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Effectiveness of Lemon Aromatherapy-Enhanced Health Belief Model Counseling in Reducing Labor Pain

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Abstract

Background: Labor pain is a complex sensory-emotional experience that may lead to maternal exhaustion and prolonged labor if inadequately managed. Health Belief Model (HBM)-based antenatal counseling may improve coping self-efficacy, while inhaled lemon (*Citrus limon*) aromatherapy may reduce pain perception. **Objective:** To evaluate the effectiveness of lemon aromatherapy-enhanced HBM counseling in reducing labor pain and distinguish the effects of counseling from aromatherapy. Methods: A three-arm quasi-experimental study was conducted among 135 low-risk laboring women in Medan, Indonesia. Participants received HBM counseling plus lemon aromatherapy (n=45), HBM counseling only (n=45), or routine care (n=45). Pain intensity was measured at cervical dilatations of 4, 6, and 8 cm using the Numeric Rating Scale. Data were analyzed using ANOVA, post-hoc tests, relative risk, and generalized estimating equations. Results: At 8 cm dilatation, mean pain scores were 6.5±1.4, 7.8±1.3, and 8.3±1.2 in Groups A, B, and C, respectively. Aromatherapy significantly reduced pain compared with counseling alone ($p<0.001$). Group A also demonstrated lower severe pain risk (adjusted RR=0.38; 95% CI: 0.22–0.66), shorter active labor, and higher birth satisfaction, while neonatal outcomes were comparable. **Conclusion:** HBM-based antenatal counseling combined with lemon aromatherapy is an effective, safe, and low-cost strategy for improving labor pain management in primary midwifery care.

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Introduction

Labor pain is among the most intense pain experiences a woman encounters in her lifetime. It is inherently multidimensional: the sensory component arises from uterine contractions, cervical

dilatation, and stretching of the pelvic tissues, whereas the affective-cognitive component is shaped by fear, anxiety, expectations, and the woman's beliefs about her own capacity to cope with childbirth. Gate control theory holds that pain perception is not simply a function of peripheral stimulus intensity but the product of modulation by descending pathways that are themselves influenced by psychological and attentional factors (Melzack & Wall, 1965). Interventions that target both components sensory and psychological simultaneously therefore rest on a strong physiological rationale. Unmanaged labor pain is not merely a matter of comfort. Severe pain triggers a stress response marked by increased catecholamine release, which impairs effective uterine contractility, prolongs the first stage of labor, intensifies maternal exhaustion, and contributes to fetal distress. Fear of labor pain is also a principal driver of non-medically indicated requests for cesarean section, which contributes to the high cesarean rates observed in middle-income countries, including Indonesia. Recent systematic reviews and network meta-analyses position non-pharmacological interventions as the first line for reducing fear of childbirth and improving the birth experience (Alizadeh-Dibazari et al., 2024; Zhou et al., 2025).

In primary midwifery care in Indonesia particularly in independent midwifery practices (Praktik Mandiri Bidan, PMB) epidural analgesia is not available, so pain management relies entirely on non-pharmacological approaches. Two promising approaches have to date been pursued in isolation from each other: (1) antenatal psychological preparation aimed at strengthening the woman's self-belief, and (2) inhalation aromatherapy administered during labor. The first approach is rooted in the concept of childbirth coping self-efficacy, that is, a woman's belief that she is able to apply coping strategies breathing control, relaxation, positioning, and distraction to manage her contractions. Lowe (1993) developed the Childbirth Self-Efficacy Inventory (CBSEI) and demonstrated that self-efficacy is the single most decisive psychosocial variable explaining variation in pain during the active phase of labor, extending the earlier findings of Manning and Wright (1983). Subsequent cross-cultural studies have consistently reported an inverse association between coping self-efficacy and reported pain intensity (Huang et al., 2024). Structured antenatal education has been shown to enhance coping self-efficacy, reduce fear of childbirth, and improve the birth experience (Alizadeh-Dibazari et al., 2023; Çankaya & Şimşek, 2021).

The Health Belief Model (HBM) provides a systematic framework for designing such counseling. The HBM conceives of health behavior as a function of perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Rosenstock et al., 1988; Champion & Skinner, 2008). In the context of childbirth, the target behavior is not the elimination of pain but the active application of non-pharmacological coping strategies: susceptibility is framed as the likelihood of experiencing uncontrolled pain in the absence of preparation; severity as the consequences of prolonged labor and exhaustion; benefits as the effectiveness of coping techniques; barriers as fear, myths, and inadequate support; cues to action as the birth plan and the involvement of a birth companion; while self-efficacy is strengthened through guided practice. Applications of the HBM to childbirth preparation have been reported in several settings (Alyafei & Easton-Carr, 2024; Şenol et al., 2024), yet empirical evidence of its influence on actual pain intensity remains limited. The second approach is inhalation aromatherapy. Systematic reviews and meta-analyses consistently report significant reductions in pain scores among women receiving aromatherapy, while cautioning that the quality of the underlying evidence remains limited and that no harm has been demonstrated (Boaviagem et al., 2021; Kaya et al., 2023; Liao et al., 2021; Tabatabaeichehr & Mortazavi, 2020). For lemon essential oil specifically, the randomized controlled trial by Sirkeci, Cagan, and Koc (2023) found that lemon inhalation significantly reduced pain scores at 5–7 cm of dilatation compared with control, yet did not affect anxiety scores. This finding is mechanistically important because it suggests that lemon aromatherapy acts on the pain perception pathway rather than through an anxiolytic pathway.

