The Implementation of the Teach-Back Method to Improve Patient Understanding with the Nuss Procedure

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Abstract

Successful management of pediatric procedures is challenging. Many procedures have a detailed list of pre-procedural requirements and post-procedural pain control regimens. Patients and families often get lost in the many requirements needed before scheduling the procedure and often delay intervention. This delay can cost both the families and facility time and money but often leave the patient needlessly suffering. Inadequate pain control results in emergency room (ER) visits or hospital admissions for acute postoperative pain management. The opioid epidemic has significantly impacted postoperative opioid prescriptions at discharge. The limited prescriptions available after discharge, paired with inadequate understanding and support of discharge postoperative instructions by the family, result in increased acute postoperative pain management admissions. Postoperative pain is the leading cause of hospital readmissions within 48 hours of discharge. These ER visits are typically for issues that are easily addressed at home. Teach-back methods have shown to be the cornerstone of education, resulting in knowledge gained and increased pain regimen adherence. A literature review exploring current evidence regarding postoperative pain control and interventions coupled with teach-back was conducted to address this concern, and an evidenced-based intervention is proposed.

Keywords: Postoperative pain, pain management, patient education, teach-back, mobile application in patient care

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Successful management of pediatric postoperative pain is challenging. Inadequate pain control results in emergency room (ER) visits or hospital admissions for acute postoperative pain management. Postoperative ER visits and hospital admissions are common and costly affecting hospital resources, patient satisfaction, and outcomes.

Problem Statement

The United States (US) is facing an opioid epidemic. There is an emphasis on postoperative opioid prescriptions as a contributing factor, resulting in efforts to limit and reduce prescriptions at discharge (Hernandez-Boussard et al., 2017). The limited prescriptions available after discharge, paired with inadequate family understanding and support of discharge postoperative instructions, result in increased acute postoperative pain management admissions. Patients and caregivers who are unsupported through surgery phases have delayed intervention, unanswered questions, ER visits, or hospital readmissions for pain. Surgical delays, knowledge deficits, and pain control issues impact the patient, the provider, and the organization with an estimated cost of approximately $17 billion to Medicare in a single year (Hernandez-Boussard et al., 2017). Pediatric patients with pectus excavatum (PE) are at high risk for ER visits for inadequate postoperative pain control following a Nuss procedure. PE is the most common anomaly of the anterior chest wall described as a concaved chest, is most common in males and has a 40% familial history (Pilegaard, 2015). The Nuss procedure is a minimally invasive repair which involves adding one or two bars under the sternum and is considered the standard technique for correction of PE (Pilegaard, 2015).

Postoperative pain is the leading cause of hospital readmissions, estimated at 10% to 19% (Hernandez-Boussard et al., 2017). Manworren et al. (2017) studied ER visits for postoperative pain, and during the two-year study period, 6% of ER visits were for acute postoperative pain within seven days of surgery; 26% of these were within 48 hours. These ER visits are typically for issues that are easily addressed at home.

Purpose and Rationale

Postoperative ER visits and hospital readmissions for acute postoperative pain management decrease patient satisfaction and consume hospital resources. The importance of addressing this issue is to determine a safe solution to pediatric postoperative pain control, to help increase patient satisfaction, and to reduce unnecessary resource consumption.

The purpose of this Doctorate of Nursing (DNP) project is to identify preoperative interventions for pediatric patients who undergo a Nuss procedure that will help improve postoperative pain and decrease the need for ER visits and readmission to the hospital.

Background/Significance

Teach-Back Method

When educating patients, it has been found valuable to couple the education with a teach-back method. The teach-back method is an evidence-based intervention strategy used to improve communication with patients and families (Klingbeil, & Gibson, 2018). This method allows the patient to teach back what they have understood from their education. Effective teach-back modules should include the use of open-ended questions to help identify misunderstandings and engages families in the process of preparing to take care of their children (Klingbeil, & Gibson, 2018). This process allows the person to evaluate if the patient has received and understood the proper education and correct any misunderstandings.

Opioid Epidemic

The US currently faces an opioid epidemic. The Centers for Disease Control and Prevention (CDC) (2020) reported US providers prescribed 168,158,611 opioids in 2018. There were 46,802 opioid overdose deaths in 2018, accounting for 69.5% of all drug overdose deaths (CDC, 2020). Responding to the crisis, Arizona began tracking and publishing raw data for the public to highlight the epidemic. In the state of Arizona, between June 15, 2017 and February 6, 2020, there have been 4,001 suspected opioid deaths, 34,647 suspected opioid overdoses, 1,342 infants diagnosed with neonatal abstinence syndrome, 71,071 doses of naloxone dispensed, and 21,541 doses of naloxone administered (Arizona Department of Health Services [AZDHS], n.d.). An alarming 34.7% of suspected opioid overdoses in the previous month had received the prescription opioids from 10 or more prescribers in the past year (AZDHS, n.d.). Although providers are educated regarding limiting opioid use for pain control, there were 268,646 opioid prescriptions dispensed in Arizona in January 2020 (AZDHS, n.d.). This epidemic is causing health care providers to look for alternative measures to control their patients' pain.

ER Visits and Hospital Admissions for Postoperative Pain

Pain is one of the most common factors for individuals to seek care. The World Health Organization (WHO, 2015) has identified pediatric pain treatment as a public health concern with damaging effects, including extended length of stay, slower healing, and emotional trauma and suffering. Pain accounts for 80% of all pediatric ER visits in the US (Thomas, 2015). The American Academy of Pediatrics (AAP, 2011) indicates the leading cause of pain in the pediatric population is acute, including necessary medical procedures, and is often inadequately treated.

Pediatric patients having a Nuss procedure

The pediatric patient who has a surgical intervention, including the Nuss procedure for correction of pectus excavatum, is at high risk for postoperative pain. The Nuss procedure has many preoperative criteria and the postoperative management can be complicated, making it challenging for patients and families to navigate the entire surgical course.

Preoperative education for postoperative pain management

Currently, the education for patients and families at the project site includes a multi-page packet describing the pre-procedural requirements and a postoperative pain management regimen. The intervention for this project is a PowerPoint presentation that details the current standard surgical process at the project site with emphasis on the pre-procedural requirements and the post-operative pain management regimen coupled with a teach-back session. Simple interventions, including describing pain management strategies and preoperative education on postoperative pain, lead to better surgical outcomes (Singhal, & Jerman, 2018).

Current management

Singhal and Jerman (2018) explain that the current process for the Nuss procedure includes preoperative evaluation, chest radiographs, computed tomography (CT) or magnetic resonance image (MRI), advanced cardiopulmonary testing, electrocardiogram (ECG), echocardiography, allergy testing, postoperative education, and procedure counseling. The discharge instructions include a follow-up appointment, postoperative medications, postoperative restrictions, and recommendations for when to go in for an ER visit.

Reduce postoperative ER visits and hospital readmissions for pain management

The outcome is measured by comparing the percentage of correct answers on the 8-question questionnaire and the percentage of correct answers on the 3 open-ended question teach-back session to assess for knowledge gained. Education coupled with teach-back methods

is the cornerstone for increasing patient knowledge. With increased knowledge, the patients and families are more prepared to navigate the surgical process involved with the complex Nuss procedure.

