EVIDENCE-BASED TRAINING FOR NURSES: IMPROVING INCENTIVE SPIROMETRY USAGE, DOCUMENTATION, AND PATIENT EDUCATION, WHILE DECREASING POSTOPERATIVE PULMONARY COMPLICATIONS IN CORONARY ARTERY BYPASS GRAFT PATIENTS

By

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ABSTRACT

CARLITHA SAUNDERS. Evidence-based Training for Nurses: Improving Incentive Spirometry Usage, Documentation, and Patient Education, While Decreasing Postoperative Pulmonary Complications in Coronary Artery Bypass Graft Patients (Under the Direction of DR. CHARLENE WHITAKER-BROWN)

Incentive spirometry (IS) is one intervention used to prevent pulmonary complications after surgery. Incidence for pulmonary complications after coronary artery bypass graft (CABG) surgery is 30-60%, which greatly affects morbidity and mortality (Yazdannik et al., 2016). Nurses play a critical role in patient IS compliance by providing education on correct use and reminders to use the IS device. Unfortunately, IS compliance is not optimal, as demonstrated in a cross-sectional survey where 86% of providers believed IS compliance was poor (Eltorai et al., 2018). While substantial evidence is available that supports IS as a treatment, there is an insufficient amount of research on improving IS compliance. A quasi-experimental pretest and posttest design was used to determine if nurses gained knowledge from an IS evidence-based education. Chart audits were completed three months before and after the nursing evidence-based education on documentation of IS frequency and volume, and incidence of pneumonia and progression of atelectasis. Nurses caring for patients in the immediate postoperative period after undergoing CABG surgery were given a 15 minute evidence-based IS education. Nurses had improved feelings on incentive spirometry efficacy following the nurse education. There was an increase of nurses that strongly agreed that IS helps reverse atelectasis (from 37.5 to 95.5%) and prevent pneumonia (from 45.8% to 95.8%). Nurses demonstrated improved understanding of correct use of the IS device following the nursing education, with 87.5% of nurses correctly identifying the target inspiratory flow. There was a 43.68% increase in total times that IS was documented in the post education patient group (148 vs. 108). An independent T-test revealed that the IS use increase was statistically significant (p=.027). In

regard to postoperative pulmonary complications, there were no patients that developed pneumonia by POD3. There were three patients that had improved atelectasis by postoperative day three, compared to six in the post education group. The present study's results mirror Eltorai et al (2019) and Alwekhyan et al. (2021) in that improved patient IS use led to decreased postoperative pulmonary complications. Further research is needed to capture true patient IS compliance and improvement in patient understanding after enhanced nursing education. Interdisciplinary teams should be included in IS quality improvement projects including respiratory therapists. Finally, standardization is needed on IS use as nurse responses on ideal daily frequency and ideal daily improvement in volume differed vastly.

ACKNOWLEDGEMENTS

With profound gratitude the completion of this DNP quality improvement project would not have been possible without the guidance of my committee: Drs. Charlene Whitaker-Brown, Erin Najarian, Shi Chen, and Ralph Christy Jr. Additionally, I thank the esteemed nurses, providers, and respiratory therapists that diligently care for patients undergoing cardiac surgery and aspire daily to improve patient outcomes.

DEDICATION

I would like to dedicate this to my mom, dad and my second mom. Thank you for your unwavering support and love and most of all being my cheering squad. To my husband Dorian, love you for giving me room and grace to finish this. Cheers to us. And finally, to my little sister in heaven, Danielle, you saw this accomplishment before I did, I know you are proud. I did it, Danielle!

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LIST OF ABBREVIATIONS

AARC	American Society of Respiratory Care
AH	Atrium Health
CABG	Coronary Artery Bypass Graft
CVICU	Cardiovascular Intensive Care Unit
FEV1	Forced Expiratory Volume in 1 second
IS	Incentive Spirometry
MIP	Maximal Inspiratory Pressure

CHAPTER 1: INTRODUCTION

The American Association for Respiratory Care (AARC) recommends incentive spirometry (IS) use for patients undergoing thoracoabdominal surgery (Martin et al., 2018). Incentive spirometry has been shown to be effective in reducing pulmonary complications and improving oxygenation after coronary artery bypass graft (CABG) surgery. Respiratory exercises such as IS require repetitive use in order to be effective. Unfortunately, IS compliance is not optimal, as demonstrated in a cross-sectional survey where 86% of providers believed IS compliance was poor (Eltorai et al., 2018). While there is substantial evidence supporting IS as a treatment, there is insufficient research on improving IS compliance.

Background

Impaired oxygenation and incongruence in gas exchange are consistent with the development of pulmonary complications (Yazdannik et al., 2016). Postoperative pulmonary complications arise from a combination of decreased lung expansion causing atelectasis, diminished mucociliary clearance, and decreased respiratory muscle function, which together give rise to colonization and proliferation of bacteria (Bilyy et al., 2020). Deep breathing maneuvers promote alveoli opening or lung recruitment (Martin et al., 2018), which can be facilitated by IS use.

The incentive spirometer is a handheld device that provides visual feedback for deep breathing. There are two types of IS devices: volume oriented and flow-oriented. Volume IS is recommended by the AARC (Restrepo et al., 2011). The Volume IS device is comprised of two chambers – one large and one small – connected to a corrugated tube attached to a mouthpiece. The larger chamber has a piston that rises in response to the volume of air inhaled, and the second smaller chamber has a ball that responds to the speed of inhalation. The volume IS works to encourage lung expansion by forcing a maximal sustained deep breath in that the effort is seen in the rise of the piston (Franklin & Anjum, 2023).

Importance should be given to accurate incentive spirometry reporting since the lack of research is partly due to the unknowns of patient IS compliance (Eltorai, 2018). Providers were surveyed on causes of weak IS compliance, of which 83.5% believed that this was due to patient forgetfulness (Eltorai, 2018). Nurses also play a critical role in patient IS compliance as they provide education on correct use and reminders to use the IS device. There has been a reported lack of nursing compliance with prescribed IS therapy, as seen in Saraceni et al, (2022). Inadequate training and ineffective self administration of IS could consequently reduce healing of postoperative complications (Restrepo et al., 2011).

Problem Statement

Incentive spirometry and early mobilization are two of a few interventions used to prevent pulmonary complications after surgery. Incidence for pulmonary complications after CABG surgeries are 30-60%, which greatly affects morbidity and mortality (Yazdannik et al., 2016). The project lead's experience in cardiovascular surgery prompted the observation that nurses are not 100% compliant with IS instruction and documentation of patients that have undergone CABG surgery. Patients that have poor IS use often end up with pulmonary complications including pneumonia and atelectasis. Atelectasis after surgery has been linked with postoperative fevers, increased admission to the intensive care unit, early post operative mortality, and increased length of stay (Eltorai et al., 2019).