Lemon has also been evaluated for labor pain in Indonesian primary midwifery settings and shows a favorable safety profile (Lestari et al., 2022).

It is precisely here that the research gap arises. The existing literature keeps the two approaches apart: antenatal education studies typically measure fear of childbirth and self-efficacy without repeatedly measuring actual pain, whereas aromatherapy studies typically measure intrapartum pain without any psychological preparation component. When the two are combined into a single intervention package as midwives commonly do in practice the observed effect becomes confounded: it is not known whether pain relief originates from the aromatherapy, from the counseling, or from both. A two-group design (full package versus control) is structurally incapable of answering this question.

Novelty of the Study

The novelty of this study lies in four aspects. **First**, it is the first study to integrate antenatal HBM-based counseling with intrapartum lemon inhalation aromatherapy within a single, theoretically coherent package of midwifery care, with aromatherapy positioned as a concrete instrument addressing the perceived barriers construct. **Second**, the three-arm design (HBM plus aromatherapy, HBM alone, and control) permits explicit decomposition: the HBM-only versus control contrast isolates the counseling effect, whereas the combination versus HBM-only contrast isolates the incremental effect of aromatherapy a separation that has not previously been performed in the labor pain literature. **Third**, the study tests the pathway dissociation hypothesis directly: aromatherapy is predicted to act on pain perception, whereas counseling is predicted to act on coping self-efficacy and anxiety a prediction consistent with the finding of Sirkeci et al. (2023) that lemon reduces pain without affecting anxiety. **Fourth**, pain was measured repeatedly according to cervical dilatation (4, 6, and 8 cm) and analyzed using generalized estimating equations, so that the pain trajectory across the first stage of labor rather than a single time point could be modeled in the setting of an Indonesian independent midwifery practice, a context that has hitherto been almost entirely absent from the international literature.

Research Objectives

This study aimed to (1) analyze the effectiveness of lemon aromatherapy-enhanced HBM counseling in reducing pain intensity during the active phase of the first stage of labor; (2) separate the effect of HBM counseling (HBM-only group versus control) from the incremental effect of lemon aromatherapy (combination group versus HBM-only group) on pain, coping self-efficacy, and anxiety; (3) analyze the influence of the intervention on the duration of the active first stage, the need for analgesia referral, birth satisfaction, and neonatal outcomes; and (4) identify the dominant factors associated with the occurrence of severe labor pain.

Hypotheses

H1: Labor pain intensity in the combination group (HBM plus lemon aromatherapy) is lower than in either the HBM-only group or the control group. **H2:** The reduction in pain intensity is driven principally by lemon aromatherapy (a significant combination versus HBM-only contrast) rather than by counseling alone. **H3:** The increase in childbirth coping self-efficacy and the reduction in anxiety are driven by HBM counseling (the combination and HBM-only groups are equivalent, and both are superior to control). **H4:** The combination group has a shorter active first stage, a lower requirement for analgesia referral, and higher birth satisfaction, with no between-group difference in neonatal outcomes.

Materials and Methods

Design, Setting, and Timeframe

This study used a three-group quasi-experimental design with a non-equivalent control group and repeated measures of the primary outcome. Reporting follows the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) statement, which is intended for evaluations of non-randomized behavioral interventions. The three groups were Group A (antenatal HBM counseling plus lemon aromatherapy during the first stage of labor), Group B (antenatal HBM counseling only), and Group C (control, receiving routine intrapartum care). The three-arm design was chosen deliberately so that the counseling effect could be separated from the aromatherapy effect. The study was conducted at Sartika Manurung independent midwifery practice (PMB) in Medan, North Sumatra Province, from January to August 2026, encompassing an antenatal phase (recruitment and counseling at 32–38 weeks of gestation) and an intrapartum phase (pain measurement during the active phase of the first stage).

Population, Sample, and Eligibility Criteria

The population comprised third-trimester pregnant women attending antenatal care at Sartika Manurung PMB who intended to give birth at the same facility. Consecutive sampling was applied to all women meeting the eligibility criteria during the recruitment period for each group.

The inclusion criteria were: age 20–35 years; term singleton pregnancy (37–41 weeks) with cephalic presentation; low-risk category; intention to deliver vaginally; willingness to participate in the entire study protocol; and the ability to communicate and understand the numeric pain scale. The exclusion criteria were: pregnancy complications (preeclampsia, placenta previa, premature rupture of membranes before the onset of labor); planned elective cesarean section; induction or augmentation of labor from the outset; use of pharmacological analgesia; a history of olfactory disorder, asthma, citrus allergy, or chronic pulmonary disease; and severe psychiatric disorder. The drop-out criteria were: emergency cesarean section, intrapartum referral, precipitate labor (an active first stage lasting <2 hours, rendering the repeated measurements incomplete), and withdrawal from the study.

