

Ethical considerations for data analysis were addressed by obtaining Washington University in St. Louis Institutional Review Board (IRB) exemption prior to data collection and analysis. Additionally, self-reported demographic data were de-identified and not utilized beyond the purpose of sample description. Accuracy of data during transcription to SPSS software was ensured via a three-person independent check by the project managers. A third party, unbiased faculty member at Goldfarb School of Nursing at Barnes Jewish College, Dr George Vineyard, assisted in the data analysis process as well. Lastly, in addition to deidentification of data, all data were stored and secured via password protection to ensure adherence to privacy protection concerns.

The educational in-service was conducted in a manner that is inclusive of all cultures and beliefs on the topic. Demographic information was obtained at the educational in-service upon arrival and was surveyed in a neutral, culturally sensitive, and confidential manner via an online self-reported form provided on a cellular device or laptop by the project managers that was completed at the time of the educational session. Beyond these cultural considerations, additional cultural considerations were not necessary as all anesthesia providers and all GA (general anesthesia) surgical cases in Pod 5 were included in this project. Clinician use of manometers was not influenced by culture, nor were cuff pressure measurements. Demographic information was only utilized to describe the educational intervention target sample and was not tied to specific intervention outcomes or sample selection.

Recruitment and Sampling Strategies

Prior to conducting in-services, a department-wide email was sent that requested participation and provided the Powerpoint education and educational handout. Participants were also recruited in person on days

that the in-services were conducted. Breakfast and snacks were provided to further encourage participation. A follow-up email was sent after the final in-service to encourage the completion of the demographic survey.

Measurement Instruments

To measure the outcomes of this DNP Project, the EPIC electronic health record was utilized. EPIC is a major software used by healthcare systems in the United States that stores electronic medical records. A report was obtained that indicated how many anesthesia providers were charting ETT cuff pressures in the airway flowsheet for six months prior to project implementation. A baseline assumption was that the number of documented cuff pressures directly correlated to the number of anesthesia providers physically measuring pressure with cuff manometry syringes. This number was compared to the proportion of providers using and documenting cuff pressures at three different time points after educational interventions were implemented. The independent variable was the staff education; the dependent variable was the number of ETT cuff pressures measured and documented in EPIC. Syringe manometry use and documentation were reported in Pod 5 only and were obtained six months before the implementation phase of this project, one-week post-intervention (days 1-7), one-month post-intervention (days 8-30), and two months post-intervention (days 31-60). The educational implementation was conducted over two weeks.

The main aim of the quality improvement (QI) project was to increase the proportion of anesthesia professionals utilizing the AG Cuffill syringe to appropriately inflate and document ETT cuff pressures within the desired range. Demographic variables of anesthesia providers' age, gender, specialty area of practice, years practicing at WUSM, and years of experience was collected via self-reported survey for purposes of quality improvement sample description but will not be tied to any quality improvement data analysis. Upon the start of each provider's educational in-service, an online survey created by the project managers was completed by each participant on a WUSM Department of Anesthesia cellular device or personal laptop. Although these participant demographics do not apply to inclusion and exclusion criteria, they will help to describe the sample population (details shown in Appendix B).

As fixed volume inflation with manual palpation has not been shown to reliably inflate ETT cuff pressures to the proper pressure range, a quantitative tool was employed to improve both the use of manometry and assist with documentation of the obtained pressure. The measurement instrument that was used on airways in the OR was an AG Cuffill syringe manometer, as illustrated in Appendix C. The AG Cuffill syringe manometer allows for a fixed volume to be used while also providing a quantitative pressure reading of the ETT cuff. Hence the use of this syringe manometer in Pod 5 will potentially lead to the desired quality improvement outcome by providing a means of quantifying ETT cuff pressures to be documented. Anesthesia professionals were provided with an educational in-service regarding the use of the AG Cuffill syringe manometer, appropriate documentation in the EPIC EHR, and the benefits of ETT cuff pressure quantification and documentation. The EPIC EHR data report was compiled for the desired data points of six months pre-intervention, and one week, one month, and two months post-intervention (specific time frames for post-intervention days are specified above). Expert review by Sarah Perez, DNP, CRNA confirmed reliability and validity of the EPIC EHR data report.