Purpose of project

The purpose of this DNP project is to improve nurses' knowledge on IS as it relates to IS effectiveness in reducing postoperative pulmonary complications, increase nursing compliance of IS documentation and patient education, and reduce postoperative pulmonary complications.

Clinical Question

Among CVICU nurses caring for postoperative CABG patients, will an evidenced based IS education session compared to basic knowledge improve nursing knowledge on IS effectiveness in preventing pulmonary complications, nursing compliance of IS documentation and patient education and decrease postoperative pulmonary complications within three months?

Project Objectives

The primary outcomes of this quality improvement project are improved nurse knowledge of IS effectiveness, patient education, and documentation of IS use. Secondary outcomes include decreased pulmonary complications after CABG surgery, specifically atelectasis and pneumonia.

CHAPTER 2: LITERATURE REVIEW

Between May, 2022 and February, 2023, the project lead performed a literature review to evaluate incentive spirometry effectiveness, patient compliance, and interventions to improve patient compliance. PubMed and CINHAL databases were searched using several arrangements of keywords: *CABG, cardiac surgery, incentive spirometry*, *compliance*, *adherence*, and *nursing education,* which yielded 130 articles with many duplicated results indicating a thorough search of the literature. Of these, only 12 articles were kept, based on relevance to the project topic. Initially, articles not relating to cardiac surgery were excluded. Given the insubstantial number of results with cardiac surgery, clinical trials including any thoracic or abdominal surgery, and traumatic injuries using IS were included, adding 4 articles for a total of 16 articles included in this literature review.

Evaluation

The final sample of this integrative review included mostly empirical reports: five randomized controlled trials, five prospective studies, and two cross sectional studies. There were also two theoretical reports included which consisted of a meta-analysis and literature review. The overall strength of the studies can be considered reliable as most were level I and level III evidence.

Analysis

Data from the literature was first organized into data relating to IS compliance. It was further organized into IS effectiveness, as evidenced by primary outcomes related to physical change or improvement in respiratory status, such as oxygen saturation and forced expiratory volume in 1 second (FEV1). Another level of organization included secondary outcomes such as length of stay and mortality. Finally, data on nursing or provider education was synthesized.

Improving IS compliance is necessary as adherence has been shown to be poor, as witnessed by the project lead, and as reflected in the literature. A cross sectional analysis revealed that 26% of patients failed to use IS correctly and 38% did not use their IS device at all (Martin et al., 2018). In this same study, 73.8% of patients were more confident using IS after brief educational intervention (Martin et al., 2018). Patient IS use is documented by nursing staff, and adherence with this communication of care is important to improve postoperative patient outcomes (Saraceni et al., 2022). For example, direct nursing observation increased IS compliance and reduced ICU length of stay by one day (Alwekyhyan, 2021). Providing education to nurses also improved IS compliance, as seen in Saraceni et al. (2022) after an in-service education was given to nurses on the benefits of IS in preventing pulmonary complications.

Patient compliance on prescribed therapies is greatly influenced by nursing. IS compliance increased with various methods of reminding patients to use their IS device. Patients had higher adherence with IS via a reminder bell (Eltorai et al., 2021), and with nurse-guided bihourly instruction (Alwekyhyan, 2021). Providers were found to be instrumental in increasing IS compliance, as seen in a study by Gupta et al. (2017), which implemented a mentoring program that allowed healthcare professionals to utilize rehearsals to improve practice and skill of IS use. A provider checklist on postoperative pneumonia prevention, which included ensuring IS was within patients' reach and verification of correct IS use, successfully decreased occurrence of postoperative pneumonia and increased patient awareness on pneumonia prevention interventions including IS use (Lamm et al., 2022). Patients with heart failure had improved daily weight and BP monitoring and understood more about the disease process after receiving routine outpatient nurse education for one year (Gonzalez et al., 2005).

IS definitively improved respiratory status, as seen in Yazdannik et al. (2016) and Alwekyhan et al. (2021); patients who underwent CABG had significantly higher arterial blood gas oxygenation, and experienced fewer hypoxic events and for a shorter duration, respectively. IS use also increased muscle strength, as demonstrated by improved maximal inspiratory pressure (MIP) after CABG surgery (Manapunosee et al., 2020). In regard to reducing pulmonary complications, use of an IS reminder bell decreased atelectasis severity by POD 4 (Eltorai et al., 2019). There were also fewer incidences of pneumonia in nurse guided IS use (Alwekhyan et al. 2021) and when IS was combined with deep breathing exercises (Manapunosee et al., 2020). In Bilyy et al. (2019), nine patients not using IS developed atelectasis/pneumonia requiring antibiotics, versus three patients in the intervention group that utilized IS. Similar results were seen in patients that used IS after sustaining rib fractures where 21 patients (75%) developed pulmonary complications compared to 7 (25%) in the control group that did not use IS (Sum et al., 2019).

Although there were some studies that only used IS a few times per day, there was a consensus in the literature for proper IS repetition and instructions on use. Ten maximal inspired breaths was the most common prescribed frequency (22 trials) in the systematic review by Narayanan et al. (2016). Crowe and Bradley (1997) and Martin et al. (2018) instructed patients to inspire to total lung capacity and hold their breath at least five seconds. Similarly, Sum et al. (2019) had patients maintain a sustained maximal inspiration for three to five seconds before exhalation, ten times per hour, for at least eight hours a day.

This integrative literature review revealed improved patient compliance with reminders through a nurse-guided IS use and a reminder bell. It was also evident that IS use was effective in decreasing pulmonary complications after surgery. Nurses can greatly impact patient IS adherence via reminders and guided instruction on correct use.

Theoretical Framework

Kurt Lewin’s model of change applies to this project in that it is a quality improvement project that will enforce a change in the routine behavior of nursing education and documentation. Lewin’s model is based on three steps: unfreezing, moving, and refreezing (Raza, 2019). First, to unfreeze, Raza (2019) states that appealing to the emotions can result in a change of the group dynamic which will lead to the group being pliable to the idea of change. The evidence-based nursing education provided on IS benefits appealed to the nurses as they shared a common goal of successfully recovering CABG patients in part by minimizing postoperative complications. The second stage is change or movement, wherein the change is implemented, as evidenced by a change in behavior (Petiprin, 2020). The nurses’ common goal inspired the second phase as nurses had a better understanding of IS effectiveness and were more willing to accurately document and teach IS correct use. Finally, to sustain or refreeze is the third phase, which establishes the change as a new process (Petiprin, 2020). Requiring nursing staff to report IS documentation, patient education, and IS volume at ICU daily round will make the process permanent. The expectation is that an interdisciplinary ICU rounding team will hear the nurses report, which will influence a continued adherence on IS reporting.

