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REVIEW ARTICLE/BRIEF REVIEW

Prophylaxis for pediatric postoperative nausea and vomiting: a scoping review of clinical trials

Prophylaxie pour les nausées et vomissements postopératoires pédiatriques : une revue de portée des études cliniques

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Abstract

Purpose *Postoperative nausea and vomiting (PONV) is common in pediatric patients undergoing general anesthesia, and clinicians seek prophylactic interventions to prevent its ill effects on patients as well as its ramifications on perioperative care. We sought to assess the body of evidence around prophylactic strategies, both pharmacologic and nonpharmacologic, targeting pediatric PONV.*

Source *We searched MEDLINE, MEDLINE ePubs Ahead of Print and In-Process Citations, Embase Classic+Embase, the Cochrane Database of Systematic Reviews, Cochrane CENTRAL (via the Ovid platform), Scopus (Elsevier), Web of Science (Clarivate Analytics), ClinicalTrials.gov, the WHO International Clinical Trials Registry Platform, and the International Standard Randomized Controlled Trial Number Registry, from their inception to 23 September 2022.*

Principal findings *Of 188 clinical trials, 157 (83%) investigated pharmacologic interventions, 25 (13%) investigated nonpharmacologic interventions, and six (3%) investigated mixed pharmacologic and nonpharmacologic interventions. The most common surgeries investigated for pediatric PONV were strabismus surgery (68 trials, 36%) and tonsillectomy or tympanoplasty (45 trials, 23%). Of four measurement tools used to assess PONV in the included trials, the most common was clinical judgement (170 trials, 90%).*

Conclusion *The majority of data in pediatric PONV prophylaxis is based on pharmacologic interventions, with a paucity of research in nonpharmacologic or mixed interventions. Assessing and documenting PONV using tools such as the Baxter Animated Retching Faces Scale or PONV numeric scoring system may help standardize pediatric PONV prophylaxis research moving forward. Furthermore, concurrently assessing pain and adverse effects associated with PONV might further inform our understanding of this complex clinical entity.*

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Résumé

Objectif *Les nausées et vomissements postopératoires (NVPO) sont fréquents chez la patientèle pédiatrique bénéficiant d'une anesthésie générale, et les équipes cliniques recherchent des interventions prophylactiques pour prévenir leurs effets néfastes sur les patient·es ainsi que leurs ramifications sur les soins périopératoires. Nous avons cherché à évaluer l'ensemble des données probantes entourant les stratégies prophylactiques pharmacologiques et non pharmacologiques ciblant les NVPO pédiatriques.*

Sources *Nous avons effectué des recherches dans les bases de données MEDLINE, MEDLINE ePubs Ahead of Print and In-Process Citations, Embase Classic+Embase, la base de données des revues systématiques Cochrane, Cochrane CENTRAL (via la plateforme Ovid), Scopus (Elsevier), Web of Science (Clarivate Analytics), ClinicalTrials.gov, le système d'enregistrement international des essais cliniques de l'OMS et le registre international normalisé des numéros d'essais contrôlés randomisés, depuis leur création jusqu'au 23 septembre 2022.*

Constatations principales *Sur 188 études cliniques, 157 (83 %) portaient sur des interventions pharmacologiques, 25 (13 %) sur des interventions non pharmacologiques et six (3 %) sur des interventions pharmacologiques et non pharmacologiques mixtes. Les chirurgies les plus fréquemment étudiées pour les NVPO pédiatriques étaient les chirurgies de strabisme (68 études, 36 %) et les amygdalectomies ou tympanoplasties (45 études, 23 %). Parmi les quatre outils de mesure utilisés pour évaluer les NVPO dans les études incluses, le plus fréquemment utilisé était le jugement clinique (170 études, 90 %).*

Conclusion *La majorité des données sur les prophylaxies pédiatriques pour prévenir les NVPO sont basées sur des interventions pharmacologiques, avec peu de recherche sur les interventions non pharmacologiques ou mixtes. L'évaluation et la documentation des NVPO à l'aide d'outils tels que l'échelle Baxter Animated Retching Faces Scale ou un système de notation numérique des NVPO peuvent aider à normaliser la recherche sur la prophylaxie pédiatrique des NVPO à l'avenir. De plus, l'évaluation simultanée de la douleur et des effets indésirables associés aux NVPO pourrait éclairer davantage notre compréhension de cette entité clinique complexe.*

Keywords clinical trials · general anesthesia · pediatric anesthesia · postoperative nausea and vomiting · prophylaxis · scoping review