Internal Evidence

Data collection is ongoing at a large free-standing pediatric hospital in the Southwestern US regarding pain-related ER visits and hospital readmissions. Currently, the hospital is investigating a strategy to identify the visits and admissions in the acute postoperative period and by surgical type, including the Nuss procedure. Increasing ER visits or hospital admissions for postoperative pain management indicates low patient satisfaction.

PICOT Question

The current healthcare environment focuses on pain management without overprescribing opioid medications. This environment has led to the PICOT question, in pediatric patients who undergo the Nuss procedure, whether participation in a standardized educational module explaining the surgical procedure and postoperative pain control with teach-back methods compared to current care increase patient comprehension with the surgical process?.

Search Strategy

A thorough review of the most current evidence was completed to answer the PICOT question. The three databases extensively searched were CINAHL, Medline, and PubMed. Qualitative studies were selected to understand the concepts (see Appendix A, Table A1).

CINAHL

The first CINAHL search used the Nuss procedure and pain and hospital, which resulted in the initial eight articles. The limiting criteria of peer-reviewed, and between the years 2015 and 2020 was entered, which resulted in the final five articles. Another CINAHL search that

used teach-back and surgical resulted in 20 articles. The limiting criteria of peer-reviewed and between the years 2015 and 2020 was entered, which resulted in the final 13 articles. Another CINAHL search used mobile application and surgical and management, which resulted in the initial 24 articles. The limiting criteria of peer-reviewed and between 2015 and 2020 were entered, which resulted in the final 19 articles. The last CINAHL search used app and pain management and postoperative, which resulted in the first three articles. The limiting criteria of peer-reviewed and between the years 2015 and 2020 was entered, resulting in the final three articles.

Medline

The first Medline search used Nuss procedure and pain and hospital, which resulted in 47 articles. The limiting criteria of peer-reviewed and between the years 2015 and 2020 was entered, which resulted in the final four articles. Another Medline search was conducted using the terms teach-back and surgical, which resulted in 44 articles. The limiting criteria of peer-reviewed and between the years 2015 and 2020 was entered, which resulted in the final three articles.

PubMed

The first PubMed search used Nuss procedure and pain and hospital, which resulted in 118 articles. The limiting criteria of peer-reviewed and between the years 2015 and 2020 was entered, which resulted in the final 50 articles. Another PubMed search was conducted using the terms teach-back and surgical, which resulted in 14,509 articles. The limiting criteria published during the past five years were entered, which resulted in the final 5,454 articles. Another PubMed search was conducted using terms mobile application and surgical and management,

which resulted in 261 articles. The limiting criteria of peer-reviewed and published during the past five years were entered, which resulted in the final 19 articles.

Critical Appraisal and Synthesis

Ten quantitative studies were retained for this review. Studies included five randomized control trials, one cohort retrospect study, one cross-sectional study, one pilot study, one small group interview study, and one system database analysis. Fineout-Overholt and Melnyk's (2009) rapid critical appraisal was used to determine the evidence's quality and strength. All studies included patients undergoing procedures. All selected studies were limited in bias and included a significant degree of demographic information, including age, race, and sex. Studies took place in various locations, including Canada, China, France, Netherlands, and the U. S.

This initial literature review demonstrates the importance of postoperative pain management and explores using a mobile app to address postoperative pain which was the projects initial focus. The final project focused on the education of patients and their families regarding the pre-procedural requirements and postoperative pain management regimen of the Nuss procedure. The second literature review demonstrated that the education coupled with teach-back methods is the EBP for knowledge gained. Current evidence suggests that patient education is essential for successful postoperative pain management. Education is valuable when coupled with either teach-back or mobile apps for postoperative pain management (see Appendix A, Table A2). There is also literature to support the use of nonopioid pain management options such as nerve blocks (see Appendix A, Table A2).

Conceptual Framework and EBP Model

The IOWA model is selected for this project because it fits its characteristics. Hanrahan et al. (2019) describe the IOWA model as a bridge between the questions triggered in the clinical

setting and the need for practice change. This model identifies sustained outcomes, which are disseminated as evidence-based practice (see Appendix B, Figure 1). The IOWA model begins by identifying a triggering issue or opportunity for change, which determines the PICOT question. Then a team is then formed to assemble, appraise and synthesize the body of evidence (Schaffer et al., 2013). If there is sufficient evidence, then a practice change is designed and piloted. The pilot results determine if the change is appropriate for integration into practice. This point in time is when reevaluation and changes are made to allow for the best version of the change to be implemented into practice (Schaffer et al., 2013).

Patient and family understanding of the Nuss procedure preoperative and postoperative surgical course is the identified triggering issue for this DNP project. After completing an initial search of the triggering issue, the PICOT question determined is, in pediatric patients who undergo the Nuss procedure, does participation in a standardized educational module explaining the surgical procedure and postoperative pain control with teach-back methods compared to current care increase patient comprehension and satisfaction with the surgical process? A local children's hospital has determined that improving patient comprehension and satisfaction with the Nuss procedure is a top priority in improving surgical care. A team has assembled to appraise and synthesize the body of evidence to determine if there is sufficient evidence to promote a practice change by implementing patient educational modules and teach-back methods to aid in understanding the surgical process and postoperative pain management. The initial process will begin by developing education modules on preoperative requirements, the intraoperative procedure, and postoperative management. An 8 question questionnaire will be given to determine baseline knowledge regarding the Nuss procedure and operative management. The families and patients will then be provided educational modules on various topics related to

the procedure and postoperative pain management. The patient and families will then participate in a teach-back process to assess comprehension and correct misunderstandings. During a teach-back session, the patients and families will then answer three open-ended questions to assess knowledge gained and evaluate changes to implement or incorporate into the educational modules. The feedback from the education modules and teach-back sessions will be used in the future for a mobile application that will be integrated into the clinical practice.

The Star Model of Knowledge Transformation (see Appendix B, Figure 2) was selected to guide the evidence-based project implementation process (Stevens, 2012). The Star Model uses five essential steps; (1) discovery research, (2) evidence summary, (3) translation to guidelines, (4) practice integration, and (5) process, outcome evaluation. Guiding the project within the IOWA framework, the Star Model of Knowledge Transformation begins with discovery research for the project regarding ER visits, readmissions to the hospital for postoperative pain, the use of apps within healthcare, and the use of a teach-back component. The data collected was evaluated and the evidence summary was created supporting the project PICOT question. The translation guidelines were determined, and a plan for practice integration was developed and implemented using educational modules and teach-back methods for patient comprehension. After the educational modules and teach-back sessions were completed, the program was evaluated for success and improvement areas to create change and improve the patient and family educational process. Feedback from the DNP project and education modules can be used in the future for designing a mobile application. Aligning with the IOWA framework, the Star Model's cyclical design allows for constant reevaluation and changes to occur within the intervention, allowing for evidence-based practice for dissemination.