Data Collection Narrative

Clinicians charted in an electronic health record on BJH computers in each operating room. EPIC is a widely used EHR system in the United States. Data points were collected by requesting and obtaining an EPIC report from the IT department and later analyzed using SPSS software. The data report was run on Pod 5 general endotracheal anesthesia (GETA) cases, specifically gathering ETT cuff pressures documented in the airway notes. The airway procedure note automatically populates for anesthesia providers to document when and how a GETA case was performed. The provider should have documented this pressure in the airway note after using the AG Cuffill syringe manometer. There is a section within the airway procedure note that allowed the clinician to type in a quantitative cuff pressure in cmH2O. Using the generated EPIC report, all Pod 5 airway notes were collected, and the cuff pressures were placed into a spreadsheet for the project managers to

evaluate. The total number of pressures charted before education and after intervention was analyzed to determine if the educational intervention was successful.

A six-month retrospective baseline report with ETT cuff documentation was obtained directly prior to the implementation phase of this project, which was the first data point. The time points that post-intervention data were collected was one week after (days 1-7), one month after (days 8-30), and finally, two months after (days 31-60). Success of the intervention was determined by an increase in documented cuff pressure at the three data time points post-interventional sessions. Rather than physically entering ORs to observe and record ETT cuff pressure documentation, which would introduce observer bias, the use of informatics to run a data report from the EPIC EHR allowed for the success of the intervention to be evaluated. Additionally, informatic tools such as SPSS were used to conduct the data analysis.

The project team utilized the Model for Improvement PDSA (plan, do, study, act) cycle to guide the data collection process. The cycle began by assessing what needed to be accomplished, how a change was made, and if that change would result in improvements. With the use of the PDSA cycle, the team was better equipped to implement this QI within the WUDA. The main goal was to increase the proportion of anesthesia providers who used syringe manometers to measure and document ETT cuffs in Pod 5 which was directly correlated with an increase in the proportion of cuffs inflated to the proper range of 20 to 30 cmH2O. This was accomplished by conducting educational in-services to the department staff. EPIC documentation was evaluated before and after the implementation phase.

Data Analysis

Both descriptive and inferential statistics were utilized for this project. Nominal provider demographic data were described as percentages. The educational intervention was a nominal independent variable (IV). The proportion of ETT cases with documented ETT cuff pressures within the appropriate pressure range, a continuous dependent variable (DV), was reported as percentages at each time point of data collection. A line graph was used to illustrate percent changes in ETT cuff pressure documentation in the appropriate range over

time. Raw data were grouped into “compliant,” which indicated appropriate documentation of a cuff pressure within 20 to 30 cmH2O, and “noncompliant,” indicating there was no documentation or the documented pressure fell outside of the recommended range. The alpha value was set at .05 ($\alpha = .05$). The categorized data as defined above were analyzed using IBM SPSS version 27 software to perform an independent t-test.

Procedures for Project Implementation

The project education was provided via PowerPoint, printed handouts, and hands-on demonstration of proper use of the AG Cuffill syringe. Educational materials were also disseminated to the anesthesia department electronically prior to the start of the in-services. In-services were conducted two days a week for two consecutive weeks. The in-services consisted of 5 minute educational sessions to participating providers. The goal was to provide education to 50 percent or more of providers that regularly work in pod 5. Following the in-service, a demographic survey was administered. A follow-up email was sent after the final in-service to encourage the completion of the demographic survey for those who had not participated in-person. Additionally, fliers were placed in Pod 5 ORs as practice reminders during the intervention phase.

The educational in-service was conducted in a manner that is inclusive of all cultures and beliefs on the topic. Demographic information was obtained at the educational in-service upon arrival and was surveyed in a neutral, culturally sensitive, and confidential manner via an online self-reported form provided on a cellular device or laptop by the project managers that was completed at the time of the educational session. Beyond these cultural considerations, additional cultural considerations were not necessary as all anesthesia providers and all GA (general anesthesia) surgical cases in Pod 5 were included in this project. Clinician use of manometers was not influenced by culture, nor were cuff pressure measurements. Demographic information was only utilized to describe the educational intervention target sample and was not tied to specific intervention outcomes or sample selection.