Postoperative nausea and vomiting (PONV) is the most common adverse reaction following general anesthesia (GA). The incidence of PONV in pediatric anesthesia remains substantial; historically quoted as high as 82%,[1] more recent studies note a baseline incidence as high as 28%.[2] In contrast, baseline incidence of PONV in adults is far lower at 10%.[3] While it is an unwanted complication in itself, PONV can lead to a series of other untoward effects including dehydration, electrolyte imbalances, aspiration pneumonia, surgical site bleeding, amplification of postoperative pain, and psychological distress. Furthermore, PONV has a significant impact on perioperative care, being the leading cause of unplanned admissions, which decreases hospital-bed availability and concomitant unanticipated health care costs.[4]

Given the potential burden of PONV on perioperative patient experience and outcome, a growing body of research focuses on strategies to prevent it altogether resulting in an extensive body of literature on PONV prophylaxis in the pediatric population.[5,6] The recent Fourth Consensus Guidelines for the Management of Postoperative Nausea and Vomiting by Gan *et al*.,[5] established by an international multidisciplinary expert panel of under the auspices of the American Society of Enhanced Recovery and the Society for Ambulatory Anesthesia, continue to support the use of multiple agents for PONV prophylaxis; however, the optimal combination of prophylactic strategies remains unknown. Furthermore, the method by which PONV is assessed across trials and the contributory role of pain in the recovery room is not entirely clear. Addressing such gaps in knowledge will enable us to further improve PONV prophylaxis and management, and aid the design of future research.

We sought to perform a contemporary assessment of the various forms of PONV prophylaxis studied in the literature to date. We conducted a scoping review of randomized controlled trials (RCTs) to identify the various pharmacologic and nonpharmacologic forms of PONV prophylaxis in pediatric patients undergoing GA.

Methods

Protocol and registration

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis Scoping Review (PRISMA-ScR) Extension guideline[7] was used in guiding the planning and implementation of this scoping review. As a scoping review, our study protocol was not eligible for registration under the PROSPERO platform. The protocol can be accessed in the Electronic Supplementary Material (ESM) eAppendix 1.

Research question(s)

In constructing our scoping review, we used the following research questions:

1. What are the existing pharmacologic and nonpharmacologic prophylaxes for pediatric PONV (including different doses of pharmacologic prophylaxes)?
2. What type of surgery is most investigated for pediatric PONV?
3. What measurement tools are used to assess PONV?
4. What other outcomes are measured in addition to PONV?
5. In reporting trial results, is pain properly measured and addressed?
6. For pharmacologic PONV prophylactic strategies, are dose-dependent antiemetic effects studied? If so, is there an optimal dose and/or dose above which patients experience side effects?

Eligibility criteria

The study population included pediatric patients less than or equal to 18 yr of age undergoing GA. The primary outcome studied was incidence of PONV or postoperative vomiting (POV), as this is the most appropriate metric as to the efficacy of a prophylactic strategy. Both pharmacologic and nonpharmacologic interventions were included in our study. As our interest was original rather than synthesized data on PONV prophylaxis, eligible study design was limited to randomized clinical trials. There was no restriction on time frame of publications and all eligible trials to date were assessed. The language of publication was restricted to English. Exclusion criteria included trials focusing on treatment rather than prophylaxis of PONV, and mixed-population trials including patients older than 18 yr.

Information sources

We searched the following databases from their inception: MEDLINE, MEDLINE ePubs Ahead of Print and In-Process, Embase Classic+Embase, the Cochrane Database of Systematic Reviews, and Cochrane CENTRAL (all via the Ovid platform); Scopus (Elsevier), the Web of Science Core Collection (Clarivate Analytics); and trial registries: ClinicalTrials.gov (National Institutes of Health), the World Health Organization International Clinical Trials Registry Platform, and the International Standard Randomized Controlled Trial Number Registry. The search strategy was developed by M. E., an information specialist, and approved by the study investigators. Studies in press/e-pubs were included in the search and conference abstracts were removed. The most recent search was performed on 23 September 2022.

Search

The original and updated search strategies are available in ESM eAppendix 1.

Selection of sources of evidence

Our study included RCTs presenting quantitative data and did not include qualitative trials, expert opinion papers, or policy documents. Duplicate trials retrieved from more than one database were removed. Titles and abstracts of resultant trials were screened by two independent reviewers (E. A., J. N.) to remove any trials that do not meet eligibility criteria. For those that fulfilled the eligibility criteria, the full article was retrieved. Disagreement between reviewers regarding study eligibility for inclusion was resolved by discussion to achieve consensus or by consulting a third reviewer (K. A.).

Data charting process

A data collection worksheet was created using DistillerSR^{TM} (Evidence Partners Inc., Ottawa, ON, Canada), designed to answer the six research questions mentioned above. Following group consensus, eligible trials in full were uploaded to this platform. Two independent reviewers (E. P. and E. A.) inputted data into the worksheet following thorough article review, with a third reviewer (K. A.) clarifying any uncertainty in extracting data as required.