CHAPTER 3: METHODS

The methodology for this DNP quality improvement project was designed to support the project objectives of implementing and assessing the efficacy of an evidenced based educational intervention. For this reason, a quasi-experimental pretest and posttest design was utilized to ascertain nurses' feelings and knowledge on IS effectiveness and correct use. Secondary project objectives were obtained by recording incidence of postoperative pulmonary complications before and following the evidenced based education intervention.

Project Design

This quality improvement project utilized a quasi-experimental pre and post test design to determine if nurses had improved feelings and knowledge from an IS evidence-based education and if pulmonary postoperative complications decreased.

Sample

The population consisted of nurses employed by Atrium Health (AH) Cabarrus scheduled to work in the CVICU during project implementation. Travel RNs were included if they had at least a six-week contract to work in the CVICU. New graduate nurses and any nurses in orientation were also included. The CVICU had several new nurses with more than nine new graduates hired in 2022. Additionally, at least 6 experienced nurses left for graduate school or remote work in the six months prior to project implementation. Nurses that were not available or scheduled to work during the project implementation were excluded from participating.

Setting

The project took place in the Cardiovascular Intensive Care Unit (CVICU) of AH Cabarrus in Concord, North Carolina. AH Cabarrus is a level III trauma center with a 457-bed capacity. The CVICU is a 14-bed unit with 40 staff nurses working 12-hour shifts. Patients undergoing CABG are transferred to the CVICU immediately following surgery and stay for at least 48 hours before transferring to the Cardiovascular Intermediate Care Unit (CVIMCU). In addition to recovering CABG patients, the CVICU also takes complex vascular surgical patients and overflow medical ICU patients.

Intervention

Nurses that were scheduled to work in the CVICU were given a 15 minute evidence-based IS education. The education session was given in the form of a PowerPoint presentation offered multiple days from 11:00 a.m. to 1:00 p.m. and 11:00 p.m. to 1:00 a.m. for two weeks. The PowerPoint presentation was ten slides in length and contained information from the literature review on IS efficacy after CABG surgery improving IS compliance to prevent postoperative lung complications. Education sessions also included a detailed review on how to correctly use the IS device and hospital policy. The PowerPoint was provided in person by the project lead investigator and nurses were required to attend one education session. After the final education was completed, nurses were provided with QR stickers containing an embedded video on the IS device correct use to enhance patient education. The nurses were instructed to place the QR stickers on incentive spirometry devices given to patients that have undergone CABG surgery.

Measurement Tool

Eltorai et al (2018) has given permission to use their questions created in Redcap that assessed nurses' understanding of IS use and reflects actual implementation of IS use in patient care (see Appendix). Immediately before and following each education session a pretest and posttest was given to nurses containing identical questions. Each test took three to five minutes to complete. There were 19 questions included in this measurement tool; 11 of these measured feelings on IS efficacy requiring nurses to respond from strongly disagree to strongly agree. Eight questions were on IS correct use and technique and were fill in the blank. For secondary outcome of postoperative complication, the EMR was audited for the three months prior to and after the education intervention for nurse documentation of frequency and volume of IS use, patient education teaching record (ETR) on IS use, and incidence of atelectasis and pneumonia for all patients who underwent routine outpatient or inpatient CABG surgery.

Method of Data Collection

Pretests and posttests were taken and collected electronically using Google Forms. A QR code was provided for nurses to take the pretest and posttest. Charts were reviewed three months before and after the education intervention for nursing documentation, IS use, and the number of occurrences of atelectasis and pneumonia, or worsening thereof, were recorded into an an Excel spreadsheet on a password protected computer and transferred to IBM Statistical Package for the Social Sciences (SPSS) for analysis.

Basic patient demographic data including age, sex, presence of hypertension, diabetes, hyperlipidemia, and chronic respiratory illness were recorded. The purpose of this data collection was to directly compare the pre education and post education patients to determine if the groups were statistically different.

Data Collection Timeline

Data collection began two weeks prior to project implementation with chart audits of nursing documentation of patients' IS volume, IS frequency, IS education, incidence of worsening or improving atelectasis, and incidence of pneumonia for the first three postoperative days. Patients that underwent CABG from August 1, 2023 to October 31, 2023 were included in the pre education chart audit group. Patients that underwent CABG from December 1, 2023 to February 28, 2024 were included in the post education chart audit patient group.

Data Analysis

Results were entered into SPSS software through IBM statistics. The nurses' pretest and posttest answers were scored on a Likert scale and the fill in the blank answers were grouped in common variables. Nurses pretest and posttest answers were not normally distributed and required nonparametric tests (Wilcoxin) for statistical analysis. The Wilcoxin pretest and posttest mean ranks were directly compared to evaluate effectiveness and statistical significance of the IS education intervention. IS use data was normally distributed and an independent T test was used to determine statistical significance. Pre-education and post-education patients' postoperative pulmonary complications were compared using a Mann-Whitney U test as these results were also not normally distributed.

Ethical Considerations

Confidentiality was protected by collecting only information needed to assess study outcomes, minimizing to the fullest extent possible the collection of any information that could directly identify subjects, and maintaining all study information in a secure manner. No identifiable data was collected from nurses' pretests and posttests. Secondary data was also collected without any patient identifiers. Data access was limited to study staff. Data and records were kept locked and secured on a password protected computer until completion of the study, after which all data will be destroyed. No reference to any individual participant will appear in reports, presentations, or publications that may arise from the study. This DNP quality improvement project was given Exempt status by UNC Charlotte IRB (IRB-24-0009) and Wake Forest University IRB (IRB-00102356).

CHAPTER 4: RESULTS

After receiving the evidence-based education on IS efficacy and correct use, nurses had an improved knowledge on IS correct use, as well as improved feelings on IS efficacy. As expected, patient IS use also increased and there were less postoperative pulmonary complications following the education intervention.

Nurses Feelings and Attitudes

Nurses had improved feelings on incentive spirometry efficacy following the nurse education. There was a 25% increase of nurses that strongly agreed that IS was essential to patient care. There was an increase of nurses that strongly agreed that IS helps reverse atelectasis (from 37.5 to 95.5%) and prevent pneumonia (from 45.8% to 95.8%). There was also a 62.5% increase of nurses that strongly agreed IS helps reverse pneumonia. For routine use of IS preoperatively and postoperatively, nurses had an increase of from 41.7% to 83.3% and 83.3% to 95.8%, respectively. A Wilcoxon rank test indicated that nine out of 11 post test ranks on feelings concerning incentive spirometry effectiveness were higher than pretest ranks (see Tables 1a-1c).

