Tzu Chi Medical Journal 2024; 36 (3): 330-339

Original Article

# Aromatherapy for the prevention of postoperative nausea and vomiting: A systematic review and meta-analysis

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**Submission** : 02-Oct-2023
**Revision** : 19-Dec-2023
**Acceptance** : 18-Mar-2024
**Web Publication** : 24-May-2024

## Abstract

**Objectives:** Postoperative nausea and vomiting (PONV) are common complications following surgical procedures. While drug-based treatments are standard, there is increasing interest in nonpharmacological alternatives, such as aromatherapy, due to potential benefits and minimal side effects. This study aimed to assess the effectiveness of aromatherapy in preventing PONV. **Materials and Methods:** A comprehensive systematic review and meta-analysis were conducted using PubMed, Cochrane Library, EMBASE, and CINAHL databases for studies published up to May 2023. The included studies were randomized controlled trials (RCTs) and nonrandomized studies of interventions that examined the impact of aromatherapy on PONV. The risk of bias was assessed, and the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach was employed to evaluate the certainty of the evidence. **Results:** Eleven studies were selected for review, with eight RCTs included in the meta-analysis. Aromatherapy effectively reduced postoperative nausea severity (standardized mean difference [SMD]: −0.93, 95% confidence interval [CI]: −1.64 to −0.22; $P$ = 0.010), but the reduction in vomiting episodes was not statistically significant (SMD: −0.81, 95% CI: −1.98-0.37; $P$ = 0.180). Subgroup analysis indicated that ginger essence, lavender, and peppermint oils were particularly effective in managing postoperative nausea. However, due to significant statistical heterogeneity and potential biases in the studies, the results should be interpreted with caution. The certainty of the evidence, as evaluated by the GRADE approach, was low. **Conclusion:** Preliminary evidence supports the potential benefit of aromatherapy in reducing the severity of postoperative nausea. However, given the low certainty of current evidence, more rigorous and standardized research is needed. The safety, affordability, and potential benefits to patient comfort make aromatherapy a promising area for further research in postoperative care.

**Keywords:** *Aromatherapy, Nausea, Postoperative period, Vomiting*

## Introduction

The realm of postsurgical care often grapples with the prevalent issues of nausea and vomiting after surgery. Current data point to an overall rate of nearly 27.7% for incidents of postoperative nausea and vomiting (PONV) [1]. Current data reveal that the overall incidence of postoperative nausea and vomiting (PONV) is nearly 27.7%, with about 31.4% of patients experiencing nausea and nearly 16.8% suffering from vomiting after surgery [1]. Su *et al*. [2] carried out an in-depth review of 33 articles on PONV incidence and 18 on prevention strategies, revealing PONV affects 23-34% of surgical cases, escalating to 40-58% in high-risk patients (Apfel score >2) [2].

Such occurrences of PONV can lead to unexpected hospital stays, extend the time spent in recovery rooms, and contribute to escalating health-care expenditures [3,4]. For instance, a study showed that patients experiencing PONV had their postanesthesia care unit (PACU) stay increased by 38%, with durations extending from 171 min to 234 min [5]. It has also been observed that each vomiting episode can prolong a patient's time in the PACU by approximately 20 min [6]. Furthermore, the impact of PONV extends to hospital

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Supplementary material available online

Access this article online

Quick Response Code:

Website: www.tcmjmed.com

DOI: 10.4103/tcmj.tcmj_240_23



**How to cite this article:** Wang JY, Huang HY, Chu WO, Peng TR, Lee MC, Chen SM, *et al.* Aromatherapy for the prevention of postoperative nausea and vomiting: A systematic review and meta-analysis. Tzu Chi Med J 2024;36(3):330-9.

discharge times, with one study noting a 25% increase in the time to discharge for patients suffering from PONV. The financial implications are significant as well; the cost of postoperative recovery for patients without PONV was found to be $728.39, compared to $830.82 for those with PONV [5]. A recent 2-year analysis of surgical cases highlighted that 1.6% of patients (28 out of 1783) faced hospital readmissions due to PONV, adding an additional cost of $1927 per case [7].

Factors contributing to PONV encompass patient-related factors, anesthesia-related aspects, and surgical types [8,9]. Consequently, PONV management should focus on multifaceted preventive approaches informed by risk evaluations and substantiated by scientific evidence [3]. Various antiemetics via different mechanisms are used for the prevention and treatment of PONV, such as serotonin receptor antagonists [10], glucocorticoids [11], anticholinergics [12], antidopaminergics [13], or neurokinin 1 receptor antagonists [14]. Combinations of antiemetics are more effective than monotherapy [14,15]. However, these pharmacological options are not without their downsides, including risks such as QT elongation [16], susceptibility to surgical infections [17], increased blood glucose [18], dry mouth, blurry vision, or agitation [19]. As an alternative, nondrug approaches, such as acupuncture [20] and aromatherapy [21], have been suggested for PONV prophylaxis.

Aromatherapy, which involves the use of volatile plant oils through inhalation or other methods, has been explored as a potential treatment for various conditions, including PONV [22], anxiety [23], insomnia [24], dysmenorrhea [25], and dementia [26]. Various studies have explored the use of essence from ginger [27-29], peppermint essential oil [30,31], as well as lavender and clary sage oil [32] for the prevention of PONV. The underlying mechanisms for aromatic therapy's effects could be both pharmacological and psychological, according to Herz [33]. Pharmacologically, following inhalation, volatile essential oil molecules pass to olfactory receptors in the nose, which recognize their molecular characteristics and send signals to the brain via the olfactory nerve. In addition, some of the constituents pass into the bloodstream via the lungs and consequently produce their effects directly on brain neurons after passing through the blood–brain barrier. One proposed mechanism of action that seems more likely is that the scent activates the olfactory system, which in turn triggers the limbic system [34]. This may produce emotional responses and may enhance the retrieval of learned memories [35]. Apart from that, based on the psychological hypothesis, the potential effects of smell depend on emotional learning, conscious perception, and belief and expectations. Hines *et al*. included 16 studies to perform an updated meta-analysis of aromatherapy for the treatment of PONV in 2018 [22]. They indicated that aromatherapy is not effective in reducing nausea severity in comparison with placebo (standard mean difference [SMD]: −0.22, 95% confidence interval [CI]: −0.63–0.18, $P$ = 0.280); however, they were less likely to require rescue antiemetics (relative risk: 0.60, 95% CI: 0.37–0.97, $P$ = 0.040).