Data items

Independent reviewers accessed eligible trials and extracted the following demographic data: author's last name, study year, country of the corresponding author, publication from a single centre or multiple centres in a single country or multinational collaboration, the type of surgery, mean or median age of the patients greater or equal to three years, mean or median length of GA of less than or equal/greater than 30 min, and whether a known high-risk population for PONV was studied (strabismus, tonsillectomy, or tympanoplasty). The reviewers then extracted whether pain was assessed with a measurement tool and/or addressed with a prespecified treatment plan, whether dose-specific adverse effects were investigated, the type of intervention, the number of interventions (arms) in the study, the intervention dose and route of

administration, the incidence of PONV or POV by intervention and control, and the secondary outcomes assessed. If PONV was assessed at multiple time points postoperatively, the 24-hr incidence of PONV in the trial was used for data extraction. Not all trials reported the mean or median duration of GA; if the mean or median duration of the operative procedure reported exceeded 30 min, it was assumed the duration of GA was also greater than 30 min and indicated as such on the data extraction worksheet.

Synthesis of results

For demographic data, we qualitatively synthesized our findings on an aggregate level. Means and standard deviations were used to describe normally distributed continuous variables, while categorical variables were expressed as counts and proportions.

Results

The PRISMA flow diagram is depicted in Fig. 1. We included 188 trials out of 7,292 screened publications (ESM eAppendix 2). The vast majority (93%) of trials were single-centre trials. Trials were included from 32 different countries (Fig. 2).

Existing prophylactic therapies in pediatric postoperative nausea and vomiting

What are existing pharmacologic and nonpharmacologic prophylaxes for pediatric postoperative nausea and vomiting?

Pharmacologic interventions were the most frequently studied, with 83% of trials reporting such as their exclusive focus. Twenty-five trials (13%) investigated nonpharmacologic interventions, and only six (3%) investigated mixed pharmacologic and nonpharmacologic interventions. The main pharmacologic and nonpharmacologic interventions are presented in Table 1. In trials studying pharmacologic or mixed interventions, the most common pharmacologic agents were ondansetron (19%), droperidol (15%), and dexamethasone (12%).

In trials investigating pharmacologic interventions, the most common dose investigated and the range of doses studied are presented in Table 2. Ondansetron was the most common pharmacologic prophylactic intervention studied in the years spanning 1996–2005, followed by dexamethasone in 2006–2021 (Fig. 3). Acupuncture/acupressure was the most frequently studied prophylactic strategy in trials investigating nonpharmacologic or mixed interventions, with 47% of trials in this group reporting its use.

What type of surgery is most investigated for pediatric postoperative nausea and vomiting?

Table 3 shows the types of surgery investigated in the trials reviewed. Strabismus surgery (36%) and tonsillectomy or tympanoplasty (23%) comprised the majority of surgeries.

What measurement tool is used to assess postoperative nausea and vomiting?

Of four measurement tools used to assess PONV in the included trials, the most common was clinical judgement (90%). The remaining specified measurement tools used included a PONV numeric scoring system (6%), the Baxter Animated Faces Retching (BARF) Scale (2%), and a visual analog scale score (< 1%).

What other outcomes are measured in addition to postoperative nausea and vomiting?

Table 4 shows the secondary outcomes assessed. The most common included the need for rescue medication for PONV (24%), anesthetic adverse events (20%), and pain (20%).

In reporting trial results, is pain properly measured and addressed?

Less than one quarter (24%) of trials assessed, measured, and addressed pain in the recovery room as part of their study protocol. Prior to 2016, the majority of trails did not report formal measurement of pain in the recovery room as part of their study protocol (Fig. 4); in the years following, those trials began to outnumber trials not reporting pain concurrent to nausea.

For pharmacologic postoperative nausea and vomiting prophylactic strategies, are dose-dependent effects studied? If so, is there an optimal dose and/or a dose beyond which patients experience side effects?

The minority (8%) of trials investigated dose-dependent adverse effects. These included QT prolongation, bronchospasm, headache, and side effects associated with neurokinin-1 receptor antagonists, 5-hydroxytryptamine 3 (5-HT_3) receptor antagonists, corticosteroids, and dopamine receptor antagonists.