Nurses Correct Use of Device

Nurses also demonstrated improved understanding of correct use of the IS device following nursing education, with 87.5% of nurses correctly identifying that target inspiratory flow is achieved by having the piston hover in the smiley face of the IS device. The majority of nurses (75% pre-education, 95.8 post-education) understood that patients should use their IS device ten breaths per session. There was a 50% increase of nurses that identified a breath hold as the most important factor in successful IS use. The ideal breath hold of three to five seconds was correctly identified by 87% of nurses. There was less than a 1% difference (70.8% pre-education and 69.6% post-education) of nurses that correctly identified that hourly use was correct hospital policy on IS frequency. A Wilcoxon test indicated that 5 of 7 posttest ranks on knowledge of correct IS use were statistically higher than pretest ranks (see Tables 1a-1c).

Patient Compliance and Population

The pre-education and post-education patient groups were similar demographically. The average patient age was 65.2 years in the pre-education and and 67 in the post-education group. Males made up 79% of patients in the pre-education group compared to 76% in the post-education group. The majority of patients were White: 75% and 79% in each the pre-education and post-education group. The remaining ethnicities were also similar in that 10.2% and 12.2% were Black, and 3% were Hispanic in each the pre-education and post-education groups (see Table 6). The majority of patients also had similar incidence of comorbidities: 87% and 42% of pre-education patients had hypertension and diabetes mellitus respectively, which is similar to the post-education group with 91% and 49%, respectively. The two patient groups were proven to not be statistically different on age, presence of diabetes mellitus, hypertension, or hyperlipidemia as indicated by Mann-Whitney U tests (see Table 11). However, the two groups were statistically different in incidence of chronic respiratory illness ($p= .03$).

Nurses had improved compliance with documenting patient IS use. There was a 43.68% increase in total times that IS was documented in the post-education patient group (see Figure 10). An independent t-test revealed that the IS use increase was statistically significant ($p=.027$). There were also four fewer patients that had no documentation of IS use by postoperative day (POD) three in the post-education group. In regard to postoperative pulmonary complications, there were no patients that developed pneumonia by postoperative three. There were three patients that had improved atelectasis by post operative day three in the pre-education group compared to six in the post-education group (see Figure 11).

CHAPTER 5: DISCUSSION

Although there was significant improvement of nurses' knowledge on IS use, feelings toward IS efficacy, and increased patient compliance, there was not a statistically significant decrease in postoperative complications as expected. Lack of expected decrease in postoperative pulmonary complications is likely from study limitations including small nurse sample size and nurse bias.

The purpose of the nurses' evidence-based education was to improve nurses' knowledge on IS use, improve patient IS compliance, and ultimately decrease postoperative pulmonary complications. The education session proved to be beneficial as there was a statistically significant increase in nurses' compliance with incentive spirometer documentation and nurses' improved knowledge on incentive spirometry use. Nurses also had more positive attitudes towards IS efficacy. Having been provided knowledge and evidence on IS effectiveness, nurses were more diligent in educating patients correctly. A similar study by Saraceni et al. (2022) in which PACU nurses were educated on hospital policy incentive spirometry adherence, there was a post-education increase in incentive spirometry use; however, overall compliance was still low. Contrary to this study's results, which showed nurses had improved knowledge following an education session, the study by Gaffney (2019) showed a decrease in nurses' incentive spirometry knowledge following an education session.

There is inconsistent evidence regarding IS effectiveness at preventing or improving postoperative pulmonary complications after thoracoabdominal surgery. The results of this nurse education intervention give supporting evidence to IS decreasing postoperative pulmonary complications, as there was a slight increase in improved lung aeration by postoperative day three. Despite this increase, the result was not statistically significant ($p= .16$).

Limitations

Although this study strongly supports the benefits of nursing education on improving patient IS compliance and decreasing postoperative pulmonary complications after CABG, it is important to point out several limitations. One limitation is that there was a small sample size of nurses which increased the likelihood of producing a type II error. In addition to the small sample of nurses, the majority of nurses had less than two years of nursing experience which decreases the generalizability of the study. There were nine nurses that had two years or less of nursing experience and five nurses that had three to five years of experience at the time of the nursing education (see Figure 1). Another limitation was bias from the nurses, given the highly positive relationship with the lead investigator. This could have affected the believability of the education session as nurses could have wanted to be favorable to the lead investigator, thus creating false positives. There were also limitations within the hospital's Electronic Medical Record (EMR) in that there was nowhere to document IS education. Furthermore, data collection limited this study's reliability as there were other providers, specifically respiratory therapists, who were also documenting IS use on at least two patients. This shared responsibility made it difficult to assess nursing compliance as a direct result of the nursing education session. Finally, the IS instructional video for patients was under-utilized.

Implications for Nursing Practice

Despite the above limitations, the results of this study illuminate key implications for nursing practice regarding postoperative care of patients that have undergone CABG surgery. Improving patient IS compliance can be beneficial in postoperative recovery by ultimately decreasing pulmonary complications which can affect length of stay, morbidity, and mortality. Another implication for practice is to include respiratory therapists in future quality improvement projects on improving IS compliance and IS education. In this study, respiratory therapists were observed documenting incentive spirometry and educating patients on correct use. It is important to note that documentation and education requirements vary by hospital. This particular hospital requires nurses to educate and document IS use as stated in the hospital policy.

Nurses are required to document several aspects of the care they provide. By the time of the chart audit following intervention, there were several newly hired nurses and new nurse graduates. Staffing shortages certainly contributed to lack of nurse documentation and education. Therefore, assessing nurse staffing in relation to quality of IS education and compliance with IS documentation warrants evaluation. Another implication for practice is to simplify nurse documentation.

Recommendations for Maintaining and Sustaining the Change

One method to maintain and sustain increased nursing and patient compliance of IS use is to require reporting at CVICU rounds. Ongoing discussions to address limitations with documentation and education such as nurse staffing and overall unit acuity. Given the high nurse turnover observed during this study, periodically educating new nurses on hospital IS documentation policy would be beneficial.

To improve research, providing an education session to a larger nurse population would enhance the study results. As some IS documentation was completed by respiratory therapists, including them in future projects would better capture compliance. More research on improving incentive spirometry compliance is needed given that increasing nursing knowledge alone did not have a statistically significant decrease in postoperative pulmonary complications. There is great evidence that incentive spirometry is effective and can decrease pulmonary complications, but without accuracy in tracking compliance, these study results are rendered weak. Stronger evidence will make it easier to translate improving nursing compliance with IS education for increasing patient IS use.

Summary

The primary focus of this study was to improve pulmonary hygiene following CABG surgery through improved IS compliance, with the expectation of decreasing postoperative pulmonary complications. The present study's results mirror Eltorai et al (2019) and Alwekhyan et al. (2021) in that improved patient IS use led to decreased postoperative pulmonary complications. Similarly, improved nurse knowledge increased nursing documentation. Further research is needed to capture true patient IS compliance and improvement in patient understanding after enhanced nursing education. Interdisciplinary teams should be included in IS quality improvement projects including respiratory therapists. Finally, standardization is needed on IS use as nurse responses on ideal daily frequency and ideal daily improvement in volume differed vastly.