Evaluation and Outcomes

Results

A total of 37 anesthesia providers participated in this study's educational in-services. These providers included CRNAs (56.8%), anesthesiologists (24.3%), and SRNAs (18.9%). Evaluation of the sample showed that 48.6% were between the ages of 25 to 35, and 59.5% were female. Most providers had been in practice for less than five years, 52.8% and were employed by WUSM Anesthesia Department for less than five years, 62.2%. In terms of specialty area, most providers reported that they worked in various OR Pods, also known as "float" (55.6%). The second largest group of providers, 19.4%, reported that they worked exclusively in Pod 5. Appendix B details this demographic data.

In the six-month period prior to the implementation phase, there were a total of 2,766 OR cases in Pod 5 that utilized ETTs. Only 3.31% of pre-intervention GETA cases had a documented cuff pressure that fell within the recommended range of 20 to 30 cmH2O. Post-intervention, there was a significant spike in overall compliance; weekly compliance rates varied from 14.94% to 25.4% in the two months following the intervention phase. During the week of the educational intervention provided to these participants, there were a total of 122 GETA cases, 25.41% of which had documented cuff pressures that fell within the recommended range. Similarly, one-month post-intervention 24.21% of 95 GETA cases had a documented cuff pressure within the proper pressure range. At the end of data collection, two months post-intervention, the proportion of documented compliant cuff pressures decreased to 14.94%. See appendix D for compliance rate trends along the entire data collection timeframe.

Utilizing SPSS version 27, an independent t-test was performed to compare cuff pressure assessment and documentation during the pre-intervention and post-intervention periods. Alpha was set at .05 ($\alpha = .05$). The results from the pre-intervention period ($M= 26$, $SD= 2.64$) compared to the post-intervention period ($M= 10$, $SD= 6.05$) indicate that the educational program resulted in a significant increase in cuff pressure

assessment and documentation, $t(10.35) = -9.37$, $p < .001$, 95% CI, and the effect size was more than three times the standard deviation, $d = 3.8$. See Appendix E.

Discussion of Outcomes

Compliance with cuff pressure measurement, adjustment to the recommended range, and charting thereof, rose from 3.51% to 25.41% in the week following the intervention. This increase was sustained over time as shown by the post-intervention data points at one, four, and eight weeks. The post-intervention mean remained seven times greater than the 6-month pre-intervention mean compliance rate. Given the sustained increase over eight weeks post-intervention, the educational in-service was considered successful. These findings are both statistically and clinically significant.

Strengths and Limitations of Findings

This project significantly increased the measurement, adjustment, and documentation of ETT cuff pressures, both clinically and statistically. This provides a strong foundation for facility-wide implementation of cuff manometry as a standardized anesthesia departmental practice. Success of the education supports that project managers did not need to physically enter each operating room to observe measurements, which would have introduced observer bias, to maintain higher manometry use and documentation. Sustainability of improved documentation occurred without reminders from project managers.

Limitations for this project included the relatively small number of participants in the educational program and short duration of post-intervention data collection relative to the pre-intervention. A longer period of recruitment and education may have increased provider participation. The post-intervention data collection period was limited by program time constraints for project completion by the end of 2022. A longer post-intervention data collection period would have been helpful in further assessing sustainability of the educational intervention at improving measurement, adjustment, and documentation of ETT cuff pressures. Additionally, to avoid disruptions in workflow, missing manometers may not have been replaced promptly enough.

Evaluation of the Process

The design of this project worked as intended to achieve the desired result of increased cuff pressure compliance with the recommended range, however, there are areas for improvement. An increased sample size and longer timeframe for data collection may have yielded even more significant results and provided more information on sustainability over time. Strengths and limitations were addressed and discussed above.

