Pediatric Postoperative Nausea and Vomiting: Assessing the Impact of Evidence-Based Practice Change

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Postoperative nausea and vomiting (PONV) is an unpleasant complication following anesthesia and surgical procedures experienced by both adults and children. Compared with adults, children are 2 times more likely to experience PONV. Many studies have identified and independently validated risk factors associated with the development of PONV in the pediatric population. Chief among these are patient age greater than 3 years, surgical duration greater than 30 minutes, surgical type, and a history of PONV. The purpose of this evidence-based practice change was to investigate if preoperative documentation of a patient's PONV history will lower PONV rates postoperatively. A PONV history assessment tab was created to aid in the documentation of the patient's PONV history, and a retrospective chart review was conducted 2 months before and 2 months after the practice change. A total of 2,279 preintervention cases were compared with 2,006 postintervention cases. Rates of PONV dropped 22%, from 153 preintervention cases to 120 postintervention cases, demonstrating a significant (P = .0043) decrease in PONV rates following a patient's reported history of PONV. Documentation of a patient's PONV history preoperatively led to a decrease in postoperative rates of PONV.

Keywords: Pediatric, postoperative nausea and vomiting, risk assessment

The issue of postoperative nausea and vomiting (PONV) is not new. What was once referred to as a "big little problem" in the early 1990s is now quite substantial.[1,2] A serious complication, PONV has been associated with a higher mortality rate in both the adult and pediatric populations.[3] Although rarely fatal, PONV has been associated with increased patient dissatisfaction and discomfort, dehydration, electrolyte disturbances, prolonged discharge from the recovery unit, unanticipated hospital admissions, prolonged hospital stays, wound dehiscence, aspiration pneumonia, esophageal rupture, and increased healthcare costs.[3]

On average, children experience 2 times the rate of PONV compared with adults.[4-6] A systematic review concluded that the rate of PONV in children ranged from 42% in low-risk patients to as high as 80% in high-risk patients.[4,7] Kovac[8] ranked PONV as the fourth most common cause of unexpected hospital admissions in pediatric surgical patients. In a more recent survey, patients reported that vomiting ranks higher than pain as the most feared and unpleasant outcome following surgery.[9,10]

The etiology of PONV in children is complex and multifactorial.[1,6,8,11] Multiple studies have identified surgical time greater than 30 minutes, a history of motion sickness or PONV, age greater than 3 years, use of inhalational anesthetics, opioid administration, and type of surgery as the biggest influence on the development of PONV.[3,7,12,13] Although some factors cannot be adjusted (age and surgery type), other factors can be modified (intravenous anesthesia over inhalational anesthesia, opioid-sparing techniques) to mitigate the development of PONV.

Several independent predictors of PONV in both the adult and pediatric populations have been identified by the American Society of Anesthesiologists.[14] In adults, independent predictors of PONV include female gender, a patient history of PONV, a patient history of motion sickness, nonsmoking status, and the use of perioperative opioids.[15] For the pediatric population, independent predictors of PONV include age greater than 3 years, surgical type, surgical length, a patient or family history of motion sickness, and a patient or family history of PONV.[15] The American Society of PeriAnesthesia Nurses stresses that a patient's baseline risk for PONV should be objectively assessed via a validated risk score based on independent predictors.[15]

Multiple preoperative screening tools such as the Eberhart score, the Koivuranta score, and the Apfel score, have been developed and validated to aid in identifying these risk factors.[1,14] However, these particular screening tools are specific to the patient population and cannot be reliably used in the pediatric population because of poor prognostic abilities. In response, the Society of Ambulatory Anesthesia guidelines advocate for the use of a simplified screening tool to evaluate baseline risk factors in the pediatric population.[14,15]

Use of a simplified predictive PONV score identifies surgical patients at low, medium, and high risk. This alerts

Risk factor	Apfel score[1]	Koivuranta score	POVOC score[4,10]
Female gender	X	X	
History of PONV	X	X	X
History of motion sickness	X	X	X
Nonsmoker	X	X	
Planned postoperative opioid	X		
Duration of surgery > 60 min		X	
Duration of surgery > 30 min			X
Age > 3 y			X
Strabismus surgery			X
Family history of PONV/motion sickness			X

Table 1. Risk Scoring Systems for Postoperative Nausea and Vomiting
Abbreviations: PONV, postoperative nausea and vomiting; POVOC, postoperative vomiting in children.