Conclusion

Compliance for IS is important to be continued as a part of daily practice. Improving patient outcomes after CABG will reduce the alarming incidence of postoperative pulmonary complications. It will take time and routine reevaluations to solidify improving IS compliance. This perseverance is bound to ensure improved outcomes for patients undergoing CABG surgery.

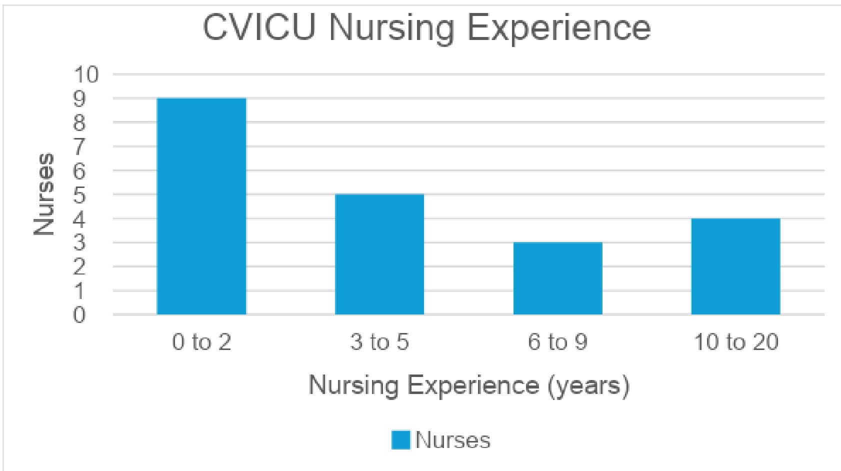

Figure 1: Nursing Experience

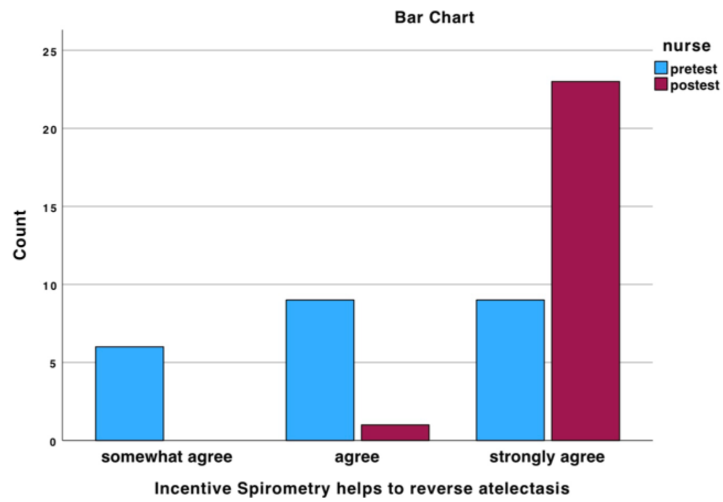

Figure 2: Nurse Feeling on IS helps to reverse atelectasis

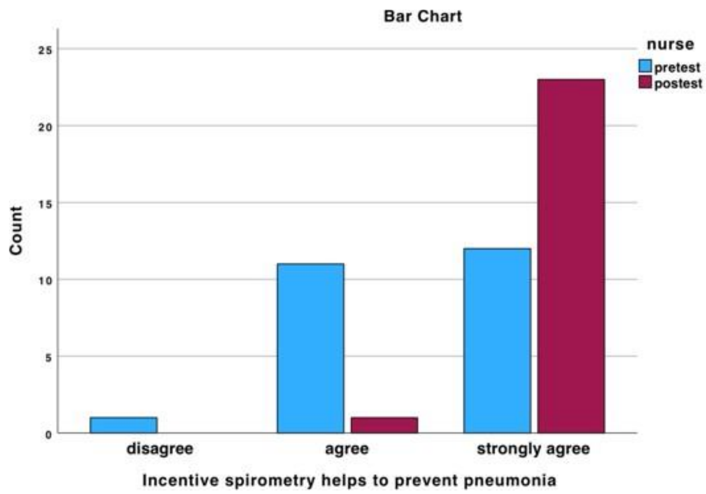

Figure 3: Nurse feelings on IS helps to prevent pneumonia

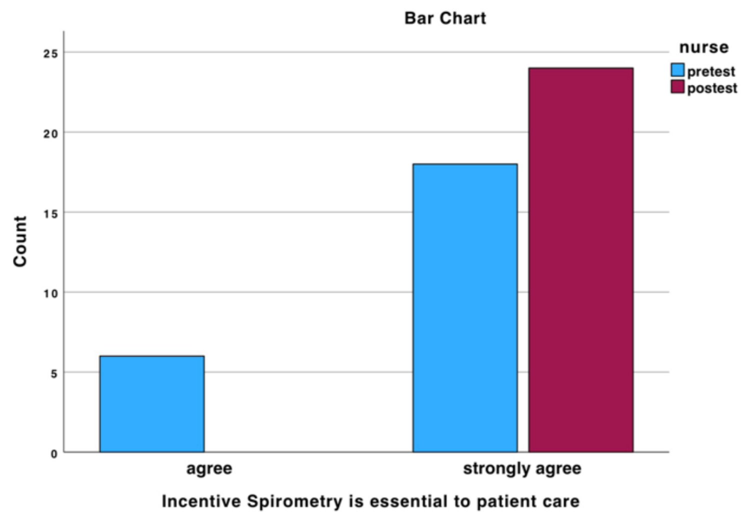

Figure 4: Nurse feelings on IS is essential to patient care

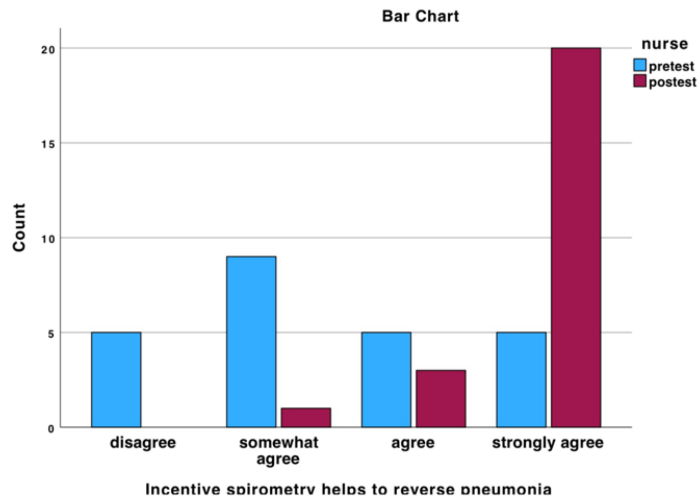

Figure 5: Nurse feelings on IS helps to reverses pneumonia

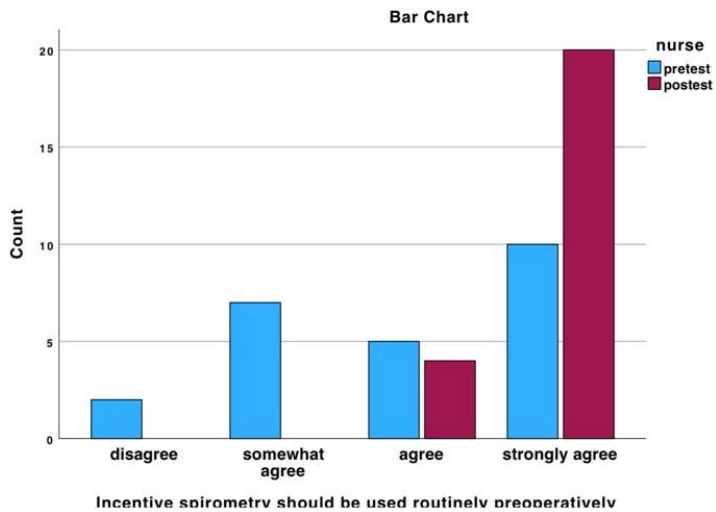

Figure 6: Nurse feelings on IS should be used routinely preoperatively

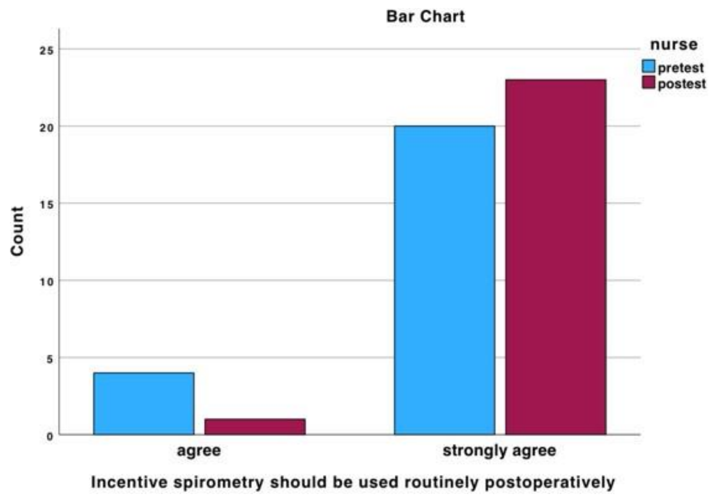

Figure 7: Nurse feelings on IS should be used routine postoperatively

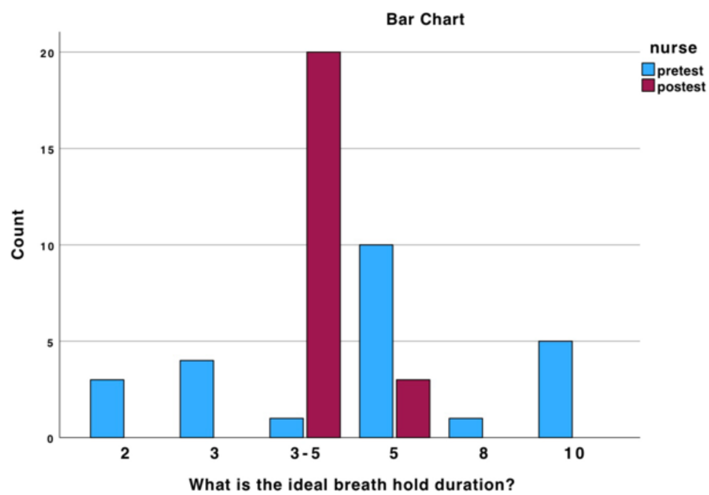

Figure 8: Nurse knowledge on IS Ideal breath hold duration

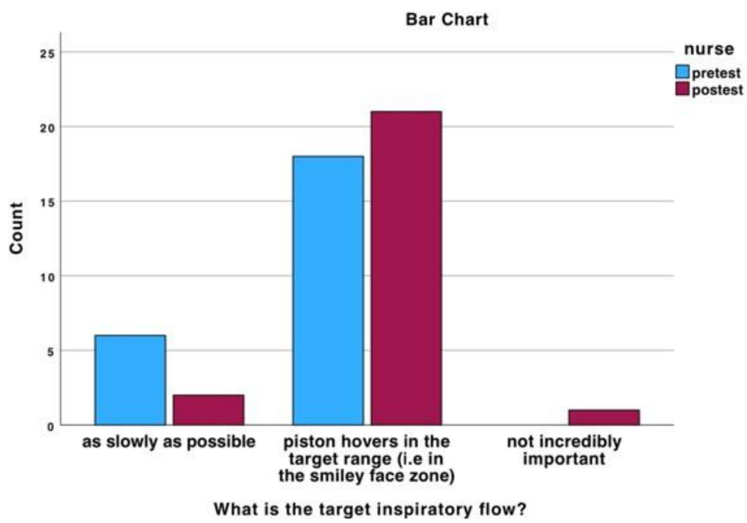

Figure 9: Nurse knowledge on what is the target inspiratory flow