System and Practice Impacts

Implications for Organizational and Systems Change

The increased cuff pressure assessment, adjustment, and documentation that occurred as a result of this project showed that staff education and readily available manometers increase the intraoperative use of ETT cuff manometry. Additionally, consistent EHR charting of cuff pressures serves as proof that the pressure was assessed and fell within the recommended range; in the future, this may help to avoid perioperative adverse airway events related to ETT cuff pressures.

Current literature advocates for maintaining ETT cuff pressures between 20 and 30 cmH2O via manometry. The use of manometry intraoperatively for ETT cuff management is recommended to prevent perioperative airway-related complications. Our findings suggest that providing staff education and manometers is a feasible means to improve anesthesia provider adherence to these recommendations. A department-wide policy encouraging the intraoperative use of manometry may further increase the adoption of these recommendations as a standard practice for anesthesia providers at Barnes Jewish Hospital.

Recommendations for Nursing Practice

Current literature advocates for maintaining ETT cuff pressures between 20 and 30 cmH2O via manometry. The use of manometry intraoperatively for ETT cuff management is recommended to prevent perioperative airway-related complications. Our findings suggest that providing staff education and manometers

will increase adherence to these recommendations. A department-wide policy encouraging the intraoperative use of manometry may further improve adherence.

Sustainability

The data collected over different time points following the educational intervention shows the use of manometry continued over time. This suggests that the practice change is feasible. Further data collection would be beneficial to evaluate long-term sustainability. Additionally, periodic practice reminders for anesthesia providers could help to maintain this practice change in the future.

Summary

Improper inflation of ETT cuffs outside of the pressure range of 20 to 30 cmH2O can lead to serious adverse airway outcomes for patients ranging from sore throat to tracheal stenosis (Kumar et al., 2021). Fixed volume inflation with manual palpation of the pilot balloon is a commonly utilized technique amongst anesthesia providers when placing ETTs, however, this method has been shown to be unreliable 50 to 80 percent of the time (Holyszko et al., 2021; Turner et al., 2020). The use of a quantitative method such as a syringe manometer is a validated means of reliably achieving ETT cuff inflation to the desired pressure range which can help to prevent postoperative airway complications (Athiraman et al., 2015; Ganason et al., 2020; Laksono et al., 2021; Liu et al., 2010; Unsal et al., 2018).

This quality improvement project utilized educational in-services for anesthesia providers to increase the use of the AG Cuffill syringe manometer as demonstrated by increased provider documentation of ETT cuff pressures in the EPIC EHR. The outcome was a significant rise in the proportion of documented ETT cuff pressures in the appropriate range within the EHR. The success of this project may improve patient outcomes, as well as lead to the possible adoption of a department-wide practice change requiring the use of ETT syringe manometers in operating rooms throughout Barnes Jewish Hospital.

Plan for Dissemination

This document was shared with project members, mentors, and key stakeholders within the WUDA. A summary of the project and findings will be presented to other students and faculty of the DNP program at Goldfarb School of Nursing at Barnes Jewish College. Additionally, the project will be disseminated as a poster presentation in the Spring of 2023. There are no plans for publication at this time.

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Appendix A

Table 1

Budget Table

Nature of Expenditure/Item	Cost per Unit	# Units	Total Estimated Cost
Direct costs			
Personnel			
- WUSM Dept. of Anesthesia staff	Salaries vary	0 (Educational in-services will not pose a salary cost as they will occur on already compensated staff time.)	$0.00
- Project managers	$40.00 per hour	3 project managers at approximately 500 hours = 1,500 hours (per DNP handbook: EBP I, EBP II, EBP III, DNP Project courses total 500 hours)	$60,000.00
- Project chairman	Salaries vary	0 (Project chair time will not pose a salary cost as it will occur on already compensated staff time.)	$0.00
- Other project members	Salaries vary	0 (Project member time will not pose a salary cost as it will occur on already compensated staff time.)	$0.00
Materials & supplies			
- Google drive/google docs	$0.00	-	$0.00
- Educational PowerPoint	$0.00	-	$0.00
- Paper for educational content	$1.25	16 (reminder flier to be posted in each OR in Pod 5)	$20.00
- Airway mannequin	$0.00	1	$0.00
Technology, hardware, software			
- EPIC	$0.00	-	$0.00
- AG Cuffill syringe manometers	$29.95	0	$0.00
- SPSS Version 27	$114.00	1 license for 2 year subscription	$114.00
Other	-	-	
- Incentives for educational in-services	$15.00	4	$60.00
Total	-	-	$60,194.00