Although aromatherapy has shown partial benefits in the treatment of various conditions, there is currently no dedicated meta-analysis specifically evaluating its effectiveness in preventing PONV. This gap in the literature highlights the need for a comprehensive review and meta-analysis to specifically assess the effect of aromatherapy as a prophylactic measure for PONV prevention. Given its potential as an alternative therapy, investigating the effectiveness of aromatherapy in PONV prevention is crucial in informing clinical practice and identifying potential therapeutic options. The PICOS question was as follows:

PICO question:

- Population: Patients scheduled for or undergoing surgery
- Intervention: Aromatherapy
- Comparison: Placebo or standard care
- Outcome: Incidence of vomiting and severity of nausea.

## Materials and methods

This systematic review and accompanying meta-analysis are compliant with PRISMA guidelines [36] and have been officially registered on PROSPERO (CRD42022299892). Ethical approval is not required because the main investigators will retrieve and analyze data from previously published studies in which informed consent was acquired.

### Search strategy

The scope of inclusion covered both randomized controlled trials (RCTs) and quasi-experimental (QE) trials that explored the influence of aromatherapy on PONV prevention. Exhaustive literature searches were carried out on databases such as PubMed, Cochrane Library, CINAHL, EMBASE, and the Airiti Library (Chinese language). The focus was solely on studies published in English and on human subjects until May 16, 2023. Specifics of the search algorithm are tabulated in Supplementary Table 1. Two independent assessors (J. Y. W. and M. C. L.) determined the relevancy of each study by initially reviewing titles and abstracts, with conflicts settled via discussion. If necessary, a third party (S. M. C.) would arbitrate.

### Data extraction, data synthesis, and statistical methods

Initially, characteristics of the included studies were extracted, which encompassed the study year, types of interventions, intervention procedures, types of control groups, and the tools used for measuring nausea scores. For trials with more than two arms, intervention or placebo groups were appropriately combined or specific groups were excluded based on the specific comparisons being performed.

A meta-analytic approach was employed to assess the prophylactic efficacy of aromatherapy in reducing PONV. Primary endpoints included nausea severity, graded on a scale from 0 to 10, and the number of vomiting episodes. Given the anticipated variability among studies regarding nausea grading scales and differing follow-up durations for vomiting episodes, standardized mean difference (SMD) was chosen as the metric for effect size. Heterogeneity was quantified using Cochran's $Q$ statistic [37] and Higgins' $I^2$ indicator [38]. In cases of high heterogeneity among the included studies, a random-effects

model was used to calculate the pooled effect size. Subgroup analysis was performed to examine the effect of different types of aromatherapies on nausea and vomiting. Sensitivity analysis was conducted by excluding each study one at a time to assess the robustness of the results. Publication bias was assessed using funnel plots or Egger's test depending on the number of included studies [39]. All statistical analyses were performed using STATA 18.0 software (StataCorp LLC, College Station, TX, USA) [40].

### Quality assessment

Quality evaluations were carried out using the Risk of Bias 2 (RoB 2) tool for RCTs [41], which evaluated five domains for each individual study: Randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. For QE trials, we employed the ROBINS-I tool [42], which examined seven domains for each study: confounding bias, selection bias of participants, bias in intervention classification, bias due to deviations from intended interventions, bias due to missing data, bias in outcome measurement, and bias in the selection of the reported result. Two autonomous evaluators (J. Y. W. and M. C. L.) examined each study, and conflicting views were harmonized through discussion. If necessary, a third party (S. M. C.) would arbitrate.

### Ratings of quality of evidence

The evaluation of the quality of evidence for each outcome of interest across studies was conducted using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach [43]. Summary tables were generated via GRADEpro/GDT software (Evidence Prime, Inc., Hamilton, ON, Canada) [44]. The GRADE system considers several factors, such as the RoB, inconsistency, indirectness, and imprecision, along with other considerations, including publication bias, the magnitude of the effect, any plausible residual confounding, and the dose–response gradient. The GRADE approach facilitates the assessment of certainty in the quality of evidence, grading it on four levels, from very low to high. In addition, it assesses the importance of the evidence at three levels – critical, important, and nonimportant [43].

### Ethical Statement

This systematic review did not involve direct human or animal subjects and therefore did not require ethical approval. All analyses were based on previously published data.

## Results

### Eligible studies and characteristics

In the eligibility assessment, a total of 2773 records were screened, and 326 full-text articles were assessed. Among them, 315 studies were excluded from the meta-analysis because they did not align with our PICO question.

After the screening process, 11 articles were selected for qualitative review, including 8 RCTs [27,28,31,32,45-48] and 3 QE trials [29,30,49] [Figure 1]. These studies involved a total of 1154 participants, and their characteristics are summarized in Table 1.

In the intervention groups of the included studies, patients received various aromatherapy treatments, such as isopropyl alcohol, ginger essence, peppermint essential oil, lavender, or clary sage oil, for the prevention of PONV. The control groups were administered either saline, sterile water, or standard antiemetic drugs. Various tools were employed to assess nausea severity, including the Visual Analog Scale, Verbal Rating Numerical Scale, Verbal Descriptive Scale, Nausea Scale, and PONV score. Notably, the studies conducted by Lee and Shin [29], Fearrington *et al*. [49], and Karsten *et al*. [30] were excluded from the subsequent meta-analysis due to the lack of reported outcomes that aligned with our predefined measures or the unavailability of necessary data. The remaining eight studies meeting the inclusion criteria were included in the meta-analysis for further analysis.