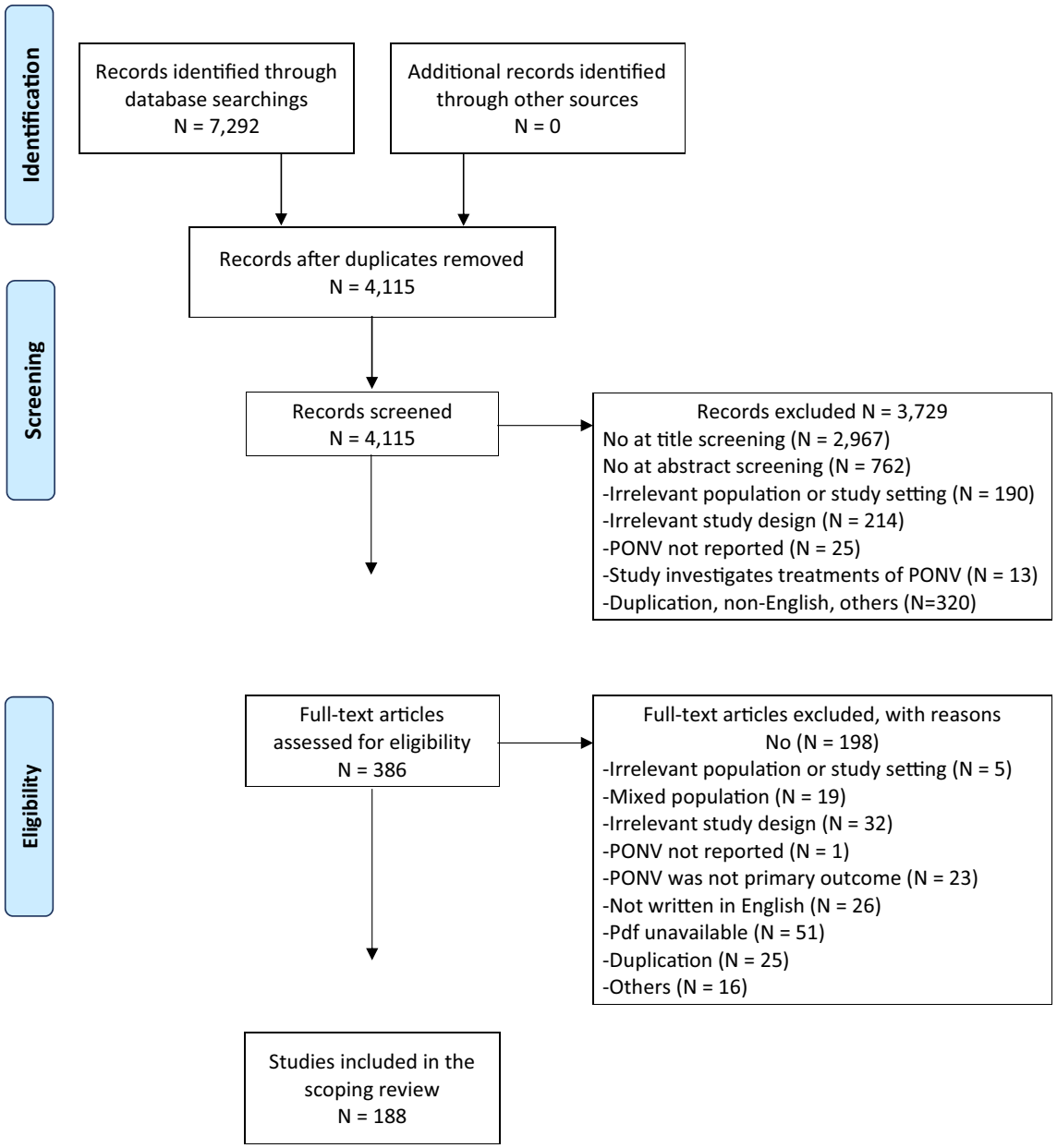

Fig. 1 PRISMA flow diagram outlining the identification, screening and inclusion/exclusion of trials, and the final number of trials included in our scoping review
PRISMA = Preferred Reporting Items for Systematic Review and Meta-Analysis

Discussion

In the present scoping review, we identified 188 trials studying PONV prophylaxis in pediatric patients undergoing GA. Our findings show that the majority of trials focused on pharmacologic interventions, while identifying a paucity of primary research on nonpharmacologic approaches to PONV prophylaxis in this population. Further, a lack of use of validated rating scales, such as the BARF scale for assessing PONV, persists. Only since 2016 have trials consistently begun to report pain concurrently with nausea and vomiting in the recovery room, a practice which has potential to supplement our understanding further.