Appendix B

Table 1

Demographic Survey

What is your role within the WUSM anesthesia department?	CRNA MD/Anesthesiologist
How long have you been employed with the WUSM anesthesia department?	0 - 5 years 5- 10 10 +
How long have you been a CRNA or MD?	0 - 5 years 5- 10 10 +
What specialty area do you work in?	Pod 1 Pod 2 Pod 3 Pod 4/CAM Pod 5 Float
What is your age?	< 25 years 25 - 35 36 - 45 46 - 55 56 - 65 66 - 75 76 - 85 85 +
What is your gender?	Male Female Nonbinary

Figure 1

Department of Anesthesiology Role

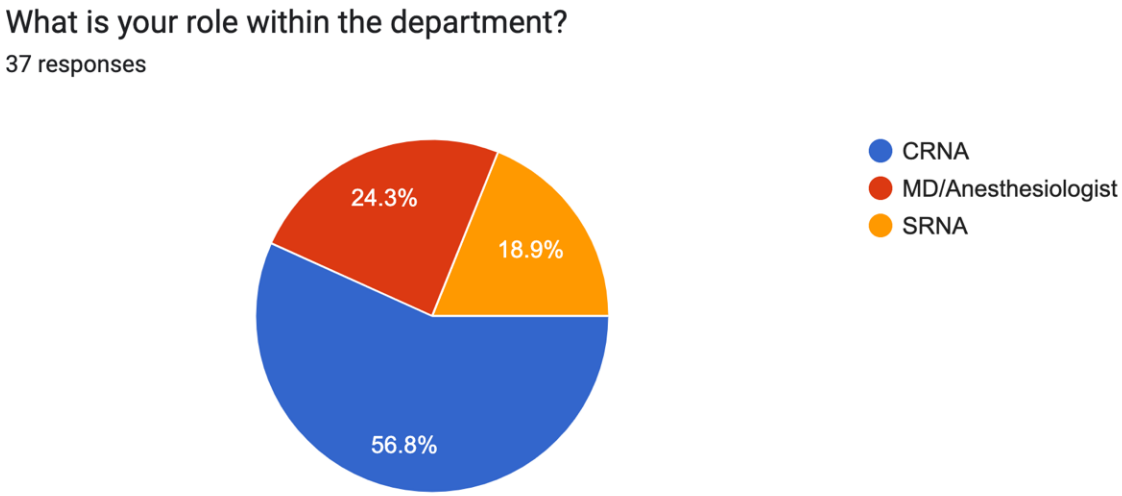


Figure 2

Duration of Employment within WUSM Department of Anesthesiology