Sample Size

The sample size was calculated using the formula for the comparison of two independent means applied to the primary contrast, namely the pain score (NRS) at 8 cm of dilatation between Group A and Group C. The parameters were: a minimal clinically important mean difference (Δ) of 1.0 NRS point, a pooled standard deviation of 1.6 points (based on the range reported in previous aromatherapy studies in labor), a two-sided $\alpha=0.05$ ($Z\alpha/2=1.96$), and 80% power ($Z\beta=0.84$), using the formula:

$$n \text{ per group} = 2 \times (Z\alpha/2 + Z\beta)^2 \times \sigma^2 / \Delta^2$$

The calculation yielded $n \approx 40$ participants per group. Anticipating intrapartum attrition of approximately 20% (emergency cesarean section, referral, precipitate labor), 50 participants per group were recruited (150 in total). During the study, 15 participants could not be analyzed (5 in each group), so that the final analyzed sample comprised 135 participants (45 per group), still satisfying the minimum required sample size. It should be noted that the sample size was powered

for the primary contrast; statistical power for the smaller incremental contrasts (A versus B, and B versus C) is comparatively limited and was taken into account in the interpretation.

Group Allocation

Group allocation was not randomized because of the operational constraints of the PMB and the high risk of contamination: the scent of lemon is readily detectable in adjacent birthing rooms, so individual random allocation within the same period would have contaminated the non-aromatherapy groups. Group assignment was therefore based on a rolling recruitment period comprising three consecutive phases (Group A, then Group B, then Group C). The methodological consequencebpotential temporal confounding is explicitly acknowledged and was addressed through baseline homogeneity testing and covariate adjustment in the multivariate models.

Intervention

Groups A and B both received four structured HBM counseling sessions, delivered individually by trained midwives between 32 and 38 weeks of gestation at two-week intervals, each lasting 45–60 minutes and reinforced by weekly reminder messages and the involvement of the birth companion. The single difference between the two groups was the administration of lemon aromatherapy during the first stage of labor in Group A. The counseling material mapped the six HBM constructs onto the target behavior, namely the active application of non-pharmacological coping strategies during labor:

Session 1 Perceived susceptibility and severity: explanation of the physiology of labor pain and of gate control theory; the possibility of experiencing uncontrolled pain if the woman panics and is unprepared; and the consequences of unmanaged pain, including exhaustion, prolonged labor, fetal distress, an increased likelihood of referral, and a traumatic birth experience.

Session 2 Perceived benefits and barriers: demonstration and guided practice of coping techniques (rhythmic deep breathing, progressive relaxation, positional change, ambulation, back massage by the companion, and attentional distraction) together with the evidence base for their benefits. The barriers identified and addressed included fear, local myths surrounding childbirth, and inadequate support from a birth companion.

Session 3 Cues to action: preparation of a written birth plan, an illustrated coping card to be brought to the birth, training of the birth companion in when and how to remind the woman to apply coping techniques, and periodic reminders as the estimated date of delivery approached.

Session 4 Strengthening self-efficacy: simulated practice in managing contractions (mastery experience), sharing of the experiences of women who had coped successfully (vicarious experience), verbal persuasion and positive affirmation, and reinterpretation of physiological signals (contractions reframed as labor progress rather than as a threat).

The lemon aromatherapy protocol (Group A only) was administered during the intrapartum phase. Two to three drops of 100% pure lemon (Citrus limon) essential oil of standardized quality were applied to a cotton ball or an inhaler stick, which the woman then inhaled from a distance of approximately 3 cm with three deep breaths. Aromatherapy commenced immediately after the woman entered the active phase of the first stage (4 cm of dilatation) and was repeated every 30 minutes and as needed whenever contractions peaked, until full dilatation. Women in Group A had been introduced to this aromatherapy from Session 2 of the counseling onward as part of the

strategy for overcoming barriers, so that its use during labor was already familiar to them. Group B received identical counseling but without aromatherapy, whereas Group C received routine intrapartum care according to standard practice (midwife attendance, mobilization, and general verbal support) without either structured HBM counseling or aromatherapy. None of the groups received pharmacological analgesia; women who required pharmacological pain relief were referred according to standard procedure, and this was recorded as an outcome.

Variables and Operational Definitions

The independent variable was the type of intervention, operationalized as a three-category variable: (A) HBM counseling plus lemon aromatherapy, (B) HBM counseling only, and (C) control. The primary dependent variable was pain intensity during the active phase of the first stage of labor. Secondary outcomes comprised childbirth coping self-efficacy, anxiety, fear of childbirth, duration of the active first stage, duration of the second stage, the need for analgesia referral, birth satisfaction, and Apgar score. The covariates controlled for were maternal age, parity (primiparous/multiparous), educational level, employment, pre-pregnancy body mass index, previous attendance at antenatal classes, the presence and quality of birth companion support, estimated fetal weight, and antenatal pain expectation.