### Quality assessment

The included RCTs were evaluated for bias using the ROB 2 tool, with results summarized in Supplementary Table 2, detailing bias risk across each domain. In terms of bias assessment, most of the domains for each study showed low risk, except for the deviation domain. This domain refers to the potential for deviations from the intended intervention protocol. All studies included in the analysis received a "some concern" rating in this domain due to the inherent difficulty in maintaining blinding in aromatherapy interventions. It is challenging to blind both participants and researchers to the specific aromatherapy treatment being administered. Furthermore, there were three studies that did not provide information on their registration. This lack of registration information makes it difficult to assess the risk of selective reporting bias. As a result, these studies were also rated as "some concern" in terms of potential selective reporting bias. Regarding the QE trials included, the RoB assessment results using ROBINS-I are presented in Supplementary Table 3. Overall, of the three studies, two were rated as "moderate" and one as "serious." This was primarily due to unreported key baseline characteristics or imbalances between groups, lack of blinding, and issues arising from not preregistering the studies.

### Effect of interventions, publication bias, and sensitivity analysis

Overall, the use of aromatherapy as a preventive measure for PONV demonstrated effectiveness in reducing nausea severity [SMD: −0.93, 95% CI: −1.64 to −0.22, $P$ = 0.010; Figure 2] compared to the control group. In the subgroup analysis, concerning the prevention of postoperative nausea, the most significant effect was observed with ginger essence, as evidenced by an SMD of −3.44 and a 95% CI of −4.00 to −2.88. In addition, lavender oil and peppermint oil also showed significant effects in preventing postoperative nausea, with SMDs of −0.64 (95% CI: −1.19 to −0.10) and −0.62 (95% CI: −0.89 to −0.35), respectively. However, the effect of aromatherapy on reducing the number of vomiting episodes did not reach statistical significance, with an SMD of −0.81 and a 95% CI from −1.98 to −0.37 [$P$ = 0.180; Figure 3]. In the subgroup analysis, ginger essence and lavender oil still showed significant effects in reducing the number of vomiting episodes,