Methods

Ethical Considerations and Human Subject Protection

Ethical considerations and human subject protection were considered, and appropriate measures were taken. CITI training was completed by those working with the sample population and the principal investigator. Two Institutional Review Boards (IRB) approved the project; Phoenix Children's Hospital (PCH) exempt with Arizona State University (ASU) deferring to the primary institution IRB. The risk was determined as minimal. There was no change in existing practice or standard of care for patients. Primary risks included a breach of data confidentiality (a result of the study). Patients filled out an 8 question questionnaire with a designated number randomly assigned, which they will use to identify themselves in the teach-back methods. An implied consent statement was provided on the top of the questionnaire, and participants had the right to leave the program at any time. Data was stored in a locked filing cabinet in the Chest Wall Anomaly Clinic at the project site. The data and any identifier were destroyed after study completion following the project's culmination and final presentation in compliance with PCH's Data Retention Policy.

Setting and Population

PCH Chest Wall Anomaly Clinic, located at the main hospital, was the only site. The Chest Wall Anomaly Clinic is considered the best destination, which employs the top Nuss procedure doctors worldwide, completing about 150 Nuss procedures annually. Bi-annually they welcome doctors around the world to attend their PE symposium, where they educate on the best evidence-based practice available.

The sample included patients between the ages of 10 and 18, presenting to the Chest Wall Anomaly Clinic, diagnosed with pectus excavatum. Participants were not capped at a maximum

number. The sample population was recruited between December 1, 2020 – March 30, 2021, using the essential eligibility criteria:

- Inclusion Criteria:
    - Diagnosed with Pectus Excavatum
        - Eligible for the corrective Nuss procedure
        - English speaking patients and families
    - Exclusion Criteria:
        - Determined ineligible for corrective Nuss procedure
        - Did not select to undergo corrective Nuss procedure

The final sample included one 17-year-old male.

Project Description

This project is a social/behavioral study including patients presenting to the Chest Wall Anomaly clinic, diagnosed with pectus excavatum. Patients and families were asked at their initial pectus excavatum appointment to voluntarily participate in the educational program with the teach-back process to learn about the NUSS procedure process. Willing participants took an 8-question questionnaire to assess baseline knowledge. The patient and family watched an educational module followed by a teach-back session with the investigator. The teach-back session consisted of three open-question teach-back session which were analyzed to determine knowledge gained from the educational modules.

Instrumentation, Data Collection, and Data Analysis

Patients were given a flyer to voluntarily participate in an educational program to review pre-procedural NUSS procedure requirements at their initial NUSS procedure evaluation. Participants who voluntarily participated were given an 8-question questionnaire to evaluate their

knowledge regarding the pre-procedural requirements needed before the NUSS procedure. Questionnaire scores were evaluated and recorded for data analysis. Participants then watched the pre-recorded, online educational modules discussing the NUSS pre-procedural requirements. Once the educational modules were completed, the participants completed a teach-back session with Adrianne Barrante, an ASU student, either during their appointment by Zoom or through a Zoom session scheduled later. Three open-ended questions were asked of participants and scored using a rubric to assess knowledge comprehension of NUSS pre-procedural requirements from the educational modules. The questions were as follows:

1. After watching the educational modules, can you describe to me three things related to the NUSS procedure that you learned?
2. Can you describe at least three requirements that are required before your son/daughter can have the NUSS procedure?
3. What are some techniques that you learned about in the modules to help your son/daughter transition to pill medications prior to the NUSS procedure, and why is this important?

The 8-question questionnaire and the three open-ended questions were analyzed based on percent correct to compare the data collected with the two tools and assess for knowledge gained. Further, this was used to determine clinical significance since the sample size was too small to be statistically significant.

Budget and Funding Received

There was no funding received to complete this study. PCH staff was paid for any participants who participated in the project through scheduling PE appointment times and meetings to synchronize and complete the project. ASU students volunteered to complete the project creating the education module, completing IRB, and implementing the project.

Results

Outcomes

The sample included one subject 17-year-old male. The pre_score questionnaire consisted of 8 questions. Each question was a True/False choice or A-D choice option. The final 8 question questionnaire used was developed and had high face validity. The subject answered four questions correctly, resulting in 50% correct (see Appendix C, Figure 1). The post-score consisted of 3 open-ended questions. The answers were given a point value using a rubric (see Appendix D, Table A). Patient 1 answered all three open-ended questions correctly, resulting in 100% correct (see Appendix C, Figure 2).

Statistical and Clinical Significance

The sample size n=1 does not allow for statistical testing or significance, however, the 50% increase between pre-score and post-score suggests a clinically significant difference. This clinical significance supports an increase in knowledge gained after watching the educational module. The knowledge gained through the teach-back methods may help to increase patient and family understanding of the surgical procedure, help with surgical procedures' timeliness, and eventually help to decrease ER visits for postoperative pain control.

Discussion

Summary

Successful management of pediatric procedures is challenging. Often there are many pre-procedural requirements and post-procedural pain regimens to follow, which leave patients and families confused. Teach-back coupled with education has been shown to be an effective evidenced-based intervention for gaining knowledge. In this DNP project, the patient sample had a 50% knowledge gained when education was coupled with teach-back. This led to a clinically significant result helping to further support the evidence that teach-back methods are effective

way to help with knowledge comprehension and retention for patients undergoing surgical procedures which are similar findings by Klingbeil & Gibson (2018).

Limitations and barriers/challenges

Limitations, barriers, and challenges during this study had a significant impact on the sample size. This study was delayed getting through the IRB process, not occurring until January 11, 2021. Delayed approval by the IRB shortened the implementation phase pushing the dates provided by project site down to 3 days. A longer implementation phase would have helped this project to show statistical significance.

A second barrier encountered, was timing of the educational implementation. The Nuss procedure is primarily a pediatric procedure and is often completed on winter and summer school breaks. This study missed both periods impacting the sample size and the results.

A third barrier occurred after the first implementation date, resulting in a pause in the project. Early engagement of key stakeholders was established but unfortunately two key physicians involved in the pectus clinic were not included in early discussions. This created some unintended miscommunication towards the end of project and led to a review of the project by one of the physicians. Revisions to the educational modules were made based on feedback received but approval was never given to continue the project, so only one participant was able to be enrolled. In the future, making sure that all key stakeholders are involved from the start of the project would help to improve the success of the intervention.

Project Impact

This DNP project aimed to identify an effective and accessible means of pre-procedural and post-procedural requirements and pain management education to a pediatric population undergoing the corrective Nuss procedure through the use of teach-back methods. The targeted

education did increase the subject's knowledge regarding the Nuss procedure, pre-procedure requirements, and postoperative pain management. The small sample size limits the generalizability of the results but does provide optimism that teach-back methods are effective for patients undergoing procedures in helping with knowledge comprehension and retention. Future projects could examine the impact of the education modules on timing of the Nuss procedure and postoperative ER readmission rates for pain control.

Project Intervention Sustainability

Results from this project are limited because of the small sample size. The clinical significance from the one patient can be conveyed to the Chest Wall Anomaly clinic to help with ongoing educational efforts with teach-back methods to help improve the surgical process. Future data from the educational modules can be used for the development of a mobile application if the clinical site chooses.

Conclusion

Postoperative pain is hard to control and is a known cause for ED visits and hospital readmissions. Providers are challenged to limit opioid use, placing more significance on patient education. Current evidence suggests that patient education is essential for successful postoperative pain management and is useful when coupled with teach-back methods. This DNP project attempted to evaluate the importance of patient education and teach-back methods on the pediatric surgical Nuss procedure and postoperative pain management. Although the sample size was small, clinical significance was achieved adding to the body of knowledge that teach-back methods for patient education continue to be an effective evidenced-based method to deliver patient education and enhance patient comprehension and knowledge.