The field of perioperative PONV research is richly studied and pioneered by landmark papers including those by Apfel *et al.*[3] and Eberhart *et al.*[8] Their identification of specific procedures (i.e., strabismus and adenotonsillectomy) as risk factors for pediatric PONV likely fuelled the heightened presence of these surgeries

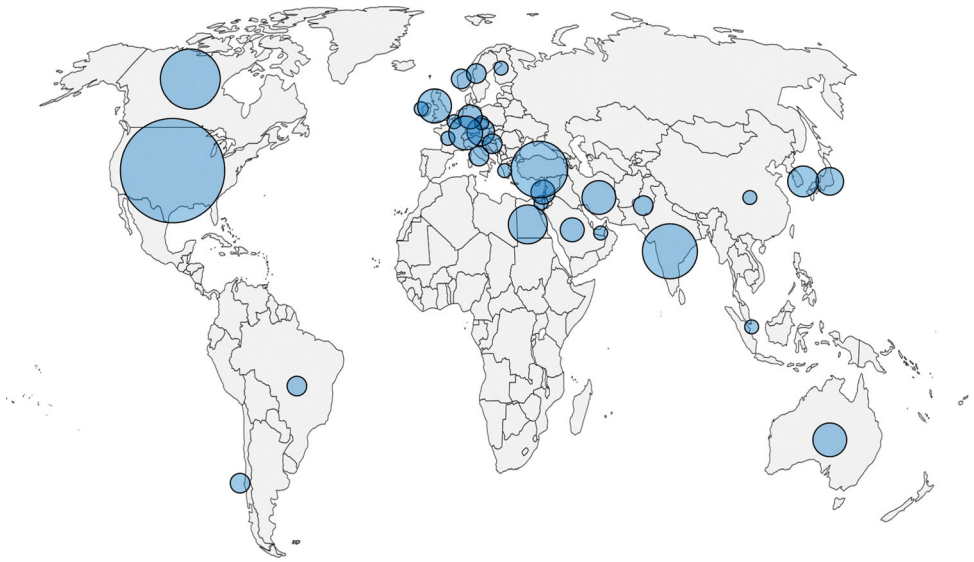

Fig. 2 The size of the circle overlying each country represents the proportion of the 188 trials included in this scoping review. The denominator is 32 countries.
PONV = postoperative nausea and vomiting

Table 1 Main pharmacologic and nonpharmacologic interventions

Top 10 pharmacologic interventions	Top 3 nonpharmacologic interventions
1. Ondansetron (44/224 [19%])	1. Acupuncture/acupressure (17/36 [47%])
2. Dexamethasone (27/224 [12%])	2. Gastric aspiration (3/36 [8%])
3. Droperidol (24/224 [10%])	3. Positive pressure ventilation (2/36 [5%])
4. Metoclopramide (13/224 [5%])	
5. Propofol TIVA (12/224 [5%])	
6. Dexamethasone and ondansetron (10/224 [4%])	
7. Granisetron (7/224 [3%])	
8. Dimenhydrinate (4/224 [1%])	
9. Dolasetron (4/224 [1%])	
10. IV fluids (4/224 [1%])	

Data are reported as proportion of the total number of pharmacologic or nonpharmacologic intervention arms (*n*/total *N* [%])

Proportions in pharmacologic or nonpharmacologic interventions do not add up to 100% as other interventions than the top most common ones are not listed

IV = intravenous; TIVA = total intravenous anesthesia

among trials noted in our review. Following international guidelines on PONV prophylaxis in 2007, a single network meta-analysis was published in 2008 based on a heterogeneous pediatric surgical population. More recently, the comprehensive Fourth Consensus Guidelines by Gan *et al.*[5] recommended prophylaxis based on individual PONV risk, with multimodal agents for pediatric patients deemed at elevated risk. Our review corroborates intraoperative steroids and 5-HT_3 antagonists as the prophylactic agents with the most supportive evidence, being the most commonly studied pharmacologic agents in pediatric PONV prophylaxis. We illustrate the temporal trends of these two agents dominating the field of PONV prophylaxis research from 1996 onward. An attractive approach, particularly for patients deemed at high risk of PONV, is combining propofol total intravenous anesthesia with additional prophylactic therapies. This is supported by the recent Fourth Edition Guidelines by Gan *et al.*;[5] yet there is not sufficient evidence to support specific strategies over others

Table 2 Doses of main pharmacologic interventions

Intervention	Most common dose investigated ($mg \cdot kg^{-1}$)	Range of doses investigated ($mg \cdot kg^{-1}$)
Ondansetron	0.15	0.01–0.2
Dexamethasone	0.5	0.05–1.0
Droperidol	0.075	0.005–0.3
Metoclopramide	0.25	0.15–0.5
Propofol TIVA	NA*	5–20 $mg \cdot kg^{-1} \cdot hr^{-1}$†
Dexamethasone and ondansetron	0.15/0.05	0.05/0.05–0.2/0.15
Granisetron	0.04	0.01–0.08
Dimenhydrinate	0.5	0.5–2-3
Dolasetron	0.35	0.045–1.8
IV fluids	30 $mL \cdot kg^{-1} \cdot hr^{-1}$	NA

*All eligible trials explored different doses of bolus and infusion

†$\mu g \cdot kg^{-1} \cdot min^{-1}$ was converted to $mg \cdot kg^{-1} \cdot hr^{-1}$

IV = intravenous; NA = not applicable; TIVA = total intravenous anesthesia

at this time. Our review also attempts to view pediatric PONV from a more comprehensive perioperative lens by inquiring whether pain is concurrently assessed, reported, and managed in these trials.