healthcare practitioners to the potential need for antiemetic therapy and influences the likelihood that the appropriate treatment regimen is selected. Preoperative identification has been shown to significantly decrease the rate of occurrence of PONV and to improve patient outcomes.[12,16]

However, provider practice surrounding the preoperative identification of PONV risk factors has been described as disorganized and inconsistent.[9] This is attributed to a lack of knowledge among healthcare providers regarding risk factors and PONV screening tools.[9,17] Many practitioners and institutions do not regularly employ an evidence-based PONV scoring system despite documented benefits and current guideline recommendations.[9]

In 2000, a randomized double-blind placebo-controlled trial was conducted to determine the weighted cost that a single episode of nausea and/or vomiting can have on the US healthcare system.[18] The median cost per episode of nausea was $194, and the median cost per episode of emesis was $303.[18] Direct and indirect costs were included, and many of the expenses were attributed to the need for more hospital-based services and staff as opposed to medication prices.[18]

The use of a PONV risk scoring system has the potential to decrease the frequency of PONV in midrisk to high-risk populations and can avoid the potential side effects associated with administration of prophylactic antiemetics in low-risk patients.[1,9,10,14-16] Identification of potential PONV risk factors can also result in a decrease in the direct and indirect financial costs of PONV.[18]

Currently there are 3 risk scoring systems available for use in clinical practice (Table 1). The Apfel and Koivuranta Scoring systems are indicated for adult patients, whereas Eberhart's postoperative vomiting in children (POVOC) scoring system is meant for use in pediatric patients.[6,9,14,18]

Literature Review

• ***Search Method.*** The purpose of a search for evidence was to answer the following PIOT (patient, intervention, outcome, time) clinical question: In children undergoing nonemergent surgery (P), what are effective screening tools (I) to predict postoperative nausea and/or vomiting (O) within 24 hours of surgery (T)? To identify all available evidence, the author conducted a review using the MEDLINE, Cochrane, Cumulative Index to Nursing & Allied Health Literature (CINAHL), Joanna Briggs Institute (JBI) Evidence-based Practice, and the National Guideline Clearinghouse databases. The search string consisted of free-text phrases and medical subject heading (MeSH) indexing terms: (*ped** OR *child** OR *you** OR *preschoo** OR *Adolescen** OR *teen** AND *post** *nausea and vomiting* OR *PONV* OR *post** *nausea* OR *post** *vomiting* AND *predict** OR *assess**). For identification of additional and potentially relevant data sources, each article that matched the PIOT criteria was examined along with its respective reference lists. Studies referenced in matching articles were reviewed for relevance and were included if matching the PIOT criteria.

Limits included defining the population term *pediatrics*. For purposes of this search, *pediatrics* is defined as ages 2 to 18 years. The rationale for this is that children younger than 2 years may present with an increased likelihood of vomiting caused by medical conditions, such as pyloric stenosis. Additionally, children aged up to 2 years do not tend to have a fully developed chemoreceptor trigger zone, one of the main pathways for development of postoperative nausea and/or vomiting.[8] The search was also restricted to human subjects studies. For maximal data return, the search was not limited to peer-reviewed articles or English-only articles. Figure 1 presents the flow of the search process.

• ***Search Results.*** A total of 383 articles were found via the databases, and another 10 articles were discovered from the reference lists from other studies. This search uncovered a clinical practice guideline based on a systematic review.[15] After final elimination of articles synthesized in the review, 5 cohort studies and a 2016 integrative review were retained for analysis.