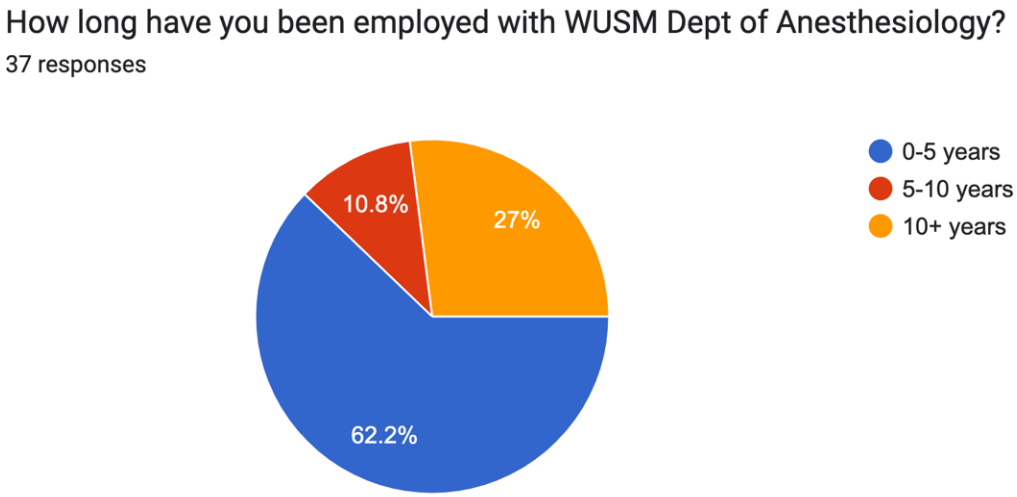


Figure 3

Years of Experience as Anesthesia Provider

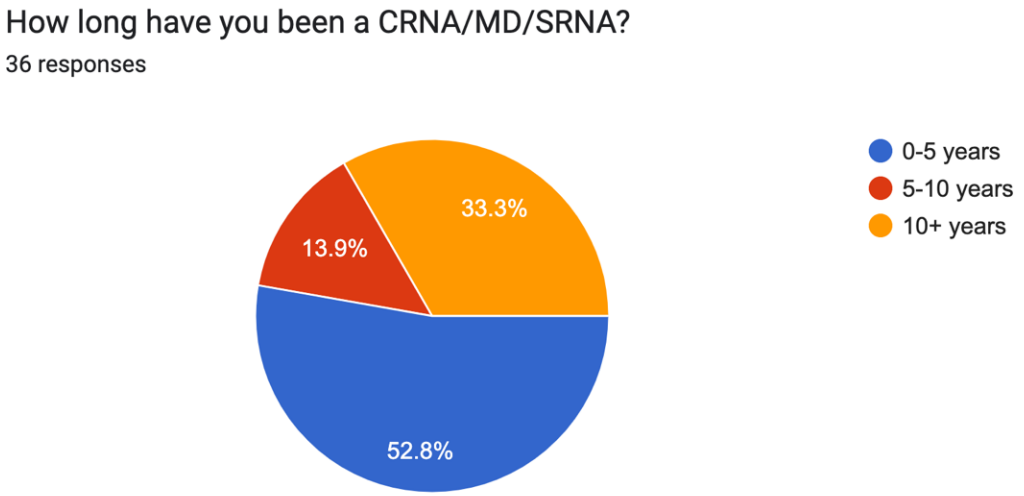


Figure 4

Anesthesia Specialty Area within BJH

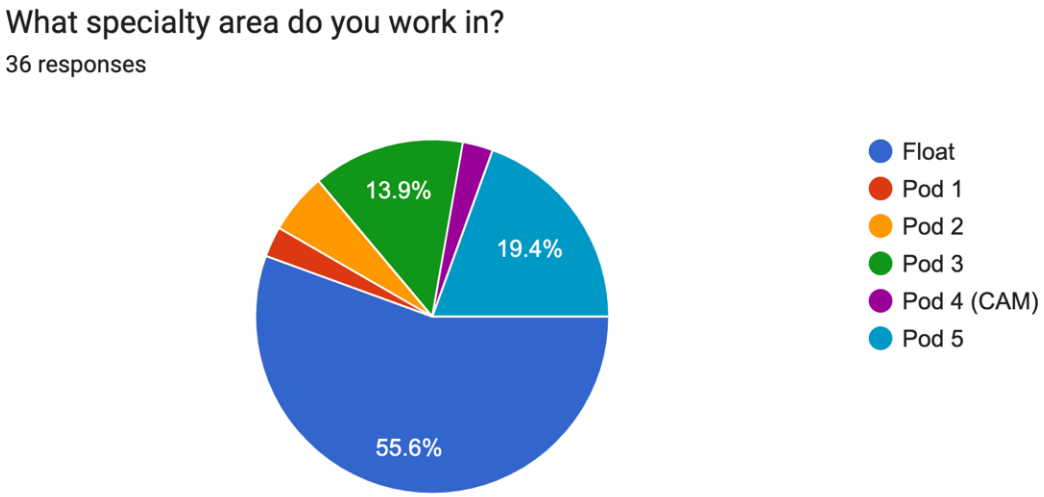


Figure 5

Sample Age Demographics

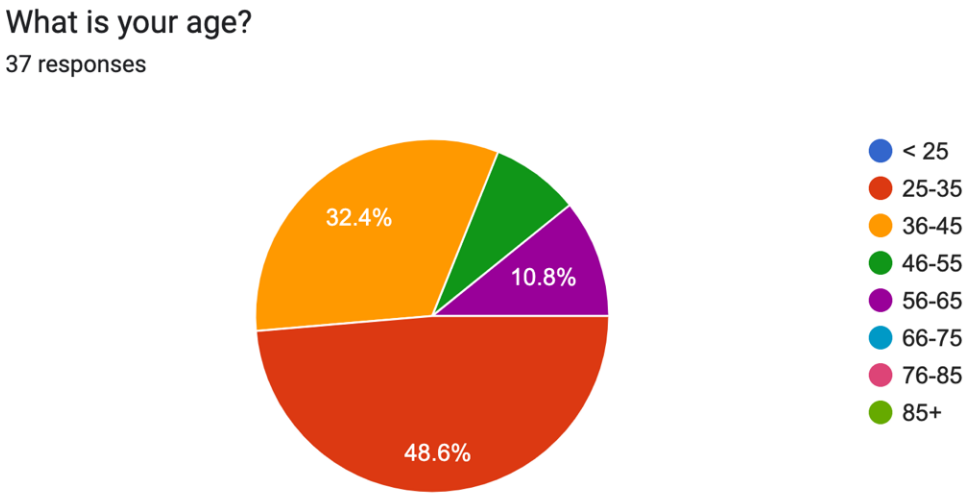
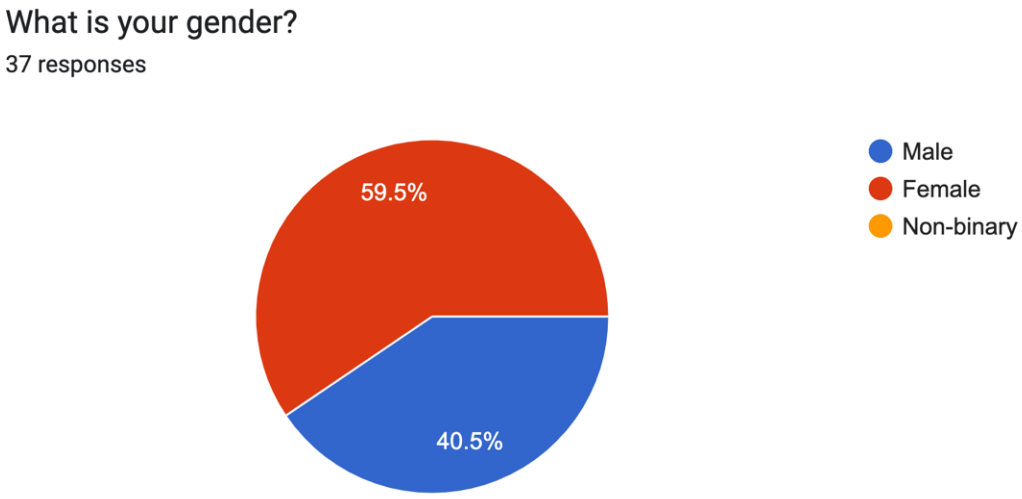