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Appendix A

Evaluation and Synthesis Tables

Table A1

Evaluation Table

Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
Billings et al., (2018). Pediatric ED visits for uncontrolled pain and postoperative added all tonsillectomy patients **Funding:** No funding noted **Bias:** No bias has claimed **Country:** US	Deductive theory	**Design:** Pediatric health information system database analysis P**urpose:** Identify demographic variables related to ED returns	**N**: 1 **n**: 861 (EG) **Setting:** 2459 patients with ED visit after adenotonsillectomy **Sample Demographics:** No significant difference between EG and CG.	**IV:** Adenotonsillectomy **DV1:** Postoperative ED visit **DV2**: Opioid administration	Descriptive statistics, Categorical and Regression analysis	SAS v 7.1 Bivariate comparisons using Chi-square. Data were entered into multiple logistic regression analysis models ($P<0.05$)	Pediatric ED revisits for postoperative pain after adenotonsillectomy were the most common ambulatory surgical procedure. Opioid pain management was provided by ED.	**LOE**: II **Strengths:** Large sample population **Weaknesses:** Limited by lack of clinical granularity, disease severity, and etiologic information detailed in database **Harm:** There was no harm by this research. **Utility to the PICOT:** This

Key: **BTPV**-bilateral thoracic paravertebral; **CG**-control group; **DV**-dependent variable; **DVPRS**-defense and veterans pain rating scale; **e**-ethnicity; **EBP**-evidence-based practice; **ED**-emergency department; **EG**-experimental group; **f**-female; **IV**-independent variable; **LOE**-level of evidence; **m**-male; **N**-number of studies; **n**-number of participants; **PCA**-patient controlled analgesia; **PCIA**-patient-controlled intravenous analgesia; **PE**-pectus excavatum; **RCT**-random control group; **SAS**-Statistical Analysis System; SPSS-Statistical Package for Social Sciences; **UG-ICNBs**-ultrasonography-guided bilateral intercostal nerve blocks; **U.S.**-United States of America; **w**-white

Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
								supports the high number of ED visits for postoperative pain management
Birnie et al., (2019). iCanCope postop: User-centered design of a smartphone-based app for self-management of postoperative pain in children and adolescents **Funding:** No funding received **Bias:** No bias claimed **Country:** Canada	Deductive theory	**Design:** RCT **Purpose:** Describe how the principles of user-centered design was applied to the development of iCanCope PostOp a smartphone-based postop pain management app and determine benefit	**N**: 1 **n:** 19 (pediatric patients) (EG) **n**: 19 parents (EG) **n**: 32 (healthcare providers) (CG) **Setting:** 70 postoperative pediatric patients (ages 8 to 18 years old), parents, and healthcare providers at The Hospital for Sick Children and Shriners Hospitals for Children, Canada	**IV:** Smartphone app **DV1**: Postsurgical assessment of pain	Pain care algorithm reported by smartphone app	Delphi surveys	Successful algorithm and app usage showed improved pain control with the EG group vs the CG group.	**LOE:** I **Strengths:** Inclusion of pediatric patients, parents, and health care providers from 2 pediatric tertiary care centers **Weaknesses:** Limited by a lack of comprehensiveness of all types of surgeries **Harm**: There was no harm by this research. Obtained consent and assent as appropriate

Key: **BTPV**-bilateral thoracic paravertebral; **CG**-control group; **DV**-dependent variable; **DVPRS**-defense and veterans pain rating scale; **e**-ethnicity; **EBP**-evidence-based practice; **ED**-emergency department; **EG**-experimental group; **f**-female; **IV**-independent variable; **LOE**-level of evidence; **m**-male; **N**-number of studies; **n**-number of participants; **PCA**-patient controlled analgesia; **PCIA**-patient-controlled intravenous analgesia; **PE**-pectus excavatum; **RCT**-random control group; **SAS**-Statistical Analysis System; SPSS-Statistical Package for Social Sciences; **UG-ICNBs**-ultrasonography-guided bilateral intercostal nerve blocks; **U.S.**-United States of America; **w**-white

Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
			Sample Demographics: No significant difference between EG & CG. m: 32 (EG) m: 7 (CG) f: 26 (EG) f: 25 (CG)					**Feasibility:** Part of a larger existing app, iCanCope, means it takes less resources increasing at feasibility and sustainability. **Utility to the PICOT**: This supports the benefit of an app on postoperative pain.
Debono et al., (2016). Postoperative monitoring with a mobile application after ambulatory lumbar discectomy: An effective tool for spine surgeons	Deductive theory	**Design:** Pilot study **Purpose**: Assess the feasibility of mobile app for postoperative monitoring after outpatient lumbar discectomy.	**N:** 1 **n:** 36 (EG) **n:** 24 (CG) **Setting:** 60 patients undergoing ambulatory lumbar discectomy from an outpatient surgical center in France.	**IV:** Smartphone app **DV1**: Patient postoperative in-person visits **DV2**: Patient satisfaction	Self-reported through mobile app, and 3-month postoperative interview and follow-up office visit	Quantitative and qualitative analysis was performed Descriptive statistics were generated	EG had increased satisfaction rates and decreased postoperative in-person visits when compared to the CG.	**LOE**: III **Strengths:** Good follow up, quantitative and qualitative analysis **Weaknesses**: Limited by the initial survey of the patient's immediate postoperative recovery

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
Funding: No funding noted. **Bias:** No bias claimed. **Country:** France			**Sample Demographics:** No significant difference between EG & CG.					became less relevant as time went on, small sample size **Harm:** There was no harm by this research. **Utility to the PICOT**: This supports benefit of an app to manage postoperative pain
Hernandez-Boussard et al., (2017). The fifth vital sign: Postoperative pain predicts 30-day readmissions and subsequent ED visits **Funding:** Veterans Affairs	Deductive theory	**Design:** Retrospect cohort study **Purpose:** Investigate the association of inpatient postoperative pain trajectories and their association with 30-day readmission to the ED	**N:** 1 **n:** 179,218 (EG) **Setting:** 179,218 patients undergoing inpatient surgeries with 2-day postoperative length of stay or greater within the Veterans Affairs Health	**IV:** Postoperative pain trajectories **DV1**: Unplanned readmission after hospital discharge **DV2**: Post-discharge ED visits within 30-days of surgery **DV3**: Post-discharge	Veterans Affairs Surgical Quality Improvement Program Data Group-based modeling of longitudinal data was used to develop pain trajectories	PROC TRAJ in SAS v 9.4 (Chi-square test) and ANOVA	EG research showed that addressing pain control expectations before discharge may help reduce surgical readmissions and high-paying categories.	**LOE**: II **Strengths:** Large sample population and a national cohort **Weaknesses**: Population is all from Veterans Affairs database and may not be generalizable to other

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
Health Services Research & Development Grant. **Bias:** No bias claimed **Country:** US.			Care System over 121 centers **Sample Demographics:** No significant difference between EG and CG. F-11,000	complications within 30-days of surgery				populations, and the population is known to have high drug dependence rates, depression, and posttraumatic stress disorder which can affect pain management and opioid tolerance **Harm:** There was no harm by this research. **Utility to the PICOT**: Promotes the benefit of preop education and predischarge education can affect postsurgical readmissions to the ER