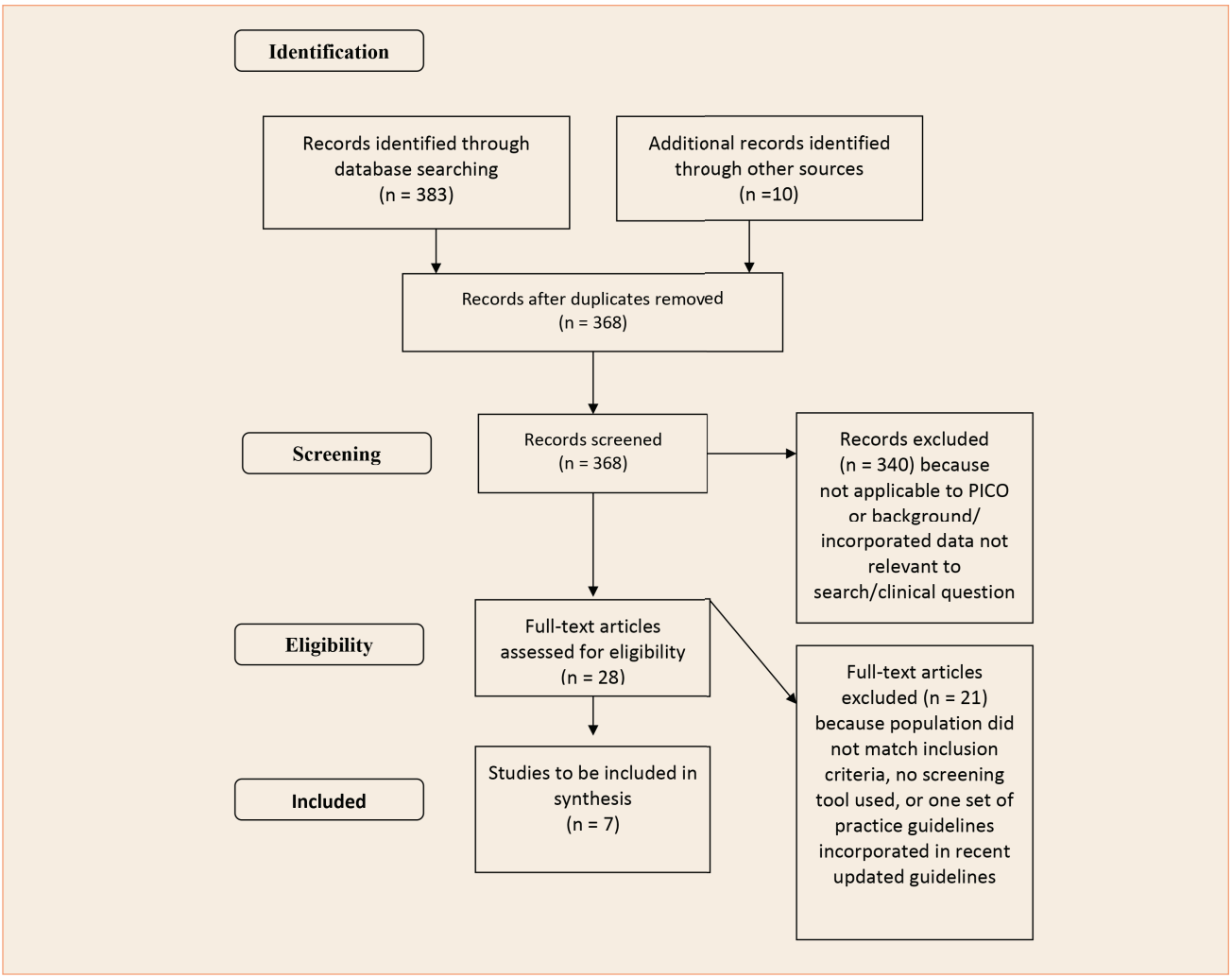

Figure 1. Search Flow Diagram
Abbreviation: PICO, patient (or population), intervention, comparison, outcome.

• ***Clinical Practice Guideline.*** Antiemetic medications have been associated with adverse effects ranging from mild headaches to QT prolongation to cardiac arrest.[15] Because of inherent differences between pediatric and adult populations, clinical decisions about the need for prophylactic antiemetics cannot be based on stand-alone risk factors; rather, a patient's baseline risk of experiencing PONV must be assessed via a validated risk score based on independent predictors.[15]

Age is a significant risk factor in the development of postoperative vomiting, particularly in the younger age group. People older than 3 years but younger than 50 years were found to be at the greatest risk, with an odds ratio (OR) of 1.79 (95% confidence interval [CI] = 1.39-2.3).[15] Female gender has been identified as a predictor of PONV in the adult population, but this is not necessarily true in the pediatric population.[15] Although there are overlapping risk factors between 2 different adult scoring systems (Table 1), the Society for Ambulatory Anesthesia determined that these predictors were not applicable in the pediatric population and that a pediatric scoring system was needed.