Table 1a: Wilcoxin test results on Nurse pre and post tests

Test Statistics[a]

	POSTIncentive Spirometry is essential to patient care - PREIncentive Spirometry is essential to patient care	POSTIncentive Spirometry improves pulmonary function - PREIncentive Spirometry improves pulmonary function	POSTIncentive spirometry helps to prevent atelectasis - PREIncentive spirometry helps to prevent atelectasis	POSTIncentive Spirometry helps to reverse atelectasis - PREIncentive Spirometry helps to reverse atelectasis
Z	-2.449[b]	-2.236[b]	-1.414[b]	-3.346[b]
Asymp. Sig. (2-tailed)	.014	.025	.157	<.001

Table 1b: Wilcoxin results continued

Test Statistics[a]

	POSTIncentive spirometry helps to prevent pneumonia - PREIncentive spirometry helps to prevent pneumonia	POSTIncentive spirometry helps to reverse pneumonia - PREIncentive spirometry helps to reverse pneumonia	POSTIn general, incentive spirometry is as effective as early ambulation? - PREIn general, incentive spirometry is as effective as early ambulation?	POSTIn general, incentive spirometry is as effective as deep breathing exercises - PREIn general, incentive spirometry is as effective as deep breathing exercises
Z	-3.357[b]	-3.822[b]	-3.466[b]	-3.508[b]
Asymp. Sig. (2-tailed)	<.001	<.001	<.001	<.001