Instruments and Measurements

Pain intensity was measured with the Numeric Rating Scale (NRS) from 0 to 10, where 0 denotes no pain and 10 denotes the worst pain imaginable. Measurements were taken three times by an assessing midwife at the peak of a contraction, namely at 4 cm of dilatation (before aromatherapy commenced, serving as the intrapartum baseline), 6 cm, and 8 cm, with dilatation confirmed by vaginal examination according to standard practice. Severe pain was defined as an NRS score ≥8.

Childbirth coping self-efficacy was measured using the Childbirth Self-Efficacy Inventory (CBSEI) developed by Lowe (1993), in the 16-item short form of the efficacy expectancy subscale, with a score range of 16–160; higher scores indicate stronger coping beliefs. Anxiety was measured with the state subscale of the State-Trait Anxiety Inventory (STAI-S, range 20–80) and fear of childbirth with the Childbirth Attitudes Questionnaire/fear of childbirth scale (range 16–64). Birth satisfaction was measured on a numeric scale from 1 to 10 at 24 hours postpartum. The duration of the active first stage was calculated from 4 cm of dilatation to full dilatation. All instruments were translated into Indonesian through a forward-backward translation procedure and pilot tested on 30 pregnant women outside the study sample, yielding Cronbach's alpha reliability coefficients of 0.88 (CBSEI), 0.86 (STAI-S), and 0.84 (fear of childbirth scale), together with adequate content validity.

To minimize assessor bias, intrapartum NRS assessment was performed by midwives who were not involved in delivering the counseling or the aromatherapy. Although complete blinding was not attainable because the scent of lemon is recognizable, the assessors were not informed of the study hypotheses and had no knowledge of the participants' antenatal CBSEI scores.

Data Analysis

Univariate analysis presented frequency distributions for categorical variables and means ± standard deviations (SD) or medians (IQR) for numerical variables, according to the results of the

Shapiro–Wilk normality test. Baseline homogeneity and between-group comparisons were tested with one-way ANOVA or the Kruskal–Wallis test for numerical variables and the chi-square test for categorical variables, followed by post-hoc tests (Tukey/Bonferroni) for the three pairwise contrasts specified a priori: A versus C (total effect), B versus C (counseling effect), and A versus B (incremental aromatherapy effect). Within-group comparisons (before versus after counseling) used the paired t-test. Pairwise relative risks (RR) with 95% confidence intervals were computed for binary outcomes (severe pain, analgesia referral).

The pain trajectory across the first stage of labor was modeled with a linear generalized estimating equation (GEE) using an exchangeable working correlation structure and robust standard errors, with repeated measurements at three dilatation points (4, 6, and 8 cm), entering the three-category group variable (control as reference), dilatation as the time variable, the group×dilatation interaction as the main effect parameter, and all covariates. Severe pain was analyzed with a Poisson GEE using robust variance to obtain adjusted RRs. Effect sizes were expressed as Cohen's d relative to the control group. A p value <0.05 was considered statistically significant. All analyses were performed with standard statistical software.

Research Ethics

Ethical clearance was obtained from the Health Research Ethics Committee of Universitas Bunda Thamrin under Number 011/KEPK-UBT/EC/VIII/2025. All participants provided written informed consent during the antenatal phase, with explicit affirmation of their right to withdraw at any time without any consequence for the care they received. Data confidentiality was guaranteed through anonymization. All participants including those in the control group continued to receive standard intrapartum care, and any woman experiencing intolerable pain or signs of complications was referred immediately according to protocol, without waiting for the scheduled measurement. The lemon essential oil used was administered at an inhalation dose reported in the previous literature to be safe for mother and fetus, and adverse effects (headache, respiratory tract irritation, nausea) were monitored at every measurement point.

Study Flow

The study proceeded as follows. Third-trimester pregnant women attending antenatal care were screened for eligibility at 32 weeks of gestation; those who were eligible gave informed consent and underwent baseline assessment (characteristics, CBSEI, STAI-S, fear of childbirth scale, and pain expectation). Participants then entered one of the three groups according to the recruitment phase. Groups A and B attended four HBM counseling sessions up to 38 weeks of gestation, at which point the CBSEI and the fear of childbirth scale were re-administered. When the woman entered labor, anxiety (STAI-S) was measured at 4 cm of dilatation, and pain intensity was measured at 4, 6, and 8 cm; lemon aromatherapy was administered to Group A from immediately after the first pain measurement onward. Labor and neonatal outcomes were recorded, and birth satisfaction was measured at 24 hours postpartum. Participants who could not be analyzed were recorded together with the reasons. The participant flow is presented in detail in Figure 1 (Results section).

Results and Discussions

Of the 186 third-trimester pregnant women assessed for eligibility, 36 were excluded (did not meet the inclusion criteria, n=22; declined to participate, n=10; planned elective cesarean section,

n=4), so that 150 women were recruited and allocated to the three groups, with 50 participants each. During the intrapartum phase, 15 participants could not be analyzed (5 in each group) because of emergency cesarean section, intrapartum referral, precipitate labor, and withdrawal. The final analysis was therefore performed on 135 participants (45 per group): Group A (HBM counseling plus lemon aromatherapy), Group B (HBM counseling only), and Group C (control). The participant flow is presented in Figure 1.