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
Highland et al., (2019). Feasibility of app-based postsurgical assessment of pain, pain impact, and regional anesthesia effects: A Pilot randomized controlled trial. **Funding:** No funding received. **Bias:** No bias claimed **Country:** US.	Deductive theory	**Design:** RCT **Purpose:** Examine the feasibility and utility of a smartphone app, mCare, for assessing pain, pain impact, and peripheral nerve block effects and patients.	**N:** 1 **n:** 24 (EG) **n:** 26 (CG) **Setting**: 50 patients at a military treatment facility undergoing same-day surgery **Sample Demographics:** No significant difference between EG and CG. Mean age: 45.36 (CG), 39.48 (EG) m: 16 (CG), f: 13 (EG). e w: 14 (CG), 17 (EG).	**IV**: Smartphone app **DV1**: Postsurgical assessment of pain **DV2**: Pain impact **DV3**: Regional anesthesia affects	DVPRS reported by phone call or by smartphone app	Bivariate tests (Mann-Whitney U, v^2, and t-tests)	EG had better pain control over the past 24 hours then CG (P= 0.005)	**LOE:** I **Strengths:** RCT **Weaknesses**: Small group size **Harm:** No harm done by the study **Utility to the PICOT**: Supports the use of an app to manage postoperative pain
Mengqiang et al., (2018). Comparison of ultrasonogra	Deductive theory	**Design:** RCT **Purpose**: Compare analgesic	**N:** 1 **n:** 34 (EG) **n:** 28 (CG) **Setting:** 62 pediatric	**IV**: Use of UG- ICNBs **DV1**: Postoperative pain	Faces Pain Scale	SPSS version 18.0 and GraphPad Prism5 (Mann-	EG is more effective than CG for postoperative analgesia in children who	**LOE:** I **Strengths:** RCT blinded

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
phy-guided bilateral intercostal nerve blocks and conventional patient-controlled intravenous analgesia for pain control after the Nuss procedure in children: A prospective randomized study **Funding:** No funding received **Bias**: No bias claimed **Country**: China		effects of UG–ICNBs with those of conventional patients controlled intravenous analgesia PCIA on acute pain after the Nuss procedure for PE repair in children	patients scheduled for the Nuss procedure at Xinhua Hospital **Sample Demographics:** No significant difference between EG and CG. Mean age: 7.8 (CG), 8.6 (EG). Sex (m:f): 15:13 (CG), 19:15 (EG). Weight 28.9 kg (CG), 30.9 kg (EG).	**DV2:** Postoperative opioid usage **DV3**: Length of hospital stay		Whitney, and t-tests)	undergo the Nuss procedure (p=<0.001)	**Weaknesses:** Nuss procedure pain varied with degree of deformity and patient age, and pain was managed with opioid and not benzodiazepines or antiepileptics to counter muscle spasms or neuropathic components. **Harm:** No harm done by this study **Utility to the PICOT:** EBP for postoperative Nuss procedure pain management
Qi, et al., (2014). A prospective randomized observer-	Deductive theory	**Design:** RCT **Purpose:** Evaluate	**N:** 1 **n:** 34 (EG) **n:** 28 (CG)	**IV:** Use of ultrasound-guided BTPV	Faces Pain Scale	SPSS (Mann-Whitney, and t-tests)	EG is more effective than CG for postoperative analgesia in	**LOE:** I **Strengths:** RCT

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
blinded study to assess postoperative analgesia provided by an ultrasound-guided bilateral thoracic paravertebral block for children undergoing the Nuss procedure **Funding:** No funding received **Bias**: No bias claimed **Country:** China		the effectiveness of the ultrasound-guided BTPV block for providing postoperative pain control in children undergoing the Nuss procedure	**Setting:** 30 pediatric patients scheduled for the Nuss procedure at West China Hospital of Sichuan University **Sample Demographics:** No significant difference between EG and CG. Mean age: 7.8 (CG), 8.6 (EG), Sex (m:f): 15:13 (CG), 19:15 (EG) Weight: 28.9 kg (CG), 30.9 kg (EG).	**DV1**: Postoperative pain **DV2:** Postoperative opioid usage **DV3:** Postoperative attempt of PCA pump usage			children who undergo the Nuss procedure (p=<0.01)	**Weaknesses:** Small group size **Harm:** No harm done by this study **Utility to the PICOT:** Supports the use of an app to manage postoperative pain
Raval et al., (2017). Pediatric patient and caregiver preferences in the	Patient-Centered	**Design:** Small group break out interviews **Purpose:** Evaluate	**N:** 1 **N:** 9 (EG) **N:** 7 (CG) **Setting:** 16 patients and their providers	**IV:** Smartphone app **DV1:** Treatment goals	Data will be self-reported one month by interview using prompts and probes to facilitate discussion.	Thematic analysis	EG benefited from the use of the app but with different features when compared to the CG.	**LOE:** III **Strengths:** Adapted app to appeal to different age

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
development of a mobile health application for management of surgical colorectal conditions **Funding**: Children's Healthcare of Atlanta, Emory University, and Georgia Institute of Technology **Bias**: No bias claimed **Country:** US.		and foster self-management techniques, enhance communication between patient and provider, improve symptom tracking, and serve as a method of data collection to better inform treatment protocols	were in rolled in the Bowel Management "Boot Camp" program hosted by the Pelvic Anorectal Care program at Children's Healthcare of Atlanta **Sample Demographics:** No significant difference between EG & CG.	**DV2:** Current medical practices **DV3:** Current electronic device use **DV4:** Ideal application characteristics **DV5:** Barriers to usage				groups and caregivers. **Weaknesses:** Limited by the level of evidence, and small sample size **Harm:** There was no harm by this research. Obtained verbal consent and assent as appropriate. **Utility to the PICOT:** This supports benefit of an app adaptable to different age groups
Thomas et al., (2015). Pediatric pain management in the ED: The triage	Deductive theory	**Design:** Descriptive, cross-sectional survey **Purpose:** Describe	**N:** 1 **n:** 147 (EG) **Setting:** 147 triage nurses at three Canadian pediatric ED	**IV:** Timeliness in treating pain **DV1:** Knowledge of pain management modalities	Novel survey tool Paper-based survey was administered	Mean, median, standard deviation, and interquartile range.	Triage-initiated pain protocols have been shown to decrease time to analgesia and increase the rate of	**LOE:** III **Strengths:** Addresses pain management in ED, use of statistical software