At the time of the 2014 guideline update, only one pediatric simplified scoring system had been reviewed and validated: Eberhart's postoperative vomiting in children (POVOC) score.[15] The POVOC score includes 4 independent predictors of postoperative vomiting in children. These are an age greater than 3 years, patient and/or family history of PONV, strabismus surgery, and duration of surgery longer than 30 minutes.[15] This scoring system assigns 1 point to any "yes" answers and 0 points to any "no" answers. The total points that can be achieved is 4, with 4 points being deemed high risk, and 2 to 3 points being designated as moderate risk. In children, the presence of 0, 1, 2, 3, and 4 of these risk factors correlates with a risk of PONV of 9%, 10%, 30%, 55%, and 70%, respectively.[15]

• ***Cohort Studies.*** A wide variety of clinical settings, from outpatient surgical centers[19,20] to hospital-based operating rooms,[21-23] were represented. A total of 2,822

children were included across the 5 studies. Individual sample sizes ranged from 100 at a single hospital[22] to 2,211 across 11 hospitals.[20] Ages of the children included in these studies ranged from 0 months[21] to 19 years.[20]

Children undergoing routine, nonemergent pediatric surgery comprised much of the population, although one study[20] did include pediatric patients undergoing emergency surgery in their study. A variety of pediatric surgical procedures were represented, including many otolaryngologic procedures,[20,23] dental procedures,[22] and oncologic procedures.[21] All children in these studies received general anesthesia, although neither anesthetic agents nor airway devices were specified.

• *Patient Factors.* All 5 cohort studies identified patient age as a risk factor. In studies with patients beginning at birth, ages greater than 2 years[21] or greater than 3 years[20,23] were at greater risk. Bourdaud et al[20] reported an adjusted odds ratio (AOR) of 2.46 in children greater than 3 years but less than 6 years. Children between 6 and 13 years were found to be at higher risk,[22] with an AOR of 3.09.[20] In contrast, Kapoor et al[19] found children 11 to 14 years to be at risk as well. Chau et al[23] reported an OR of 1.4 for any child greater than 3 years as well as a 40% increase in this number for every 2-year increase in age.

Patient history of motion sickness (OR = 4.4)[23] or previous postoperative vomiting (AOR = 1.81)[20] and a family history of either motion sickness or PONV (OR = 5.3)23 were identified as independent risk factors. Female gender in children aged more than 13 years was identified as a risk factor in 2 studies only.[19,22]

• *Surgical Factors.* Anesthesia duration greater than 45 minutes was identified as an independent risk factor in one study with an AOR of 1.44.[20] Surgical type was identified as a risk factor in 3 of the 5 cohort studies.[21-23] For patients with malignancy, orthopedic procedures and neurosurgery seem to be risk factors.[21] Otolaryngologic procedures, herniorrhaphy, laparotomy,[19,20] and strabismus surgery (OR = 2.13)[20] were associated with higher levels of postoperative vomiting.

• *Postoperative Factors.* Postoperative administration of opioids in the presence of postsurgical pain has been identified as a risk factor in pediatric patients by 4 of the 5 cohort studies.[19-22] One study estimated the AOR to be 2.76 in pediatric surgical patients receiving opioids postoperatively.[20] The frequency and doses of postoperative opioids were not disclosed by all the studies.

• ***Integrative Review.*** Comparison of existing PONV scoring systems identified many similarities between the Apfel and Koivuranta adult scoring systems, with female gender being the highest predictor for PONV in adults.[18] In the pediatric population, it was determined that both age and previous personal or family history of motion sickness and/or PONV influence the likelihood of experiencing PONV.[18] Similarities among the 3 scoring systems include a patient history of PONV and/or motion sickness.

In reviewing the literature, the author acknowledged other independent risk factors not originally included in Eberhart's POVOC scale. Whereas Eberhart's original POVOC score design focused only on strabismus surgery as a risk factor, recent evidence gained from newer pediatric studies has incorporated other surgical procedures such as hernia repair, orchiopexy, penile surgery, orthopedic surgery, and other types of emetogenic surgeries.[18]

• ***Application to Practice.*** The clinical practice guidelines recommend the use of the POVOC scoring system for pediatric patients. This simplified scale includes 4 independent predictors of postoperative vomiting in children: age greater than 3 years, patient and/or family history of PONV or postoperative vomiting, strabismus surgery, and surgical duration greater than or equal to 30 minutes. This system may be limited because it includes only one surgical type: strabismus surgery. Newer evidence gleaned from pediatric studies has independently validated other surgical types, such as urology, otolaryngology, orthopedic, and general surgical procedures. Incorporating these procedures when screening for PONV, in conjunction with strabismus surgery, may result in the identification of higher-risk patients.