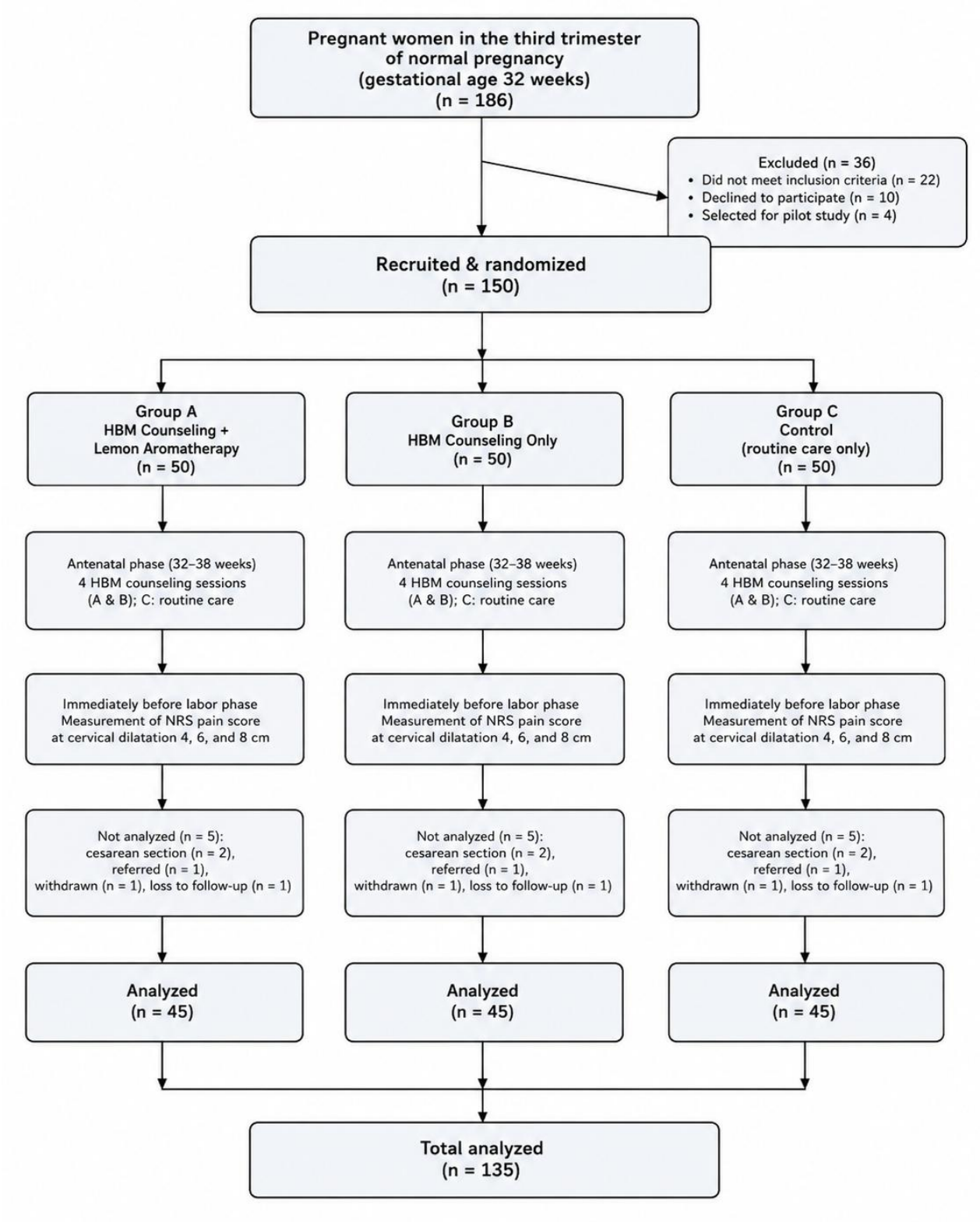

Figure 1. Participant flow diagram of the study (TREND reporting guideline).

Table 1. Baseline characteristics and homogeneity of respondents (n=135)