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
nurses' perspective **Funding:** No funding noted. **Bias:** No bias claimed **Country:** Canada		the triage pain treatment protocols used, knowledge of pain management modalities, and barriers and attitudes towards implementation of pain treatment protocols	(Stollery Children's Hospital, IWK Health Centre, and Children's Hospital of Eastern Ontario **Sample Demographics:** No significant difference between EG & CG.	**DV2:** Barriers and attitudes towards implementation of pain treatment protocols		One-way analysis of variance and the Kruskal-Wallis test, Fisher exact test, X^2 tests. SAS for windows V 9.2 ($p<0.05$)	provision to children with pain.	**Weaknesses:** Surveys are inherently limited by recall bias **Harm:** There was no harm by this research. **Utility to the PICOT:** EBP for pediatric pain management at the ED
Van der Meij et al., (2016). Substitution of usual perioperative care by eHealth to enhance postoperative recovery in patients undergoing general surgical or gynecologic	Deductive theory	**Design:** RCT single-blinded **Purpose:** Evaluate whether an eHealth care program can improve perioperative health care in patients	**N:** 1 **n:** 173 (EG) **n:** 171 (CG) **Setting: 344** patients on the waiting list for a laparoscopic cholecystectomy, inguinal hernia surgery, or laparoscopic adnexal surgery for benign	**IV:** Smartphone app, activity tracker, website **DV1:** Accelerated recovery **DV2:** Reduction in costs	Data will be self-reported one month before surgery, and one week, 3 weeks, 6 weeks, 3 months, and 6 months after surgery by electronic questionnaires, telephone, or mail.	SPSS (t-tests, Mann-Whitney U tests, Chi-square tests, or Fisher exact tests)	EG resumed normal activities sooner with lower costs in comparison to the CG.	**LOE:** I **Strengths:** RCT single-blinded study and multiple imputation, bootstrapping, and multilevel analysis **Weaknesses:** Limited by the results have not been heterogeneity

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
al procedures: Study protocol of a randomized controlled trial **Funding:** No funding received **Bias:** No bias claimed **Country:** Netherlands		undergoing commonly applied abdominal surgical procedures leading to accelerated recovery and to a reduction in costs in comparison to usual care.	indication from 7 different teaching hospitals in the Netherlands **Sample Demographics:** No significant difference between EG & CG.					of surgical procedures, carried out over 7 hospitals which may vary in care that the CG receives, and baseline activity tracker is only used for 1 week prior to surgery which may not be an accurate account of their baseline **Harm:** There was no harm by this research. Obtained consent and assent as appropriate. **Utility to the PICOT:** This supports the benefit of an app for preoperative and

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Citation	Theory/Conceptual Framework	Design/Method	Sample/Setting	Major Variables & Definitions	Measurement/Instrumentation	Data Analysis	Findings Results	Level/Quality of Evidence; Decision for practice/application to practice
								postoperative management.

Key: **BTPV**-bilateral thoracic paravertebral; **CG**-control group; **DV**-dependent variable; **DVPRS**-defense and veterans pain rating scale; **e**-ethnicity; **EBP**-evidence-based practice; **ED**-emergency department; **EG**-experimental group; **f**-female; **IV**-independent variable; **LOE**-level of evidence; **m**-male; **N**-number of studies; **n**-number of participants; **PCA**-patient controlled analgesia; **PCIA**-patient-controlled intravenous analgesia; **PE**-pectus excavatum; **RCT**-random control group; **SAS**-Statistical Analysis System; SPSS-Statistical Package for Social Sciences; **UG-ICNBs**-ultrasonography-guided bilateral intercostal nerve blocks; **U.S.**-United States of America; **w**-white

Table A2

Synthesis Table

	Billings, K., et al.	Birnie, K., et al.	Debono, B., et al.	Hernandez-Boussard, T., et al.	Highland, K., et al.	Mengqian, L., et al.	Qi, J., et al.	Raval, M., et al.	Thomas, D., et al.	Van der Meij, E., et al.
Study Characteristics										
Year	2018	2019	2016	2017	2019	2018	2014	2017	2015	2016
Design/LOE	SDA/II	RCT/I	PS/III	RCS/II	RCT/I	RCT/I	RCT/I	SGI/III	CSS/III	RCT/I
Setting	US.	Canada	France	U.S.	US.	China	China	US.	Canada	Netherlands
IV										
Timeliness in treating pain									x	
Mobile application/website		x	x		x			x		x
Activity tracker										x
Pain expectation education				x						
Adenotonsillectomy	x									
Use of UG-ICNBs						x				
Use BTPV block							x			
DV										

Key: **BTPV**-bilateral thoracic paravertebral; **CG**-control group; **DV**-dependent variable; **DVPRS**-defense and veterans pain rating scale; **IV**-independent variable; **LOE**-level of evidence; **mngmt**-management; **PCA**-patient controlled analgesia; **PS**-pilot study; **RCS**-retrospective cohort study; **RCT**-random control group; **SDA**-system database analysis; **SGI**-small group interviews; **UG-ICNBs**-ultrasonography-guided bilateral intercostal nerve blocks; **U.S.**-United States of America

	Billings, K., et al.	Birnie, K., et al.	Debono, B., et al.	Hernandez-Boussard, T., et al.	Highland, K., et al.	Mengqian, L., et al.	Qi, J., et al.	Raval, M., et al.	Thomas, D., et al.	Van der Meij, E., et al.
Postoperative pain		x			x	x	x			
Knowledge of pain mngmt									x	
Accelerated recovery					x	x				x
Reduction of costs										x
Opioid administration	x					x	x			
Postoperative PCA usage							x			
Postoperative visits	x		x	x						
Patient satisfaction			x							
Treatment goals								x		

Key: **BTPV**-bilateral thoracic paravertebral; **CG**-control group; **DV**-dependent variable; **DVPRS**-defense and veterans pain rating scale; **IV**-independent variable; **LOE**-level of evidence; **mngmt**-management; **PCA**-patient controlled analgesia; **PS**-pilot study; **RCS**-retrospective cohort study; **RCT**-random control group; **SDA**-system database analysis; **SGI**-small group interviews; **UG-ICNBs**-ultrasonography-guided bilateral intercostal nerve blocks; **U.S.**-United States of America