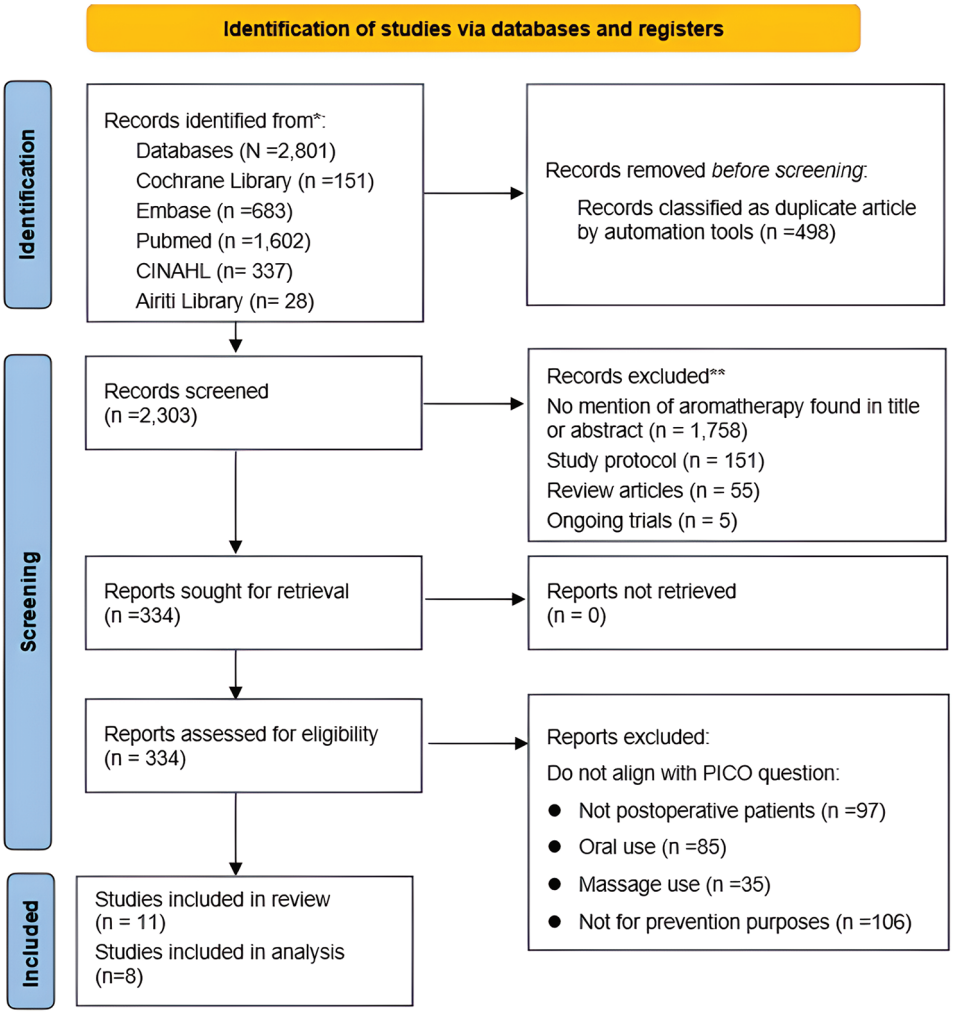


**Figure 1:** Flowchart of the literature search

with SMDs of −2.55 (95% CI: −2.90 to −2.20) and −0.56 (95% CI: −1.11 to −0.22), respectively. It is important to note that significant statistical heterogeneity was observed in both the severity of nausea outcomes ($I^2$ = 94.09%) and the number of vomiting episodes ($I^2$ = 96.5%). Sensitivity analysis was performed by excluding individual studies to assess their impact on the overall results of the meta-analysis. For the outcome of nausea severity, excluding the study conducted by Adib-Hajbaghery and Hosseini [27], which had the largest difference in effect compared to other studies, resulted in a substantial decrease in heterogeneity from 94.0% to 30.8%. Despite this reduction, the findings remained statistically significant, indicating that the results were robust and not solely driven by the excluded study. In addition, for the outcome of reducing the number of vomiting episodes, removing the study conducted by Maghami *et al*. [31], which also had a notable difference in effect, led to a decrease in heterogeneity from 96.5% to 95.6%. Although the heterogeneity remained relatively high, the results became statistically significant.

For publication bias assessment, since the number of studies was <10, Egger's test was used to examine the presence of small-study effects and potential publication bias. The results of Egger's test indicated that there was no significant evidence of small-study effects for the severity of nausea score ($P$ = 0.130). Similarly, for the outcome of vomiting, Egger's test also did not show significant evidence of small-study effects or publication bias ($P$ = 0.640). These findings suggest that there is no strong indication of publication bias in the available studies for both outcomes.

### Certainty of the evidence

We used GRADE to evaluate the certainty of evidence of the included studies [Supplementary Table 4]. The certainty of evidence for the importance of nausea severity scores after the preventive use of aromatherapy was rated as "low," indicating that there are limitations or uncertainties in the available evidence. However, it is still recognized as an important outcome in the context of evaluating the effectiveness of aromatherapy for managing postoperative symptoms. Similarly, the certainty of evidence for the reduction of vomiting episodes after aromatherapy was also rated as "low," acknowledging the limitations or uncertainties in the evidence. However, the importance of this outcome in the context of evaluating the impact of aromatherapy on postoperative symptoms is still recognized.

**Table 1: Overview of study characteristics**

| Study, country | Design | Population | Study size | Age, mean (SD) | Female (%) | Intervention | Control | Procedure | Nausea assessing tools (range) |
|---|---|---|---|---|---|---|---|---|---|
| Teran and Hawkins, 2007 [45]; USA | RCT | Patients scheduled for laparoscopic surgical procedure | 57 | NR | NR | IPA (*n*=22) | GRA/ no Tx (*n*=16/19) | Intervention: 3 deep breaths of a 70% IPA swab<br>Control: (1) 0.1 mg of GRA IV 15–30 min before emergence and extubation. (2) no prophylactic Tx | VAS (0–10) |
| Radford *et al*., 2011 [46]; USA | RCT | Patients scheduled for surgery, mostly laparoscopic and gynecological surgical procedures | 76 | 35.5 (10.1) | 96.1 | IPA + OND (*n*=38) | OND (*n*=38) | Intervention: 3 deep breaths of 70% IPA vapors before preoxygenation + 4-mg IV OND 15–30 min before emergence<br>Control: 4-mg IV OND 15–30 min before emergence | VNRS (0–10) |
| Adib-Hajbaghery and Hosseini, 2015 [27]; Iran | RCT | Patients scheduled for nephrectomy | 120 | 43.7 (16.7) | 33.3 | GEO (*n*=60) | NS (*n*=60) | Intervention: 2 drops of GEO applied to a 2″ × 2″ gauze attached to their clothing collar and repeated every 30 min for 2 h<br>Control: NS | VAS (0–10) |
| Hosseini and Adib-Hajbaghery, 2015 [28]; Iran | RCT | Patients scheduled for open and laparoscopic nephrectomies | 100 | 46.5 (17.2) | 35.0 | GEO (*n*=50) | NS (*n*=50) | Intervention: 2 drops of GEO applied to a 5 cm × 5 cm gauze attached to their clothing collar and repeated every 30 min for 2 h<br>Control: NS | VAS (0–10) |
| Lee and Shin, 2017 [29]; Korea | QE | Patients scheduled for major abdominal surgery | 60 | <60: 46.7%<br>≥60: 53.3% | 36.7 | GEO (*n*=30) | NS (*n*=30) | Intervention: an aromatherapy necklace containing 0.3 mL of GEO. The necklace was provided to the patients as soon as they arrived at the PACU. Patients were instructed to wear the necklace for 24 h<br>Control: NS | PONV score (0–32) |
| Fearrington *et al*., 2019 [49]; USA | QE | Patients scheduled for ambulatory surgery or a 23-h stay | 322 | 54.9 (16.8) | 49.1 | PEO, GEO, or mixed (*n*=143) | RC (*n*=179) | Intervention: Inhalers contained 4 drops of PEO or GEO, or a combination containing 2 drops of each of the two oils<br>Control: RC | Verbal Descriptive Scale (0–3) |
| Karsten *et al*., 2020 [30]; USA | QE | Patients admitted to the PACU | 100 | NR | NR | PEO (*n*=50) | NS (*n*=50) | Intervention: A cotton ball with 3 drops of PEO was waved under the patient's nostrils upon arrival in the PACU<br>Control: NS | Nausea Scale (0–5) |
| Ahmadi *et al*., 2020 [47]; Iran | RCT | Patients undergoing abdominal surgery | 120 | 15–30: 17.5%<br>31–48: 25.8%<br>49–65: 30.7% | 50.8 | 10%/30% PEO (*n*=40/40) | SW | Intervention: 0.2 mL equivalent of two drops of 10% peppermint essential oil was added to 2 mL of distilled water. This mixture was then poured onto a 4 × 4 piece of gauze and placed at a distance of 10 cm from the patient's nose for 5 min<br>Control: Colored SW | VAS (0–100) |
| Amirhosseini *et al*., 2020 [32]; Iran | RCT | Patients undergoing percutaneous nephrolithotomy | 79 | NR | 34.2 | LEO/CSEO (*n*=27/26) | RC (*n*=26) | Intervention: The researcher, supervised by a doctor, applied three drops of the desired aromatic oil (100% lavender or clary sage) onto a sterilized gauze. The gauze was then placed within 10 cm of the patient's nose, and the patient was instructed | VAS (0–10) |