Methods

Findings obtained from the literature review were presented at the hospital's monthly quality improvement (QI) meeting. It was discovered that the hospital, via use of its electronic medical record (EMR) system, was already screening for 3 of the 4 risk factors identified via the POVOC scale. The institution was also screening for PONV risk factors in patients undergoing urology, orthopedic, otolaryngology, and general surgical procedures.

The single risk factor that was not consistently being screened for or documented was the patient's history of postoperative nausea and/or vomiting. A brief inquiry revealed the lack of a PONV history assessment tab in the preanesthetic assessment data forms. The hospital's information technology department then created a PONV history assessment tab.

• ***Intervention.*** To ensure full compliance with documentation of PONV history, the history assessment tab was made a "hard stop," meaning the screening provider had to select either "yes" or "no," or the provider would not be able to proceed to the next screen. When a provider documented "yes" under the PONV history tab, a reminder message would populate intraoperatively. This reminder message would alert the anesthesia provider that the patient has a history of PONV and might require antiemetic prophylaxis. For the purposes of this project, creation of the PONV history assessment tab and subsequent documentation of the patient's PONV history will be considered the intervention or "practice change."

• ***Design.*** A retrospective chart analysis of de-identified patient data before and after the practice change was

Surgical type	No. of preintervention cases	No. of postintervention cases
General surgery	594	528
Ophthalmology	176	127
Orthopedics	525	497
Otolaryngology	661	602
Urology	323	252
Total	2,279	2,006

Table 2. Preintervention and Postintervention Demographics

obtained via convenience sampling. Comparison data were collected for the 2 months before and 2 months after practice change. In total, 2,279 preintervention cases were collected and compared with 2,2006 postintervention cases.

• Setting. The setting for this study was a 21-bed pediatric operating room located in a 527-bed nonprofit pediatric hospital. This department performs more than 30,000 surgical cases per year, not including nonoperating room procedures or cardiac surgeries. Approval of this project was granted for exempt review by the institutional review board (IRB) of both the participating institution and the university. All data were de-identified by the hospital before review by the author. No consents were deemed necessary for this project.

• ***Sample.*** De-identified data were collected using the "modified" POVOC criteria (certain surgical procedure types besides strabismus surgery). For data to be included, the patient's age had to have been greater than or equal to 3 years but less than 18 years old; surgical duration must have been 30 minutes or greater; and surgical type must have been strabismus, urologic, orthopedic, otolaryngologic, or general surgical procedure. Additionally, the surgical cases must have been scheduled as elective operations and not considered emergent. Data not matching the criteria, as well as patients undergoing more than 1 surgical procedure under the same anesthetic, were excluded. The number of eligible preintervention cases was 2,279 compared with 2,006 postintervention cases, for a total sample population of 4,285. Table 2 provides a breakdown of preintervention and postintervention data by surgical type.

• ***Data Collection.*** Preintervention and postintervention data were pooled from and collected via EMR review for 2 months before and 2 months after practice change implementation. The de-identified data were examined and filtered based on the predetermined inclusion and exclusion criteria. Data received consisted of the following information: surgical date, surgical type, duration of procedure, and the presence of emesis within 12 hours postoperatively. Given the subjective nature of nausea and the inability of younger children to accurately describe it, nausea data were not collected. Although the data were filtered by patient age, demographical data such as gender or age were not collected or obtained by the author. All data were stored in compliance with the institution's IRB via secured and encrypted electronic servers in the research department on-site.

• ***Data Analysis.*** The expected outcome was a reduction in postoperative vomiting rates following implementation of the PONV history assessment tab. The aggregate data were composed of 3 components: surgical service, surgical length, and the presence of emesis within 12 hours following the postoperative period. Categorical data were summarized using percentages and counts. Data regarding the occurrence of postoperative emesis were analyzed via the χ^2 test to determine differences between the preintervention and postintervention groups.

A null hypothesis and alternative hypothesis were created. The null hypothesis stated that a practice change will not cause a decrease in PONV rates. The alternative hypothesis stated that a practice change will cause a decrease in PONV. All raw data were checked for errors and analyzed using a spreadsheet (Excel, Microsoft) with significance determined as $P < .05$. To help decrease the likelihood of a type 1 error, the author used a 5% level of significance (an α of .05 was selected) and 95% confidence intervals.