Appendix B

Models and Frameworks

Figure 1

IOWA Model Map

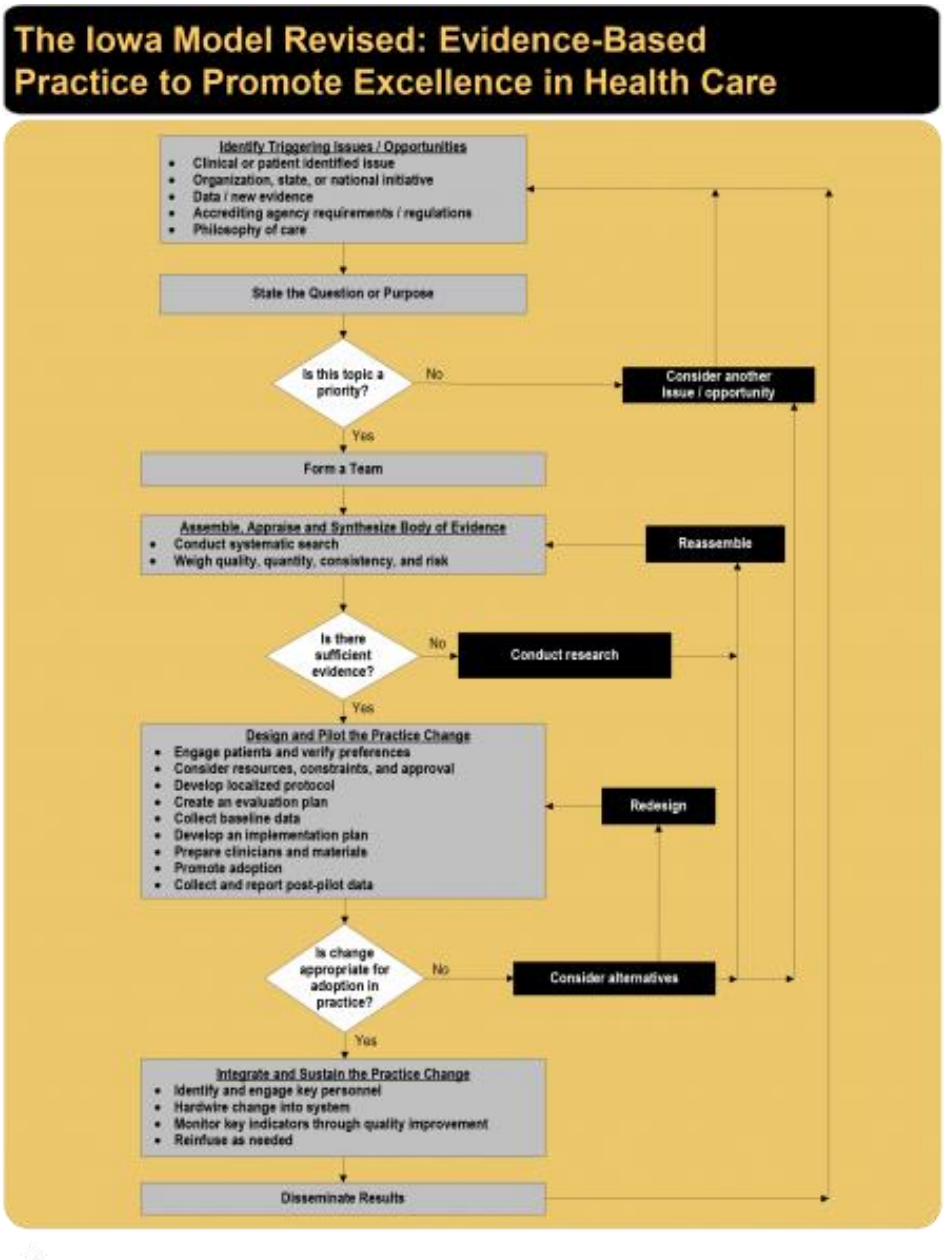
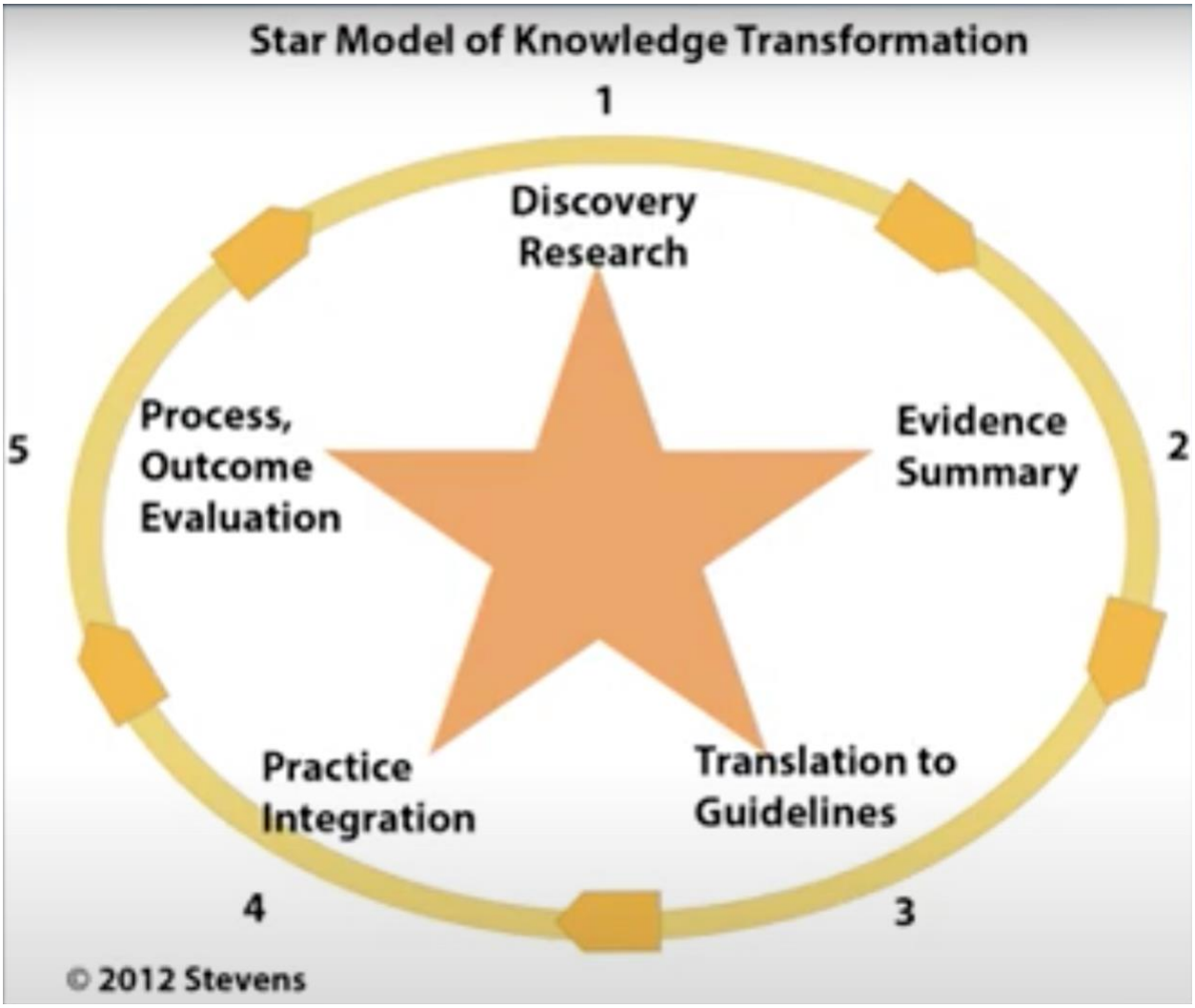