*Contd...*

**Table 1: Contd...**

| Study, country | Design | Population | Study size | Age, mean (SD) | Female (%) | Intervention | Control | Procedure | Nausea assessing tools (range) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | to inhale the aroma for a duration of 5 min<br>Control: RC | |
| Maghami *et al*., 2020 [31]; Iran | RCT | Patients undergoing open heart surgery | 56 | 59.8 (9.8) | 30.4 | 10% PEO (*n*=30) | RC (*n*=26) | Intervention: 3 phases: Preextubation, 4 and 8 h postextubation. Initially, PEO with distilled water was given via a ventilator nebulizer for 10 min. In later phases, a nebulizer mask was used. After mask removal, oxygen was administered nasally. Patients drank distilled water 30 min after the final phase<br>Control: RC | Nausea severity scores (0–100) |
| Shilpa *et al*., 2023 [48]; India | RCT | Patients scheduled for laparoscopic surgeries | 80 | 50.2 (10.4) | 47.5 | IPA + OND | NS + OND | Intervention: IPA vapors from a commercially available 70% IPA pad immediately prior to preoxygenation. The anesthesia provider removed the IPA pad from the package and held it approximately 0.5″ from the nares and instructed the patient to take 3 deep nasal inhalation of the IPA vapors. A 4 mg IV OND was administered 15–20 min prior to induction<br>Control: NS + 4 mg IV OND | VNRS scale (0–10) |

CSEO, clary sage essence oil; GEO, ginger essence oil; GRA, granisetron; IPA, isopropyl alcohol; IV, intravenous; LEO, lavender essence oil, NVAS, nausea visual analog scale; NR, not reported; NS, normal saline; OND, ondansetron; PACU, postanesthesia care unit; PEO, peppermint essence oil; PONV, postoperative nausea and vomiting; QE, quasi-experimental; RC, routine care; RCT, randomized controlled trial; SD, standard deviation; SW, sterile water; Tx, treatment; VAS, visual analogue scale, VNRS, verbal numeric rating scale scores

## Discussion

The mechanism of action underlying aromatherapy's potential preventive effect on PONV is an area of ongoing investigation. Smith and Kyle proposed that aromatherapy might stimulate the limbic system via olfactory senses, triggering hypothalamus and pituitary gland activation [50]. This process, as well as the potential absorption of essential oils through the skin, might play crucial roles in influencing cellular and organ functions, potentially reducing postoperative nausea [51].

The results of this systematic review and meta-analysis lend preliminary support to the potential of aromatherapy as a prophylactic intervention in reducing the severity of postoperative nausea. However, its effectiveness in significantly curtailing the incidence of vomiting episodes remains less conclusive. Subgroup analyses suggest differential effectiveness across specific essential oils, with ginger, lavender, and peppermint presenting more promising effects in managing postoperative nausea. Nevertheless, the substantial statistical heterogeneity observed across both outcomes underscores the need for judicious interpretation of the findings. The observed heterogeneity can potentially be attributed to the variation in the methodological designs across the included studies. Variations in intervention procedures, types of essential oils used, and patient demographics might have contributed to the observed inconsistencies. Future research endeavors could aim to standardize intervention protocols and further investigate specific essential oils with potent antiemetic properties, thereby reducing heterogeneity. In addition, three QE trials were included in the review but not synthesized, as they lacked outcomes relevant to our focus. However, their findings are in line with our results. Lee and Shin [29] showed that ginger essential oil significantly reduced PONV scores. Fearrington *et al.* [49] noted that peppermint, ginger essence oil, or a combination decreased the need for antiemetics. Karsten *et al*. [30], using peppermint, observed no statistically significant impact on PONV incidence and severity, but their results were more favorable toward aromatherapy.

In this study, one significant limitation includes differences in outcome measurements and the timing of these measurements. The timing from exposure to aromatherapy to measurement varied across studies, possibly affecting the observed efficacy of aromatherapy in managing PONV. In addition, heterogeneity in anesthesia administration across studies could have influenced the effect of aromatherapy on PONV, as different types of anesthesia can variably affect PONV risk. Furthermore, the studies included in our review did not account for patient American Society of Anesthesiologists (ASA) status or specific PONV risk assessment. These factors could significantly influence the