Limitations and strengths

A limitation of our study is its reliance on robust methodology of the individual trials comprising our review to synthesize data qualitatively and draw conclusions. In an effort to minimize heterogeneity between trials included in our study, we included only RCTs in our search strategy. A risk of bias assessment on eligible trials is not required for scoping reviews, yet we attempted to minimize selection bias by using independent reviewers during the screening and full-text assessment of our study. Admittedly, some heterogeneity exists between trials on the definition of PONV, and the time frame of postsurgery is not standardized across trials. Further, postdischarge nausea and vomiting is considered as a

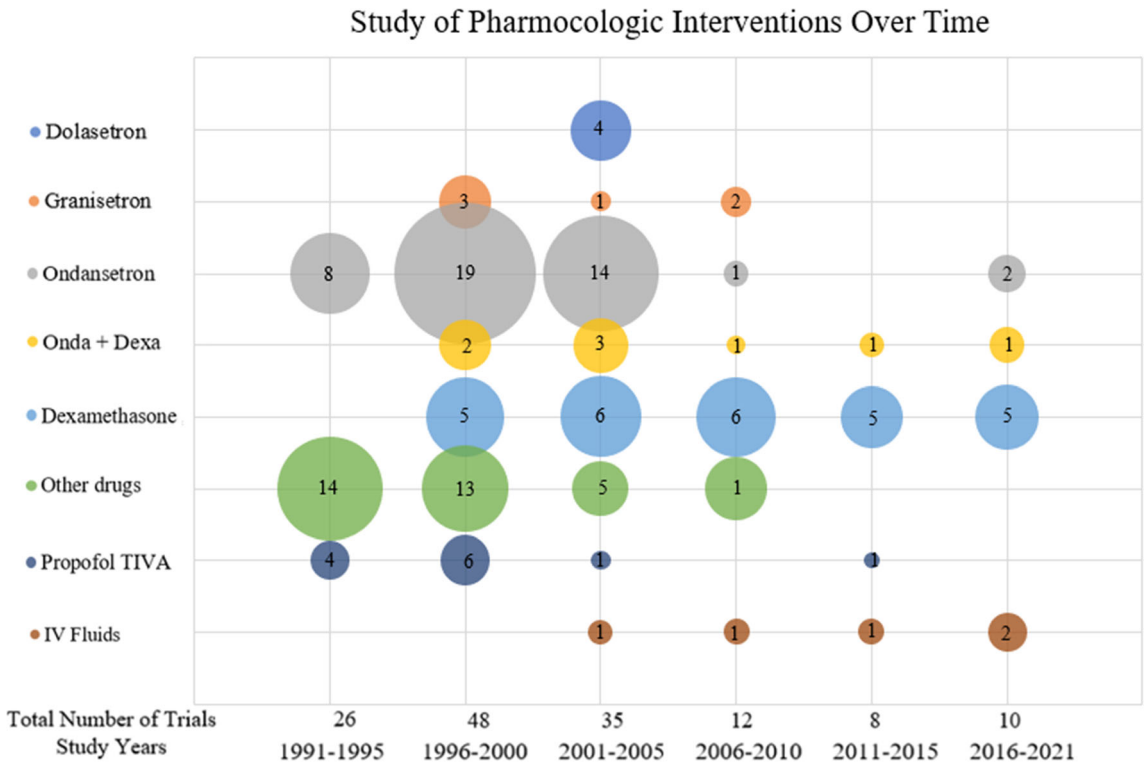

Fig. 3 Trials investigating strictly pharmacologic prophylactic interventions for PONV are depicted. To show temporal trends, each agent is depicted as a portion of a bubble chart across five-year intervals shown on the *x* axis. The size of the bubble is relative to the combined sample size investigating the agent in all studies within the respective time interval. The number of trials studying each pharmacologic agent across the five-year intervals is depicted as data labels on each bubble while the total number of trials in each interval are summed in the *x* axis.
IV = intravenous; Onda + Dexa = ondansetron and dexamethasone; TIVA = total intravenous anesthesia

discrete and separate event, although an argument could be made that it constitutes PONV if it falls within the defined postoperative time period. Another limitation is the inability to comment on the optimal dose of prophylactic strategies, in particular the commonly used ondansetron and dexamethasone, because of the broad range of doses outlined in Table 2. The small number of trials assessing dose-dependent adverse effects limited our ability to make any meaningful conclusions from the data from a dosage perspective.