• ***Costs.*** The creation of the PONV history assessment tab required submission of various forms and applications to the hospital's IT department. Because the design of the tab mimicked other current tabs, it was able to be easily incorporated within the preanesthesia assessment evaluation section. This also meant that there was a limited added cost since the tab did not need to be custom designed.

This retrospective chart view involved the collection and generation of multiple computerized reports. At the time this project was being conducted, the anesthesia QI department was collecting similar information related to another unrelated project reviewing the amount of time that patients ingested nothing by mouth. Because of the similarities in demographic data (age restrictions, surgical case types and lengths), the QI department was able to modify current data reports to generate the PONV reports, incurring little to no additional expense.

Results

The preintervention group consisted of 2,279 patients aged 3 to 18 years old undergoing nonemergent surgi-

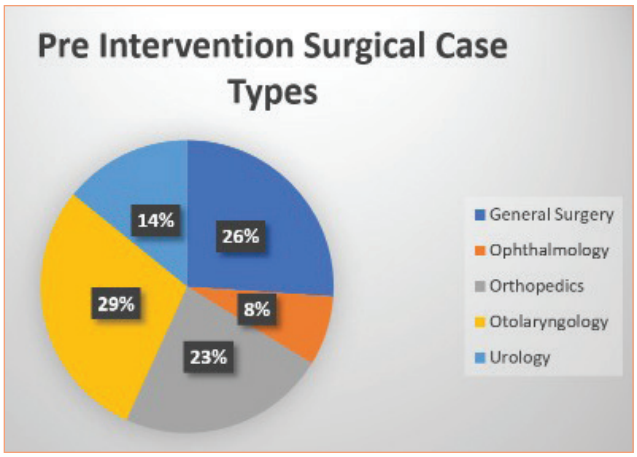

Figure 2. Preintervention Surgical Case Types

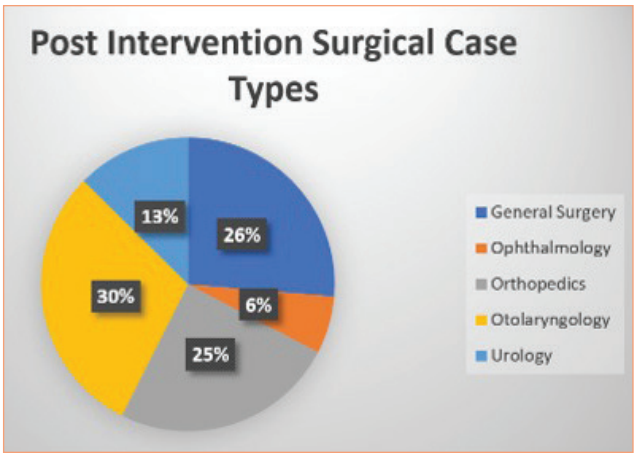

Figure 3. Postintervention Surgical Case Types

cal procedures. The cases were divided into 5 groups based on surgical type: general surgery, ophthalmology, orthopedics, otolaryngology, and urology. Most cases were otolaryngologic (29%), followed by general surgery (26%), orthopedics (23%), urology (14%), and ophthalmology (8%). Figure 2 provides a graphical representation of preintervention surgical types.

The postintervention group consisted of 2,006 patients aged 3 to 18 years old undergoing nonemergent surgical procedures. As with the preintervention data, the cases were divided into the same 5 groups based on surgical type. Once again, most of the cases were otolaryngologic (30%), followed by general surgery (26%), orthopedics (25%), urology (13%), and ophthalmology (6%). Figure 3 provides a graphical representation of postintervention surgical types.

From the 2,279 preintervention cases, only 153 patients experienced PONV (χ^2 = 1.4353). Of these, patients undergoing orthopedic procedures experienced the highest rate of PONV (54), followed by general surgical patients (49). Table 3 provides an overview of the rate of PONV for each service.

By comparison, only 120 cases of the 2,006-case postintervention group reported PONV (P = .0043). This accounted for a roughly 22% total decrease in PONV rates between groups. As with the preintervention group, the highest incidence of PONV was found in orthopedic patients (n = 44), followed by general surgical patients (n = 33). Between the groups, ophthalmologic patients experienced the highest decrease in PONV rates (50%), followed by general surgical patients (30%) otolaryngologic patients experienced a 27% decrease, whereas orthopedic patients experienced only a 19% decline. Of note, the incidence of PONV almost doubled in the urology postintervention group (7 reported preintervention cases vs 12 postintervention cases). More research is needed to better understand these findings. Table 3 provides an overview of postintervention PONV rates for each service. Figure 4 compares the PONV rates by service between both groups.