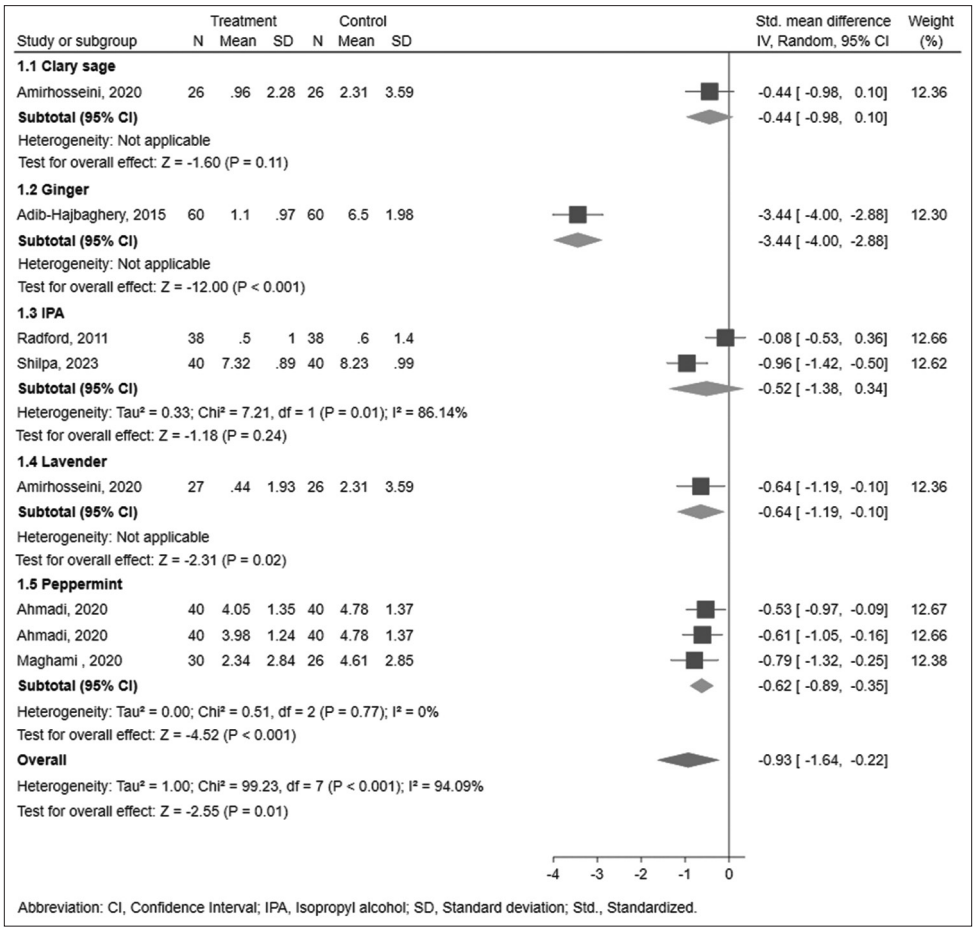


**Figure 2:** Forest plot of the nausea severity score. CI: Confidence interval, SD: Standard deviation, IPA: Isopropyl alcohol, Std: Standardized

incidence and severity of PONV and, therefore, potentially confound the observed effects of aromatherapy.

Regarding safety, aromatherapy is generally considered safer than medications, presenting fewer side effects. In our study, no adverse effects were reported in the included research. However, caution is still advised during use. Posadzki *et al*. [52] reviewed 42 case reports and case series involving 71 patients, with the most frequently reported adverse effect being dermatitis from topical use. Lavender, peppermint, tea tree oil, and ylang-ylang were the essential oils most frequently reported.

Furthermore, regarding cost-effective, Gress *et al.* [6] noted that patients are willing to pay between $46.85 and $132.98 out of pocket to avoid the occurrence of PONV. For hospitals, the lost revenue due to decreased staffing efficiency and increased PACU time caused by PONV is estimated at approximately $723.27. Given that aromatherapy is a low-cost intervention, if it proves effective in preventing or reducing the severity of PONV, it appears to be a cost-effective approach. Exploring the cost-effectiveness of aromatherapy in preventing PONV remains an important area for future research.

Despite the presence of substantial heterogeneity and certain methodological limitations, the results of this meta-analysis should not be discounted. The indication of the potential effect of aromatherapy as a nonpharmacological intervention in managing postoperative nausea warrants further exploration. The ability to mitigate postoperative nausea without relying solely on pharmacological interventions may not only reduce the overall treatment cost but also improve patient comfort, making aromatherapy a potentially viable adjunctive or alternative treatment.

Our review was also limited by the small number of studies included in the analysis, potential biases within these studies, and the challenge in maintaining blinding in aromatherapy interventions. These limitations potentially affect the reliability and generalizability of our findings. Moreover, due to the wide variety of essential oils and their methods of administration in the included studies, drawing definitive conclusions about the effectiveness of a particular type of aromatherapy remains challenging. Future research should aim to establish standardized intervention protocols to reduce this source of heterogeneity.

The evidence generated from this review, as per the GRADE approach, is of low certainty, suggesting a high probability of further research impacting our confidence in the effect estimate and possibly leading to a revision of our current estimate. Given these considerations, our findings must be interpreted with caution. There is a need for future high-quality, robust RCTs. These should control for potential