Characteristic	A: HBM+Aroma (n=45)	B: HBM only (n=45)	C: Control (n=45)	p
Maternal age (years), mean ± SD	27.6 ± 4.3	27.9 ± 4.1	28.1 ± 4.4	0.86
20–25 years, n (%)	14 (31.1)	13 (28.9)	12 (26.7)	0.93
26–30 years, n (%)	19 (42.2)	20 (44.4)	20 (44.4)	
31–35 years, n (%)	12 (26.7)	12 (26.7)	13 (28.9)	
Primiparous, n (%)	24 (53.3)	23 (51.1)	24 (53.3)	0.97
Gestational age at birth (weeks), mean ± SD	39.1 ± 1.0	39.0 ± 1.1	39.2 ± 1.0	0.68
Secondary–higher education, n (%)	31 (68.9)	30 (66.7)	30 (66.7)	0.97
Employed, n (%)	16 (35.6)	15 (33.3)	16 (35.6)	0.96
Pre-pregnancy BMI (kg/m^2), mean ± SD	23.1 ± 3.0	23.3 ± 3.2	23.4 ± 3.1	0.88
Previous attendance at antenatal classes, n (%)	12 (26.7)	11 (24.4)	12 (26.7)	0.96
Accompanied by husband/family during birth, n (%)	38 (84.4)	37 (82.2)	37 (82.2)	0.95
Estimated fetal weight (grams), mean ± SD	3,120 ± 310	3,150 ± 295	3,140 ± 320	0.89
Antenatal pain expectation (NRS), mean ± SD	8.0 ± 1.3	7.9 ± 1.2	8.1 ± 1.3	0.74

Note. SD: standard deviation; BMI: body mass index; NRS: Numeric Rating Scale. One-way ANOVA (numerical variables) and chi-square test (categorical variables); all p>0.05, indicating that the three groups were homogeneous at baseline.

The three groups were comparable across all demographic, obstetric, and psychosocial characteristics, including the proportion of primiparous women and antenatal pain expectation (all p>0.05). This homogeneity is important because parity and pain expectation are strong predictors of labor pain intensity.

Table 2. Comparison of psychological outcomes at antenatal baseline (32 weeks of gestation)

Outcome (baseline)	A: HBM+Aroma	B: HBM only	C: Control	p
Coping self-efficacy (CBSEI, 16–160)	92.4 ± 17.8	94.1 ± 17.2	93.3 ± 18.0	0.89
Fear of childbirth (scale 16–64)	41.2 ± 6.8	40.6 ± 7.1	41.0 ± 6.9	0.92
Anxiety (STAI-S, 20–80)	46.8 ± 7.9	47.2 ± 8.1	47.0 ± 7.6	0.97

Note. CBSEI: Childbirth Self-Efficacy Inventory (higher scores = stronger coping beliefs); STAI-S: State-Trait Anxiety Inventory, state subscale (higher scores = greater anxiety). No significant differences were observed at baseline (all p>0.05).

Table 3. Labor pain intensity (NRS 0–10) by cervical dilatation primary outcome.

Cervical dilatation	A: HBM+Aroma (n=45)	B: HBM only (n=45)	C: Control (n=45)	p*
4 cm (before aromatherapy)	5.1 ± 1.2	5.2 ± 1.1	5.2 ± 1.2	0.88
6 cm	5.7 ± 1.3	6.7 ± 1.3	7.1 ± 1.2	<0.001
8 cm (peak pain)	6.5 ± 1.4	7.8 ± 1.3	8.3 ± 1.2	<0.001
Severe pain (NRS ≥8) at 8 cm, n (%)	11 (24.4)	26 (57.8)	32 (71.1)	<0.001

Note. *One-way ANOVA (NRS scores) and chi-square test (severe pain). Post-hoc tests at 8 cm of dilatation: A vs C Δ −1.8 (p<0.001); A vs B Δ −1.3 (p<0.001); B vs C Δ −0.5 (p=0.048, marginal). At 6 cm of dilatation: A vs C Δ −1.4 (p<0.001); A vs B Δ −1.0 (p<0.001); B vs C Δ −0.4 (p=0.12, not significant).

At 4 cm of dilatation that is, before aromatherapy was administered the three groups had comparable pain scores, confirming that the differences that subsequently emerged did not arise from differences in initial pain threshold. As labor progressed, pain increased in all groups, but the rate of increase was considerably flatter in Group A. The mechanistically decisive observation is that the A versus B contrast (which isolates aromatherapy) was strongly significant at both measurement points, whereas the B versus C contrast (which isolates counseling) was only marginal at 8 cm and non-significant at 6 cm. In other words, pain relief derived principally from lemon aromatherapy rather than from counseling alone.

Table 4. Change in childbirth coping self-efficacy (CBSEI) before and after counseling.

Group	Baseline (32 weeks)	Endline (38 weeks)	Δ	p*
A (HBM+Aroma)	92.4 ± 17.8	128.6 ± 18.9	+36.2	<0.001
B (HBM only)	94.1 ± 17.2	125.4 ± 18.3	+31.3	<0.001
C (Control)	93.3 ± 18.0	99.7 ± 17.5	+6.4	0.004

Note. *Paired t-test. The between-group comparison at endline was significant (ANOVA p<0.001); post-hoc tests: A vs C and B vs C were significant (p<0.001), whereas A vs B was not (p=0.38). The increase in coping self-efficacy was driven by HBM counseling rather than by aromatherapy.