Figure 2

The Star Model of Transformation Cycle



Appendix C

Data Evaluation

Figure 1

8-question Questionnaire: Baseline knowledge

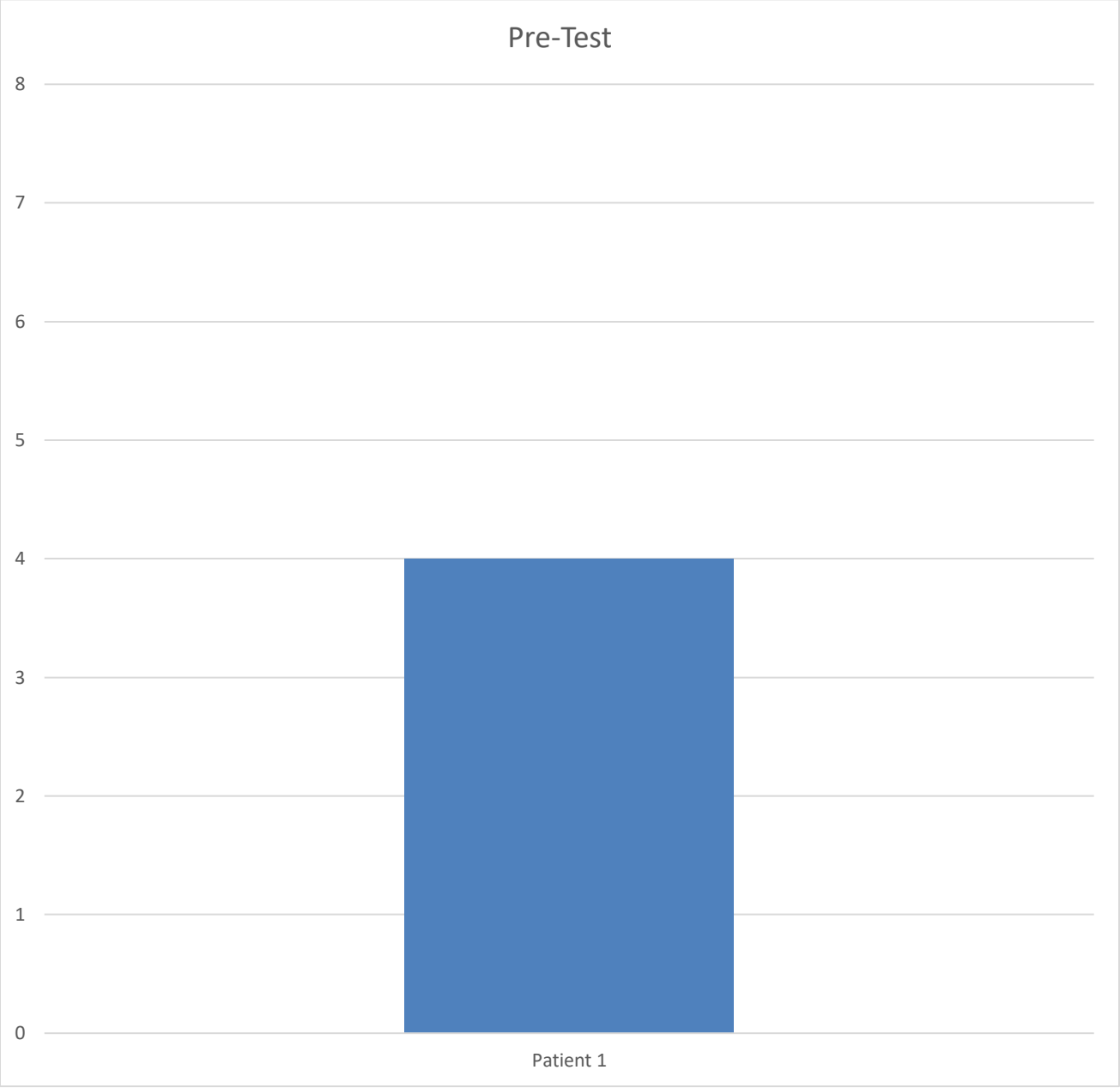
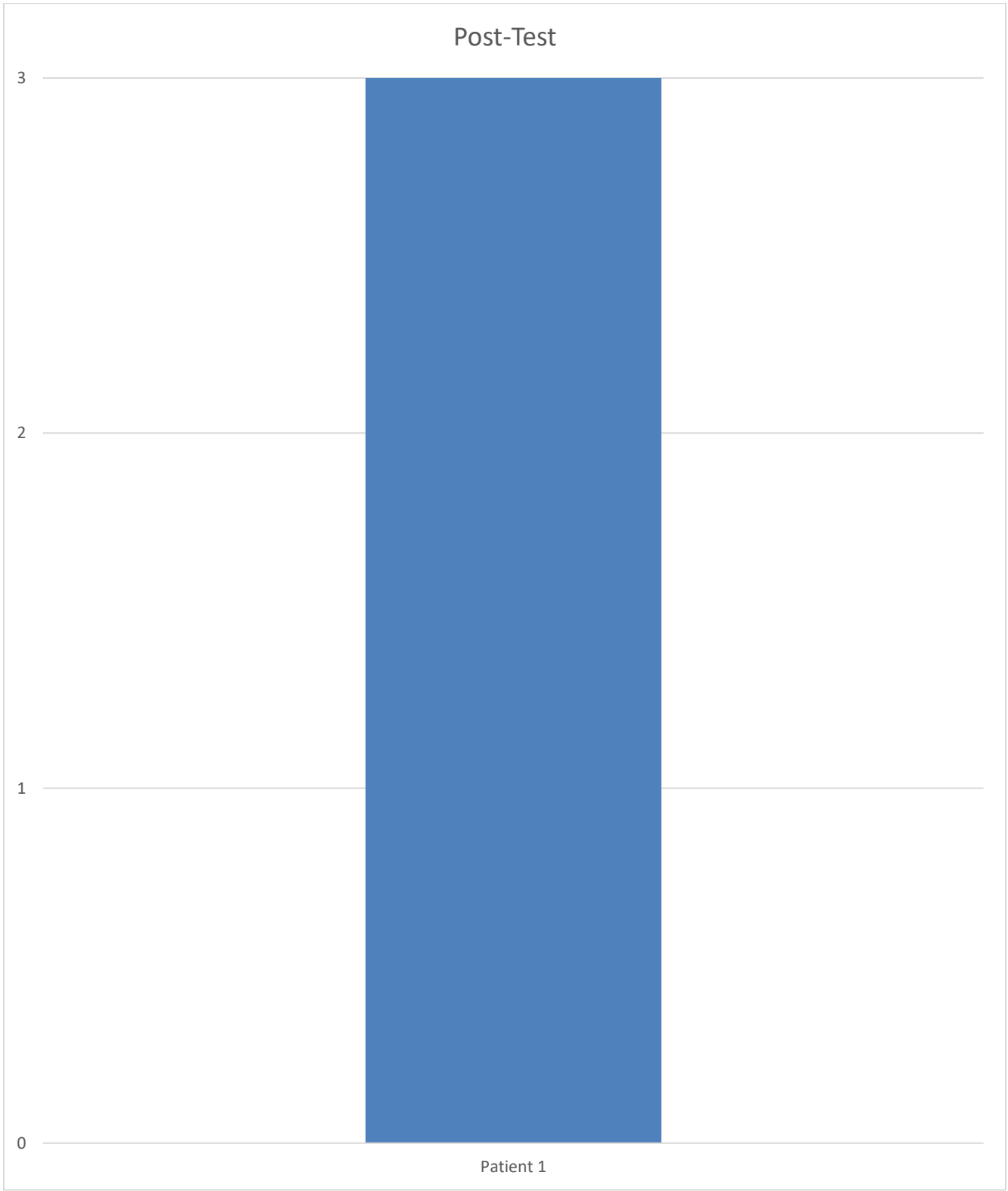


Figure 2

3 Open-ended question teach-back: Knowledge gained



Appendix D

Teach-Back Grading Criteria

Table A

Grading Evaluation Table

Teach-Back Grading Criteria				
Criteria	**Ratings**			**Points**
Question #1	2 points: Mastery Answers correctly with full comprehension	1 point: Progressing Answers partially correct missing some key details	0 points: Emerging Answers incorrectly	
Question #2	2 points: Mastery Answers correctly with full comprehension	1 point: Progressing Answers partially correct missing some key details	0 points: Emerging Answers incorrectly	
Question #3	2 points: Mastery Answers correctly with full comprehension	1 point: Progressing Answers partially correct missing some key details	0 points: Emerging Answers incorrectly	