Test Statistics[a]

	POSTIn general, incentive spirometry is as effective as directed coughing - PREIn general, incentive spirometry is as effective as directed coughing	POSTIncentive spirometry should be used routinely preoperatively - PREIncentive spirometry should be used routinely preoperatively	POSTIncentive spirometry should be used routinely postoperatively - PREIncentive spirometry should be used routinely postoperatively	POSTIdeally, how many breaths should a patient take per session? - PREIdeally, how many breaths should a patient take per session?
Z	-3.703[b]	-2.952[b]	-1.342[b]	-2.456[b]
Asymp. Sig. (2-tailed)	<.001	.003	.180	.014

Table 1c: Wilcoxin Result Continued

Test Statistics[a]

	POSTWhat is the ideal breath hold duration? - PREWhat is the ideal breath hold duration?	POSTWhat is the initial target inspiratory volume? (ml) - PREWhat is the initial target inspiratory volume? (ml)	POSTWhat is the ideal daily improvement in inspiratory volume? (ml) - PREWhat is the ideal daily improvement in inspiratory volume? (ml)	POSTIdeally, how often should a patient use his or her incentive spirometry device? - PREIdeally, how often should a patient use his or her incentive spirometry device?
Z	-3.481[c]	-3.404[b]	-1.300[c]	-2.989[c]
Asymp. Sig. (2-tailed)	<.001	<.001	.194	.003

Test Statistics[a]

	POSTWhat is the most important factor for successful incentive spirometry use? - PREWhat is the most important factor for successful incentive spirometry use?	POSTWhat is the target inspiratory flow? - PREWhat is the target inspiratory flow?
Z	-3.441[b]	-1.717[b]
Asymp. Sig. (2-tailed)	<.001	.086

a. Wilcoxon Signed Ranks Test

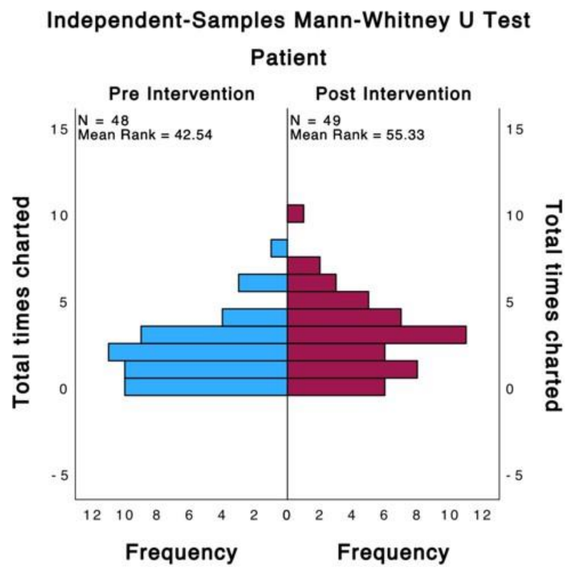

Figure 10: IS frequency pre and post intervention

Table 2: IS Frequency

Statistics

		Preintervention	Postintervention
N	Valid	49	49
	Missing	0	0
Mean		2.1020	3.0204
Std. Deviation		1.81711	2.17457
Skewness		1.124	.746
Std. Error of Skewness		.340	.340
Minimum		.00	.00
Maximum		8.00	10.00
Sum		103.00	148.00

Frequency Table

Table 3: Independent T-test on IS Frequency

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of
		F	Sig.	t
Total times charted	Equal variances assumed	1.089	.299	-2.240
	Equal variances not assumed			-2.244

Independent Samples Test

		t-test for Equality of Means		
			Significance	
		df	One-Sided p	Two-Sided p
Total times charted	Equal variances assumed	95	.014	.027
	Equal variances not assumed	92.992	.014	.027

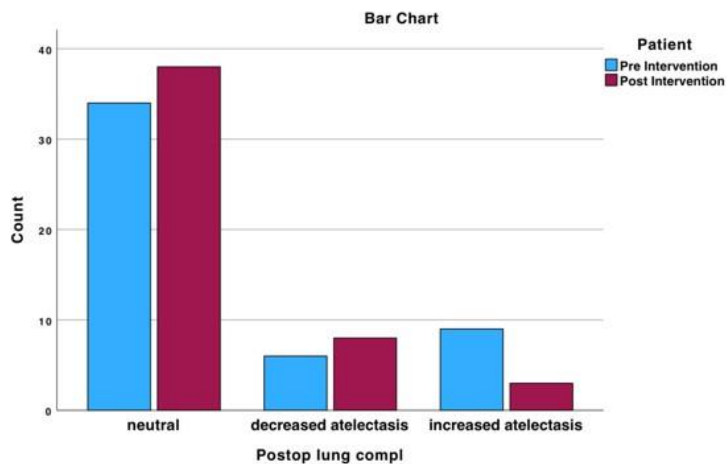

Figure 11: Incidence of Postoperative Lung Complications

Table 4: Incidence of Postoperative Lung Complications

Postop lung compl * Patient Crosstabulation

			Patient	
			Pre Intervention	Post Intervention
Postop lung compl	neutral	Count	34	38
		% within Postop lung compl	47.2%	52.8%
		% within Patient	69.4%	77.6%
		% of Total	34.7%	38.8%
	decreased atelectasis	Count	6	8
		% within Postop lung compl	42.9%	57.1%
		% within Patient	12.2%	16.3%
		% of Total	6.1%	8.2%
	increased atelectasis	Count	9	3
		% within Postop lung compl	75.0%	25.0%
		% within Patient	18.4%	6.1%
		% of Total	9.2%	3.1%
Total		Count	49	49
		% within Postop lung compl	50.0%	50.0%
		% within Patient	100.0%	100.0%
		% of Total	50.0%	50.0%

Table 5a: Mean Ranks of postoperative lung complications

Mann-Whitney Test

Ranks

	Patient	N	Mean Rank	Sum of Ranks
Postop lung compl	Pre Intervention	49	52.95	2594.50
	Post Intervention	49	46.05	2256.50
	Total	98		

Table 5b: Mann Whitney U test post op lung complications

Test Statistics[a]