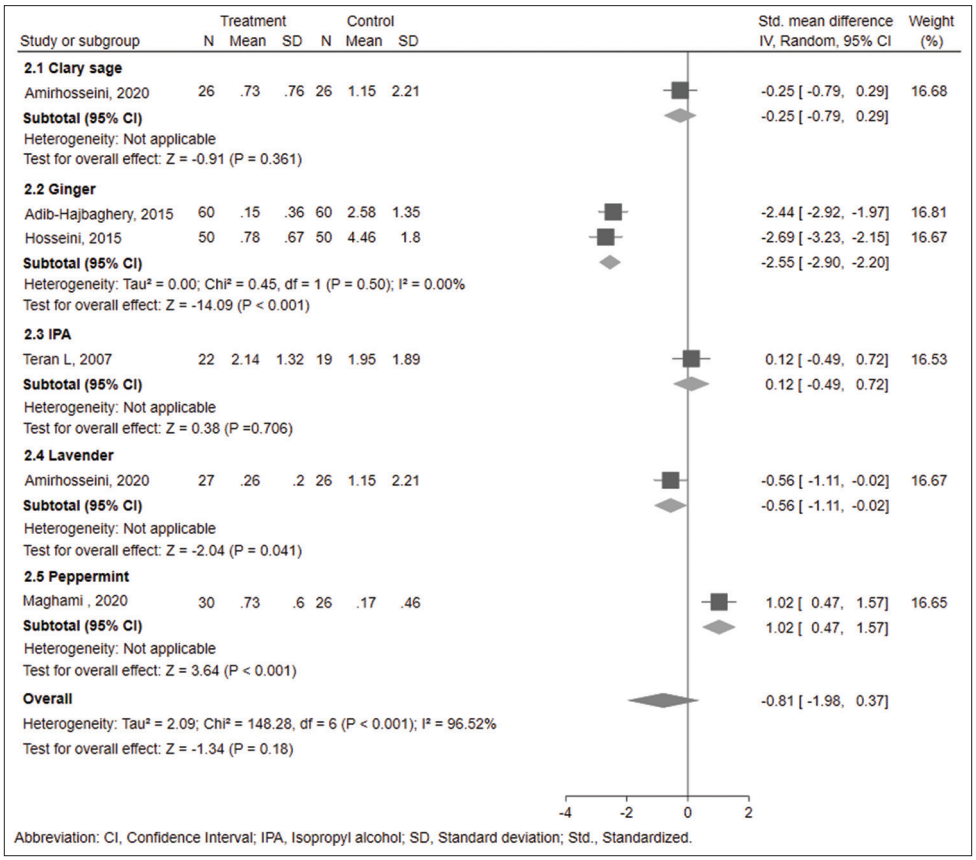


**Figure 3:** Forest plot of the number of vomiting episodes. CI: Confidence interval, SD: Standard deviation, IPA: Isopropyl alcohol, Std: Standardized

confounders, including ASA status, PONV risk factors, and anesthesia types, and aim to standardize intervention protocols, outcomes, and their measurement times.

## Conclusion

This review provides preliminary evidence supporting the potential benefit of aromatherapy, particularly ginger, lavender, and peppermint essential oils, in reducing the severity of postoperative nausea. However, its effectiveness in reducing the incidence of vomiting episodes remains unclear. Despite the observed heterogeneity and methodological limitations in the included studies, as well as the low certainty of the current evidence, our findings should not be entirely discounted. Considering the safety, affordability, and ease of administration of aromatherapy, we suggest that clinicians contemplate incorporating aromatherapy as a preventive measure against PONV in their practice. The decision to employ aromatherapy should be guided by the individual patient's condition and the clinician's professional judgment and supported by more rigorous future research. The potential for improved patient comfort and reduced treatment costs makes aromatherapy an avenue worth pursuing in future clinical research and practice.

### Data availability statement

All data generated or analyzed during this study are included in this published article and its supplementary information files.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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**Supplementary Table 1: Search strategy**

| Database | Search strategy | Results |
|---|---|---|
| PUBMED | #1. Aromatherapy[MeSH Terms] | 1053 |
| | #2. Plants, Medicinal[MeSH Terms] | 62,418 |
| | #3. Mentha piperita[MeSH Terms] | 748 |
| | #4. Ginger[MeSH Terms] | 2014 |
| | #5. Complementary Therapies[MeSH Terms] | 244,502 |
| | #6. Naturopathy[MeSH Terms] | 1063 |
| | #7. Phytotherapy[MeSH Terms] | 42,025 |
| | #8. Holistic Health[MeSH Terms] | 8007 |
| | #9. peppermint[MeSH Terms] | 748 |
| | #10. isopropyl alcohol[MeSH Terms] | 1879 |
| | #11. aromatherap* | 1957 |
| | #12. (plant* or traditional or complementary) AND medicin* | 494,607 |
| | #13. naturopath* | 2367 |
| | #14. phytotherap* | 48,496 |
| | #15. #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 | 672,265 |
| | #16. Postoperative Nausea and Vomiting[MeSH Terms] | 4587 |
| | #17. Anesthesia Recovery Period[MeSH Terms] | 5524 |
| | #18. postoperative AND (care or nausea or vomit*) | 218,755 |
| | #19. recovery AND (room or anesthesia or period) | 115,812 |
| | #20. PONV | 12,531 |
| | #21. #16 OR #17 OR #18 OR #19 OR #20 | 322,553 |
| | #22. #15 AND #21 Filters: Clinical Study, Clinical Trial, Clinical Trial, Phase II, Clinical Trial, Phase III, Clinical Trial, Phase IV, Controlled Clinical Trial, Randomized Controlled Trial, Humans | 1602 |
| Cochrane Library | #1. MeSH descriptor: [Holistic Health] explode all trees | 104 |
| | #2. MeSH descriptor: [Aromatherapy] explode all trees | 393 |
| | #3. MeSH descriptor: [Medicine, Traditional] explode all trees | 1973 |
| | #4. MeSH descriptor: [Naturopathy] explode all trees | 32 |
| | #5. MeSH descriptor: [Phytotherapy] explode all trees | 4748 |
| | #6. MeSH descriptor: [Plants, Medicinal] explode all trees | 1039 |
| | #7. MeSH descriptor: [Ginger] explode all trees | 255 |
| | #8. MeSH descriptor: [Mentha piperita] explode all trees | 83 |
| | #9. (Aromatherapy or “Holistic Health” or “Medicine, Traditional” or Naturopathy or Phytotherapy or “Plants, Medicinal” or Ginger or “Mentha piperita”):ti, ab, kw | 8253 |
| | #10. #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 | 9659 |
| | #11. MeSH descriptor: [Postoperative Nausea and Vomiting] explode all trees | 2846 |
| | #12. MeSH descriptor: [Postoperative Care] explode all trees | 5479 |
| | #13. MeSH descriptor: [Recovery Room] explode all trees | 353 |
| | #14. MeSH descriptor: [Anesthesia Recovery Period] explode all trees | 2200 |
| | #15. (postoperative* or post surg* or surgical or recovery) and (vomit* or nausea* or sick* or PONV) | 24,851 |
| | #16. #11 OR #12 OR #13 OR #14 OR #15 | 31,734 |
| | #17. #10 AND #16 | 189 |
| | #18. #17 in Trials | 151 |
| EMBASE | #1. “aromatherapy”/exp OR aromatherapy OR aromatherap* | 3841 |
| | #2. “alternative medicine”/exp OR “alternative medicine” | 98,810 |
| | #3. “medicinal plant”/exp OR “medicinal plant” | 318,783 |
| | #4. “mentha piperita”/exp OR “mentha piperita” | 1585 |
| | #5. “peppermint”/exp OR “peppermint” | 3964 |
| | #6. “ginger”/exp OR “ginger” | 13,633 |
| | #7. “phytotherapy”/exp OR “phytotherapy” | 29,823 |
| | #8. isopropyl AND (“alcohol” OR “alcohol”/exp OR alcohol) | 4209 |
| | #9. holistic AND (“health”/exp OR “health”) | 29,417 |
| | #10. naturopath* | 3379 |
| | #11. phytotherap* | 34,069 |
| | #12. #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 | 466,083 |
| | #13. “postoperative nausea and vomiting”/exp OR “postoperative nausea and vomiting” | 14,514 |
| | #14. “anesthetic recovery”/exp OR “anesthetic recovery” | 9067 |