Table 5. Anxiety and fear of childbirth by group

Indicator	A: HBM+Aroma	B: HBM only	C: Control	p
Fear of childbirth at 38 weeks (16–64)	29.4 ± 6.1	30.2 ± 6.4	38.8 ± 7.0	<0.001
Anxiety (STAI-S) at 4 cm of dilatation	42.1 ± 7.2	44.3 ± 7.6	52.4 ± 8.1	<0.001

Note. One-way ANOVA with post-hoc tests. Fear of childbirth: A vs C and B vs C were significant (p<0.001), whereas A vs B was not (p=0.54). Intrapartum anxiety: A vs C and B vs C were significant (p<0.001), whereas A vs B was not (p=0.15). Both psychological outcomes were driven by counseling rather than by aromatherapy consistent with the finding that lemon inhalation reduces pain without affecting anxiety.

The pattern in Tables 4 and 5 is the mirror image of the pain pattern in Table 3. For coping self-efficacy, fear of childbirth, and anxiety, the two counseled groups (A and B) were equivalent to each other and both were markedly superior to control an effect that clearly originates from counseling. For pain, by contrast, the combination group separated sharply from the counseling-only group. This double dissociation constitutes the core finding of the study.

Table 6. Labor and neonatal outcomes by group.

Outcome	A: HBM+Aroma	B: HBM only	C: Control	p
Duration of active first stage (hours), mean ± SD	4.3 ± 1.1	4.9 ± 1.2	5.4 ± 1.3	<0.001
Duration of second stage (minutes), mean ± SD	38.2 ± 12.4	42.6 ± 13.1	46.8 ± 14.0	0.010
Referral for analgesia/intolerable pain, n (%)	4 (8.9)	9 (20.0)	15 (33.3)	0.014
Birth satisfaction (scale 1–10), mean ± SD	8.5 ± 1.0	7.9 ± 1.1	6.8 ± 1.3	<0.001
1-minute Apgar score <7, n (%)	2 (4.4)	3 (6.7)	3 (6.7)	0.88
Aromatherapy adverse effects (headache/irritation), n (%)	1 (2.2)	-	-	-

Note. Post-hoc tests for the duration of the first stage: A vs C p<0.001; A vs B p=0.014; B vs C p=0.058 (marginal). RR for analgesia referral: A vs C 0.27 (95% CI 0.10–0.75); B vs C 0.60 (95% CI 0.29–1.25, not significant). No between-group difference in Apgar scores was observed, and adverse effects of aromatherapy were minimal (one participant reported mild headache, which resolved after temporary discontinuation).

The combination group had the shortest active first stage and required the fewest analgesia referrals, while also reporting the highest birth satisfaction. Notably, birth satisfaction showed a full gradient (A > B > C), indicating that counseling made a distinct contribution to the birth experience even though its contribution to pain intensity was limited. The absence of any difference in Apgar scores, together with the minimal adverse effects, supports the safety of the aromatherapy protocol.

Table 7. Decomposition of between-group effects: pairwise contrasts on the principal outcomes.

Outcome	A vs C (total effect)	B vs C (counseling effect)	A vs B (aromatherapy effect)
Pain NRS at 8 cm, Δ (p)	−1.8 (p<0.001)	−0.5 (p=0.048)	−1.3 (p<0.001)
Pain NRS at 6 cm, Δ (p)	−1.4 (p<0.001)	−0.4 (p=0.12)	−1.0 (p<0.001)
Severe pain (NRS ≥8), RR (p)	0.34 (p<0.001)	0.81 (p=0.18)	0.42 (p=0.003)
Coping self-efficacy (CBSEI), Δ (p)	+28.9 (p<0.001)	+25.7 (p<0.001)	+3.2 (p=0.38)
Anxiety (STAI-S), Δ (p)	−10.3 (p<0.001)	−8.1 (p<0.001)	−2.2 (p=0.15)
Duration of active first stage, Δ (p)	−1.1 hours (p<0.001)	−0.5 hours (p=0.058)	−0.6 hours (p=0.014)
Birth satisfaction, Δ (p)	+1.7 (p<0.001)	+1.1 (p<0.001)	+0.6 (p=0.011)

Note. Δ: between-group mean difference; RR: relative risk. The B vs C column isolates the effect of HBM counseling; the A vs B column isolates the incremental effect of lemon aromatherapy. Note the dissociation pattern: pain is driven by aromatherapy (A vs B strongly significant; B vs C weak or non-significant), whereas self-efficacy and anxiety are driven by counseling (B vs C strongly significant; A vs B non-significant).

Table 7 presents the core contribution of the three-arm design. A clear double dissociation is apparent: one intervention component affects one set of outcomes without affecting the other, and vice versa. Intermediate outcomes such as the duration of the first stage and birth satisfaction which are theoretically influenced by both pain and self-belief do indeed show contributions from both components, as would be expected.

Table 8. Linear GEE model of pain intensity across the active first stage of labor (repeated measurements at 4, 6, and 8 cm of dilatation)

Predictor	β	95% CI	p
Group B × dilatation (vs control)	−0.18	−0.41 to 0.05	0.120
Group A × dilatation (vs control)	−0.63	−0.86 to −0.40	<0.001
Group A × dilatation (vs Group B)	−0.45	−0.68 to −0.22	<0.001
Primiparity	+0.52	0.21 to 0.83	0.001
Coping self-efficacy (per 10 CBSEI points)	−0.14	−0.24 to −0.04	0.006
Anxiety (per 5 STAI-S points)	+0.21	0.09 to 0.33	0.001
Birth companion support	−0.28	−0.54 to −0.02	0.036

Note. β: group×dilatation interaction coefficient (change in NRS score per stage of increasing dilatation) from a linear GEE model with an exchangeable correlation structure and robust standard errors, adjusted for all covariates listed in Table 1. Negative β values indicate a flatter pain trajectory. The Group B effect was not significant, whereas the Group A effect was strongly significant—both against control and against Group B.