	Postop lung compl
Mann-Whitney U	1031.500
Wilcoxon W	2256.500
Z	-1.552
Asymp. Sig. (2-tailed)	.121

a. Grouping Variable: Patient

Table 6: Patient Race

			Patient		
			Pre Intervention	Post Intervention	Total
Race	White	Count	37	39	76
		% within Race	48.7%	51.3%	100.0%
		% within Patient	75.5%	79.6%	77.6%
		% of Total	37.8%	39.8%	77.6%
	Black	Count	5	6	11
		% within Race	45.5%	54.5%	100.0%
		% within Patient	10.2%	12.2%	11.2%
		% of Total	5.1%	6.1%	11.2%
	Hispanic	Count	3	3	6
		% within Race	50.0%	50.0%	100.0%
		% within Patient	6.1%	6.1%	6.1%
		% of Total	3.1%	3.1%	6.1%
	Asian	Count	3	1	4
		% within Race	75.0%	25.0%	100.0%
		% within Patient	6.1%	2.0%	4.1%
		% of Total	3.1%	1.0%	4.1%
	Native American	Count	1	0	1
		% within Race	100.0%	0.0%	100.0%
		% within Patient	2.0%	0.0%	1.0%
		% of Total	1.0%	0.0%	1.0%
Total		Count	49	49	98
		% within Race	50.0%	50.0%	100.0%
		% within Patient	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

Table 7: Patient Incidence of Hypertension

HTN * Patient Crosstabulation

			Patient		
			Pre Intervention	Post Intervention	Total
HTN	yes	Count	43	45	88
		% within HTN	48.9%	51.1%	100.0%
		% within Patient	87.8%	91.8%	89.8%
		% of Total	43.9%	45.9%	89.8%
	no	Count	6	4	10
		% within HTN	60.0%	40.0%	100.0%
		% within Patient	12.2%	8.2%	10.2%
		% of Total	6.1%	4.1%	10.2%
Total		Count	49	49	98
		% within HTN	50.0%	50.0%	100.0%
		% within Patient	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

Table 8: Patient Incidence of Diabetes Mellitus

DM * Patient Crosstabulation

			Patient		
			Pre Intervention	Post Intervention	Total
DM	yes	Count	21	24	45
		% within DM	46.7%	53.3%	100.0%
		% within Patient	42.9%	49.0%	45.9%
		% of Total	21.4%	24.5%	45.9%
	no	Count	28	25	53
		% within DM	52.8%	47.2%	100.0%
		% within Patient	57.1%	51.0%	54.1%
		% of Total	28.6%	25.5%	54.1%
Total		Count	49	49	98
		% within DM	50.0%	50.0%	100.0%
		% within Patient	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

Table 9: Patient Incidence of Chronic Respiratory Illness

CRI * Patient Crosstabulation

			Patient		
			Pre Intervention	Post Intervention	Total
CRI	yes	Count	16	4	20
		% within CRI	80.0%	20.0%	100.0%
		% within Patient	32.7%	8.2%	20.4%
		% of Total	16.3%	4.1%	20.4%
	no	Count	33	45	78
		% within CRI	42.3%	57.7%	100.0%
		% within Patient	67.3%	91.8%	79.6%
		% of Total	33.7%	45.9%	79.6%
Total		Count	49	49	98
		% within CRI	50.0%	50.0%	100.0%
		% within Patient	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

Table 10: Patient Incidence of Hyperlipidemia

HLD * Patient Crosstabulation

			Patient		
			Pre Intervention	Post Intervention	Total
HLD	yes	Count	42	45	87
		% within HLD	48.3%	51.7%	100.0%
		% within Patient	85.7%	91.8%	88.8%
		% of Total	42.9%	45.9%	88.8%
	no	Count	7	4	11
		% within HLD	63.6%	36.4%	100.0%
		% within Patient	14.3%	8.2%	11.2%
		% of Total	7.1%	4.1%	11.2%
Total		Count	49	49	98
		% within HLD	50.0%	50.0%	100.0%
		% within Patient	100.0%	100.0%	100.0%
		% of Total	50.0%	50.0%	100.0%

Table 11: Mann Whitney U Test for patient demographics

Test Statistics[a]

	Sex	Race	HTN	DM	CRI	HLD
Mann-Whitney U	1151.500	1135.500	1151.500	1127.000	906.500	1127.000
Wilcoxon W	2376.500	2360.500	2376.500	2352.000	2131.500	2352.000
Z	-.482	-.633	-.664	-.605	-2.992	-.955
Asymp. Sig. (2-tailed)	.630	.527	.507	.545	.003	.340

Test Statistics[a]

	Postop lung compl
Mann-Whitney U	1075.500
Wilcoxon W	2300.500
Z	-1.148
Asymp. Sig. (2-tailed)	.251

a. Grouping Variable: Patient

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APPENDIX

Incentive Spirometry Test

1. Incentive Spirometry is essential to patient care *Mark only one oval.*

- Strongly Agree
- Agree
- Somewhat agree
- Disagree
- Strongly Disagree

2. Incentive Spirometry improves pulmonary function *Mark only one oval.*

- Strongly agree
- Agree
-
-
-

Somewhat agree

Disagree

Strongly disagree

3. Incentive spirometry helps to prevent atelectasis *Mark only one oval.*

- Strongly Agree
- Agree
- Somewhat agree
- Disagree
- Strongly Disagree

4. Incentive Spirometry helps to reverse atelectasis *Mark only one oval.*

- Strongly agree
- Agree
- Somewhat agree
- Disagree
- Strongly disagree

5. Incentive spirometry helps to prevent pneumonia *Mark only one oval.*

- Strongly agree
- Agree
- Somewhat agree
- Disagree
- Strongly disagree

6. Incentive spirometry helps to reverse pneumonia *Mark only one oval.*

- Strongly agree
- Agree
- Somewhat agree
- Disagree
- Strongly disagree

7. In general, incentive spirometry is as effective as early ambulation?

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Disagree
- Strongly disagree

8. In general, incentive spirometry is as effective as deep breathing exercises

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Disagree

Strongly disagree

9. In general, incentive spirometry is as effective as directed coughing *Mark only one oval.*

- Strongly agree
- Agree
- Somewhat agree
- Disagree
- Strongly disagree

10. Incentive spirometry should be used routinely preoperatively *Mark only one oval.*

- Strongly agree
- Agree
- Somewhat agree
- Disagree
- Strongly disagree

11. Incentive spirometry should be used routinely postoperatively *Mark only one oval.*

- Strongly agree
- Agree
- Somewhat agree
- Disagree
-

Strongly disagree

12. Ideally, how often should a patient use his or her incentive spirometry device?

Mark only one oval.

- every 30 min
- every 60 min
- every 90 min
- every 2 hr every
- every 4 hr every
- 6hr

13. Ideally, how many breaths should a patient take per session?

14. What is the ideal breath hold duration?

15. What is the initial target inspiratory volume? (ml)

16. What is the ideal daily improvement in inspiratory volume? (ml)

17. What is the most important factor for successful incentive spirometry use?

Mark only one oval.

- Achieving target inspiratory Bow
- Achieving target inspiratory volume
- Breath hold

18. What is the target inspiratory flow?

Mark only one oval.

- As slowly as possible
- As quickly as possible
- Piston hovers in the target range (i.e in the smiley face zone)
- Not incredibly important