Service type	PONV+	PONV–	Total
Preintervention			
General surgery	49	545	594
Ophthalmology	2	174	176
Orthopedics	54	471	525
Otolaryngology	41	620	661
Urology	7	316	323
Total	153	2,126	2,279
Postintervention			
General surgery	33	495	528
Ophthalmology	1	126	127
Orthopedics	44	453	497
Otolaryngology	30	572	602
Urology	12	240	252
Total	120	1,886	2,006

Table 3. Preintervention and Postintervention PONV Rates by Service

Abbreviations: PONV, postoperative nausea and vomiting; +, history of PONV present; –, no history of PONV.

Discussion

The creation and subsequent use of the PONV history assessment tab resulted in a clinical and statistical decrease in reported PONV rates in pediatric patients undergoing orthopedic, otolaryngologic, ophthalmic, and general surgical procedures. This finding correlates with the previously established independent risk factors discussed in the current literature. Of note, orthopedic procedures accounted for the highest occurrence of PONV in both groups despite it being the third highest total number of cases compared with general surgical and otolaryngology services. Patients undergoing orthopedic procedures did experience a 19% decrease in PONV rates between groups following the creation of the PONV assessment tab.

In contrast, an increase in PONV rates was observed in patients undergoing urologic procedures. This observa-

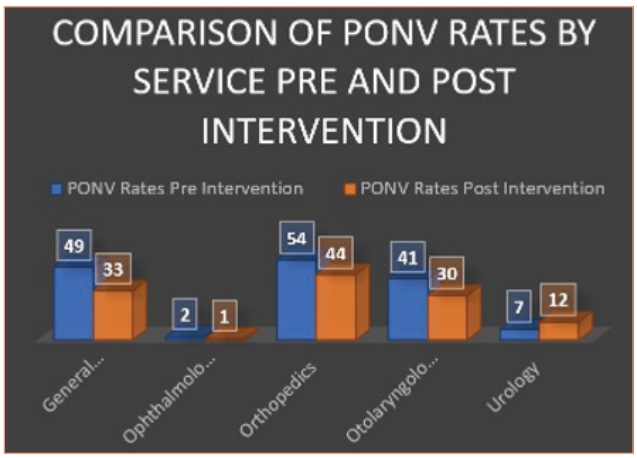

Figure 4. Comparison of PONV Rates by Service Before and After Intervention
Abbreviation: PONV, postoperative nausea and vomiting.

tion reinforces the notion that urologic procedures carry a higher risk of PONV rates compared with other surgical types. It also suggests that prior assessment of a patient's PONV history may not have as much an impact on PONV rates in this surgical milieu.

Except for the urologic population, a patient history of PONV may be a more important indicator of PONV than originally theorized. Subsequent decreases in PONV rates in ophthalmology (50%), general surgery (30%), otolaryngology (27%), and orthopedics (19%) procedures following the intervention demonstrate this. Regarding urology, and perhaps even orthopedics, surgical type or service may be a more important risk factor.

• ***Limitations.*** This study has several limitations. Children undergoing surgery for the first time, who therefore would not have a history of PONV, were not eliminated from this study. This study examined only nonemergent cases in a select group of surgical types and did not examine emergency cases or "combined" cases wherein more than 1 surgical service is involved but the patient remains under a single anesthetic.

• ***Implications for Practice and Future Research.*** This project demonstrated the importance of screening for independent predictors for PONV in the pediatric surgical population. Using a modified POVOC score that incorporated other independently validated surgical procedures appeared beneficial. The presence of the PONV assessment tab improved PONV rates postoperatively and should remain in place at this institution.

Multiple research questions remain following this project. The increase in postintervention urology PONV rates is puzzling and would need to be further investigated. Other investigations can center on practitioner response and attitudes regarding the creation of the PONV tab as well as the intraoperative reminder message in the EMR. Studies can be conducted to see if the reminder message itself had any impact on PONV rates.

Conclusion

The results of this project demonstrate a statistically significant decrease in PONV rates following the preoperative assessment of PONV predictors, specifically a history of PONV. The use of the modified PONV risk assessment tool led to a decrease in pediatric PONV.

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DISCLOSURES

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