*Contd...*

**Supplementary Table 1: Contd...**

| Database | Search strategy | Results |
|---|---|---|
| | #15. “postoperative care”/exp OR “postoperative care” | 118,804 |
| | #16. “recovery room”/exp OR “recovery room” | 11,361 |
| | #17. (“recovery” OR “recovery”/exp) AND period | 110,670 |
| | #18. #13 OR #14 OR #15 OR #16 OR #17 | 250,421 |
| | #19. #12 AND #18 | 1597 |
| | #20. #19 AND (“clinical article”/de OR “clinical trial”/de OR “control group”/de OR “controlled clinical trial”/de OR “controlled study”/de OR “crossover procedure”/de OR “double blind procedure”/de OR “major clinical study”/de OR “multicenter study”/de OR “randomized controlled trial”/de OR “randomized controlled trial topic”/de OR “single blind procedure”/de) | 922 |
| | #21. #20 AND “human”/de | 683 |
| CINAHL | #1. TX aromatherapy OR TX alternative medicine OR TX ginger OR TX peppermint OR TX isopropyl | 144,253 |
| | #2. TX postoperative OR TX nausea OR TX vomit* OR TX PONV | 2840 |
| | #3. (TX postoperative OR (TX nausea OR TX vomit*) OR TX PONV) AND (#1 AND #2) | 337 |
| Airiti Library | #1. [ALL3]=((手術 OR 術後) AND (噁心 OR 嘔吐)) | 466 |
| | #2. [ALL3]=(精油 OR 芳香 OR 吸入) | 4177 |
| | #3. #1 AND #2 | 28 |

**Supplementary Table 2: Risk of bias summary using Risk of Bias 2 tool for included randomized controlled trials**

| Study ID | D1 | D2 | D3 | D4 | D5 | Overall |
|---|---|---|---|---|---|---|
| Teran L, 2007 | Low risk | Some concern | Low risk | Low risk | Some concern | Some concern |
| Radford, 2011 | Low risk | Some concern | Low risk | Low risk | Some concern | Some concern |
| Adib-Hajbaghery, 2015 | Low risk | Some concern | Low risk | Low risk | Low risk | Some concern |
| Hosseini, 2015 | Low risk | Some concern | Low risk | Low risk | Low risk | Some concern |
| Ahmadi, 2020 | Low risk | Some concern | Low risk | Low risk | Low risk | Some concern |
| Amirhosseini, 2020 | Low risk | Some concern | Low risk | Low risk | Low risk | Some concern |
| Maghami, 2020 | Low risk | Some concern | Low risk | Low risk | Low risk | Some concern |
| Shilpa, 2023 | Low risk | Some concern | Low risk | Low risk | Some concern | Some concern |

D1 Randomization process. D2 Deviations from the intended interventions. D3 Missing outcome data. D4 Measurement of the outcome. D5 Selection of the reported result

**Supplementary Table 3: Risk of bias summary using the Risk of Bias in Non-Randomized Studies - of Interventions tool for included quasi-experimental trials**

| Study ID | Bias due to confounding | Bias in selection of participants into the study | Bias in classification of interventions | Bias due to deviations from intended interventions | Bias due to missing data | Bias in measurement of outcomes | Bias in selection of the reported result | Overall bias |
|---|---|---|---|---|---|---|---|---|
| Lee, 2017 | Low | Low | Low | Moderate | Low | Moderate | Moderate | Moderate |
| Fearrington, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Karsten, 2020 | Serious | Low | Low | Moderate | Low | Moderate | Low | Serious |

**Supplementary Table 4: Grading of Recommendations, Assessment, Development, and Evaluations summary of findings table**

| Certainty assessment | | | | | | | Number of patients | | Effect | | Certainty | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Aromatherapy | Control | Relative (95% CI) | Absolute (95% CI) | | |
| **Nausea severity score (scale from: 0 to 10)** | | | | | | | | | | | | |
| 7 | Randomized trials | Not serious[a] | Very serious[b] | Not serious | Not serious[c] | None | 301 | 296 | - | SMD: −0.93 (−1.64–−0.22) | ⊕⊕◯◯ - low | Important |
| **The number of vomiting episodes** | | | | | | | | | | | | |
| 6 | Randomized trials | Not serious[a] | Very serious[d] | Not serious | Not serious[c] | None | 215 | 207 | - | SMD: −0.81 (−1.98–−0.37) | ⊕⊕◯◯ - low | Important |

[a]The evaluation results using the RoB 2 tool showed that all five domains in the studies were consistently classified within the "low" to "some concern" risk categories, [b]$I^2$=94.02% (considerable heterogeneity), [c]Total number of patients >400, [b]$I^2$=96.52% (considerable heterogeneity). CI: Confidence interval, SMD: Standardized mean difference, RoB 2: Risk of Bias 2