Figure 6

Sample Gender Demographics



Appendix C

Figure 1

AG Cuffill Syringe

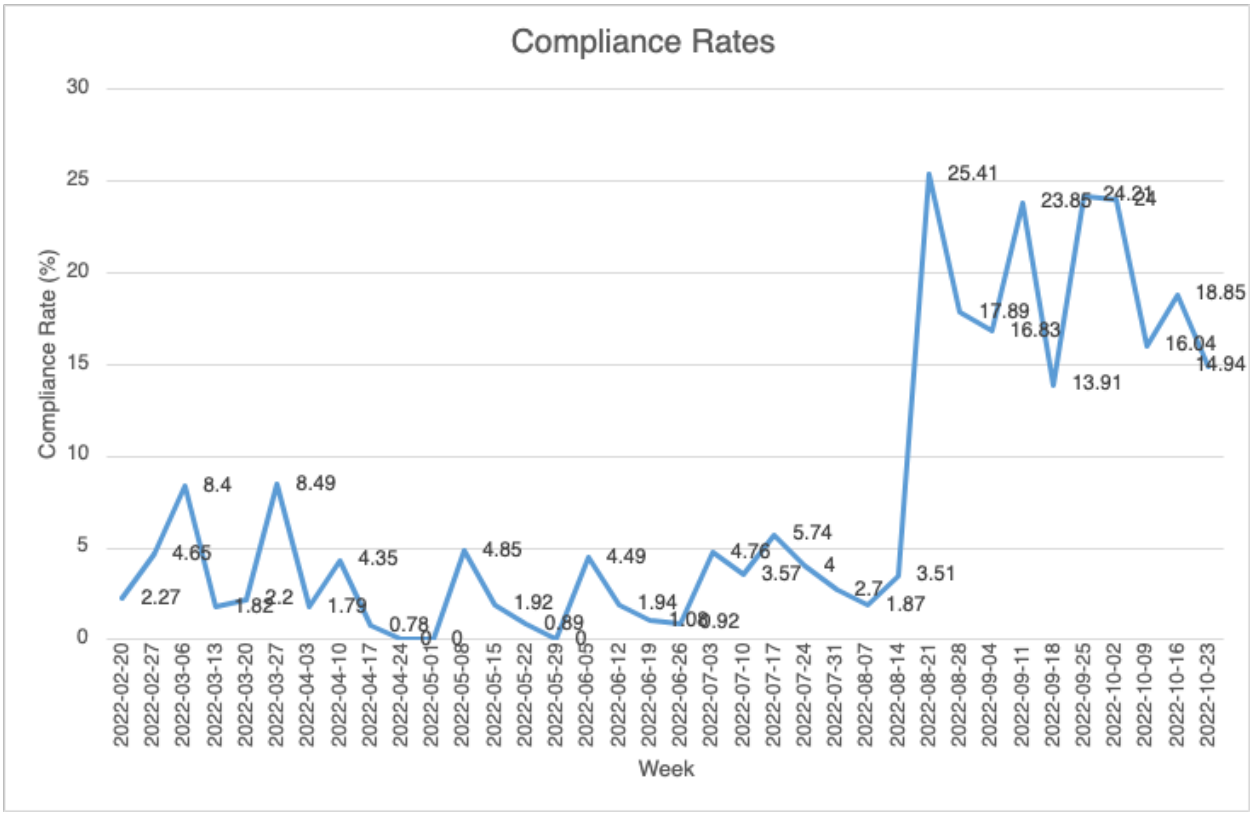
Note. The figure above is of the AG Cuffill syringe with included link to manufacturer's website:

https://www.cuffill.com/

Appendix D

Figure 1

Results Graph



Note. The graph above displays data ranges beginning on 02/20/2022 (six-month pre-intervention) until 10/23/2022 (two-month post-intervention).

Appendix E

Table 1

Pre-Intervention and Post-Intervention Statistics

Group Statistics

	Intervention	N	Mean	Std. Deviation	Std. Error Mean
Compliance	Pre	26	3.23	2.643	.518
	Post	10	21.80	6.052	1.914

Table 2

Independent Two Sample T-Test for Pre-Intervention and Post-Intervention Statistical Analysis

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Compliance	Equal variances assumed	11.867	.002	-12.959	34	<.001	-18.569	1.433	-21.481	-15.657
	Equal variances not assumed			-9.366	10.349	<.001	-18.569	1.983	-22.967	-14.172

Table 3

Measures of Effect for Pre-Intervention and Post-Intervention Statistical Analysis

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Compliance	Cohen's d	3.851	-4.822	-6.165	-3.457
	Hedges' correction	3.939	-4.715	-6.028	-3.380
	Glass's delta	6.052	-3.068	-4.624	-1.480

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control group.