Table 3 Type of surgery most investigated for pediatric postoperative nausea and vomiting

Type of surgery	Proportion of trials
Mixed surgical population	11/188 (5%)
Strabismus surgery	68/188 (36%)
Tonsillectomy ± adenoidectomy	29/188 (15%)
Tonsillectomy or tympanoplasty	45/188 (23%)
Other	35/188 (18%)

Proportion of trials data are reported as *n*/total *N* (%)

PONV = postoperative nausea and vomiting

Table 4 Secondary outcomes assessed in addition to postoperative nausea and vomiting

Secondary outcome	Proportion of trials
Need for rescue medication for PONV	46/188 (24%)
Adverse events	39/188 (20%)
Pain	39/188 (20%)
Extended PACU or hospital stay	24/188 (12%)
Number of vomiting episodes	19/188 (10%)
Time to first oral intake	17/188 (9%)
Time to PACU discharge	13/188 (6%)
Time until first vomit	12/188 (6%)
Analgesic requirements	10/188 (5%)
Time to awaken	9/188 (4%)

Proportion of trials data are reported as *n*/total *N* (%)

PACU = postanesthetic recovery unit; PONV = postoperative nausea and vomiting

While our study is comprehensive in covering a span of 30 years in PONV prophylaxis research, anesthetic practice has changed significantly and this expansive body of literature does not necessarily reflect modern approach to antiemetic prophylaxis. While certain pioneer studies undoubtedly shaped and directed PONV prophylaxis research, certain techniques (i.e., halothane) have more historic than practical significance in resource-rich settings. Thus, current antiemetic prophylaxis techniques likely comprise a modern snapshot of the trials we assessed.

The concern for research misconduct associated with publications by researcher Yoshitaka Fujii have previously marred the field of anesthesia research;[9–11] hence, any trials containing Fujii in the authors list were removed from data extraction. Appropriately, this author's studies are not taken into account in any of the recommendations of both the Third and Fourth Consensus Guidelines published by Gan *et al*.[5,12] Additional international guidelines such as those released by the Association of Pediatric Anaesthetists of Great Britain and Ireland[13] also clearly state his publications were excluded from analysis. It is reassuring that contemporary guidelines have taken due diligence to eliminate any impact from such research misconduct.

Our scoping review has several strengths. Our study performed a comprehensive assessment of PONV prophylactic strategies in the pediatric population in the major databases from their inception to 22 September 2022. We followed the PRISMA-ScR format to guide our

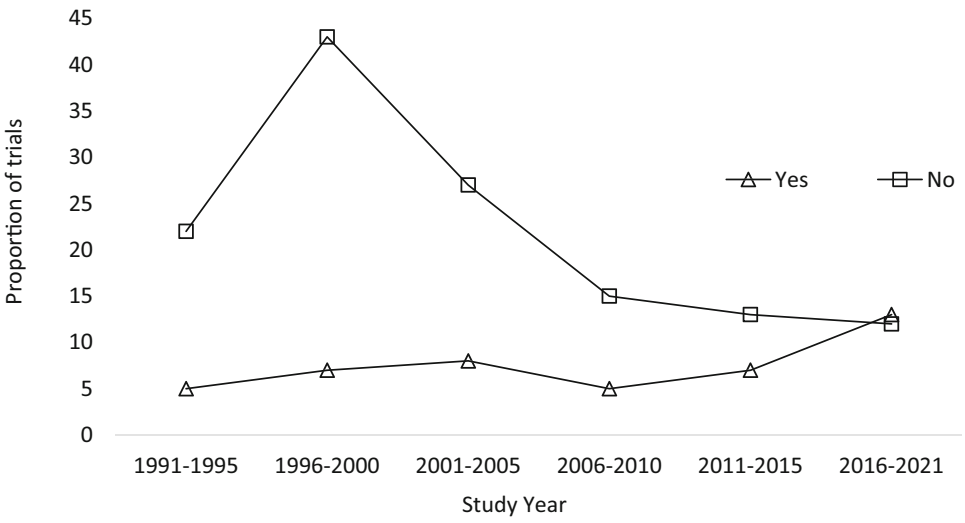

Fig. 4 The number of trials measuring pain as part of their study (yes, triangles) or not (no, squares) are depicted across five-year intervals. The proportion of trials depicted in the *y* axis equates to the number of trials per each five-year interval.

review. Our extensive data collection illustrated some temporal trends in the field of PONV prophylaxis, i.e., how trials focusing on ondansetron and dexamethasone dominated and waned in particular decades. Additionally, our extraction of qualitative data such as demographics and secondary outcomes provided a more thorough and arguably wholesome depiction of PONV prophylaxis in the perioperative pediatric population. An interesting and novel observation is shown in Fig. 2, depicting the international origin of clinical trials included in our study. We note that the majority of pediatric PONV prophylaxis trials are based from relatively few "high-output" centres, based in North America and western Europe. This regionally concentrated output should certainly continue to be encouraged; yet, it offers the opportunity for international collaboration. In particular, collaboration between researchers in higher-resource settings with those in more restricted settings could pave a more cohesive and consistent approach to trial methodology and assessment of PONV. Further, such international collaboration would aid in standardizing not only assessment and research in pediatric PONV prophylaxis but also clinical practice. This is one way in which international collaboration could potentially improve patient perioperative outcomes.

Implications

Our study highlights the gaps which exist in current PONV prophylaxis in pediatric patients undergoing GA. The "tried and true" pharmacologic agents such as dexamethasone and ondansetron, frequently studied in the decades prior, now leave room for further research in less studied pharmacologic agents, combination therapy, and nonpharmacologic approaches. For example, since the benefit of prophylactic acupuncture is unclear, there is precedent to continue to investigate and explore the impact of this modality on pediatric PONV.

Our findings have the potential to bolster future research trials on pediatric PONV prophylaxis. A unified, or universal, definition of PONV that spans a specific time frame could be adopted by future researchers. The consideration of postdischarge nausea and vomiting, considered a separate entity to PONV, may need to be taken into account when considering ramifications on patient experience and metrics such as hospital readmission. Knowing the risk factors associated with PONV,[5,8,14] future trials would be well served to stratify their patients accordingly and account for differing effects of prophylactic agents based on baseline patient risk of PONV. The lack of use of a standardized scale of PONV measurement despite an existing validated tool, such as the BARF scale, call for more widespread use of such tools in PONV research going forward. While clinical judgement may be adequate for assessment of vomiting, assessing nausea in children less than six years of age (who may not be able to identify and communicate the sensation) may be challenging and lends itself well to a visual rating scale. The drawback to using rating scales based on facial expressions includes pain being misinterpreted for nausea, and vice versa, particularly in children unable to verbalize.[15] For example, these scales often use various degrees of frowning and eyebrow furrowing, which could be the consequence of nausea, pain, or even fear. Yet, for this population, no superior alternative exists. We endeavour that future research in PONV prophylaxis in the perioperative pediatric population explore nonpharmacologic or mixed strategies in addition to the breadth of available pharmacologic agents. Viewing the pediatric PONV research community from a "world-view" lens highlights the potential in collaboration between international sites in making new breakthroughs going forward. Collaboration between "high-output" research centres across North America and western Europe, which also incorporates groups from less resource-rich settings, makes for a more inclusive approach. Lastly, the interplay between postoperative pain and nausea/vomiting is undoubtedly a complex one. Assessing pain concurrently to PONV is not standard in this research field, as indicated by our results. While an indirect measure, comparing opioid consumption (as a metric for pain) with PONV could be a useful way to retrospectively compare and contrast these two entities. A link between postoperative pain and PONV has been shown in adult ambulatory surgery patients,[16,17] but pediatric trials assessing both pain and PONV are limited. In an interesting prospective observational cohort study, Lagrange *et al.*[18] investigated whether a change in a standardized postoperative care plan following pediatric tonsillectomy had any impact on pain scores and PONV, among other factors. Although they did not report any significant changes in postoperative pain and PONV outcomes, this is a unique study taking both outcomes into account. Concurrent measurement and assessment of postoperative pain in addition to PONV in the recovery room could very well be the key to advancing future research as well as improving the perioperative patient experience.

Conclusions

Our scoping review sheds light on the paucity of research on nonpharmacologic interventions studied in pediatric PONV prophylaxis. Using a validated rating score such as the BARF scale when reporting PONV may be another important step in the ease of comparing trials. Concurrent

measurement of related metrics such as pain and adverse effects may further illuminate our understanding of this complex clinical entity.

Author contributions *Evelina Pankiv*, *Maria-Alexandra Petre*, and *Kazuyoshi Aoyama* conceived this paper. *Evelina Pankiv*, *Alfonso E. Albornoz*, *Jessica Nghiem*, *Maria-Alexandra Petre*, *Marina Englesakis*, *Mehwish Rana*, *Conor Mc Donnell*, *Jason Hayes*, and *Kazuyoshi Aoyama* developed the protocol. *Marina Englesakis* performed the systematic literature searches and managed database results and documentation. *Evelina Pankiv*, *Alfonso E. Albornoz*, *Jessica Nghiem*, *Mehwish Rana*, and *Kazuyoshi Aoyama* performed the systematic review and data extraction. All authors performed the analysis on the result of the literature search and extracted data. All authors provided input on the interpretation. *Evelina Pankiv* and *Kazuyoshi Aoyama* wrote the initial draft of the manuscript, and *Maria-Alexandra Petre*, *Marina Englesakis*, *Conor Mc Donnell*, and *Jason Hayes* helped draft the final version.

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