Table 9. Multivariate analysis of severe pain (Poisson GEE, adjusted RR) and effect sizes

Parameter	Group B (HBM only) vs control	Group A (HBM+Aroma) vs control
Severe pain (NRS ≥8): aRR (95% CI)	0.84 (0.63–1.12); p=0.23	0.38 (0.22–0.66); p<0.001
Analgesia referral: aRR (95% CI)	0.62 (0.30–1.29); p=0.20	0.29 (0.11–0.79); p=0.015
Cohen's d — pain at 8 cm	0.40 (small)	1.38 (large)
Cohen's d — coping self-efficacy	1.44 (large)	1.58 (large)
Cohen's d — intrapartum anxiety	1.03 (large)	1.34 (large)
Cohen's d — duration of active first stage	0.40 (small)	0.92 (large)

Note. aRR: adjusted relative risk from a Poisson GEE model with robust variance, with control as the reference category, adjusted for age, parity, education, BMI, birth companion support, estimated fetal weight, and antenatal pain expectation. The A vs B contrast for severe pain: aRR 0.45 (95% CI 0.26–0.79; p=0.005). Cohen's d was calculated relative to control (0.2 small; 0.5 medium; ≥0.8 large). Other independent predictors of severe pain: CBSEI per 10 points aRR 0.93 (0.88–0.98); STAI-S per 5 points aRR 1.09 (1.03–1.15); primiparity aRR 1.31 (1.04–1.65).

Taken together, the results reveal three principal findings. First, lemon aromatherapy is the principal driver of pain relief: the combination group had the flattest pain trajectory (β −0.63 per

stage of dilatation) and a 62% lower risk of severe pain than control (aRR 0.38), whereas the counseling-only group did not differ significantly from control on either outcome. Second, HBM counseling is the principal driver of coping self-efficacy and anxiety reduction, with large effect sizes in both counseled groups and no difference between them. Third, the two pathways each contribute independently to pain in the multivariate model coping self-efficacy reduces pain (β −0.14 per 10 CBSEI points) and anxiety increases it (β +0.21 per 5 STAI-S points) so that their combination yields the best labor outcomes.

This three-arm quasi-experimental study demonstrates that antenatal counseling based on the Health Belief Model (HBM), supplemented by inhaled lemon aromatherapy, significantly reduces pain intensity during the active phase of the first stage of labor, shortens the duration of the first stage, reduces the need for analgesia referral, and improves birth satisfaction without affecting neonatal outcomes. The principal contribution of this study, however, lies not in the finding that the intervention package works, but in the explanation of which component works for what. The three-arm design reveals a double dissociation: lemon aromatherapy drives the reduction in pain, whereas HBM counseling drives coping self-efficacy and the reduction in anxiety.

Lemon Aromatherapy as the Driver of Pain Relief

The contrast between Group A and Group B two groups that received identical HBM counseling and differed only in the administration of aromatherapy isolates the aromatherapy effect directly. This contrast was strongly significant across all pain outcomes: a difference of 1.3 NRS points at 8 cm of dilatation ($p<0.001$), a more than halved risk of severe pain (aRR 0.45), and a markedly flatter pain trajectory (β −0.45 per stage of dilatation). By contrast, the Group B versus control contrast which isolates counseling yielded only a marginal difference of 0.5 points, which did not persist in the adjusted GEE model (β −0.18; $p=0.12$).

These findings are consistent with the best available experimental evidence. The randomized controlled trial by Sirkeci, Cagan, and Koc (2023) reported that inhalation of lemon essential oil significantly reduced pain scores at 5–7 cm of dilatation compared with control, yet did not affect anxiety scores a pattern that is almost exactly replicated in the present study. Meta-analyses and systematic reviews of aromatherapy in labor have likewise consistently reported reductions in pain intensity (Boaviagem et al., 2021; Kaya et al., 2023; Liao et al., 2021; Tabatabaeichehr & Mortazavi, 2020), although these reviews emphasize that the quality of the underlying evidence remains limited and call for higher-quality trials (Kaya et al., 2023). Trials using other essential oils lavender (Rivaz et al., 2021), neroli (Scandurra et al., 2022), lemon in Indonesian primary midwifery settings (Lestari et al., 2022), and mixed-oil protocols pooled in recent meta-analyses (Karaahmet & Bilgiç, 2023) support the same direction of effect.

From a mechanistic perspective, gate control theory offers a plausible explanation (Melzack & Wall, 1965). A strong and pleasant olfactory stimulus draws attentional resources and activates limbic pathways that modulate pain transmission in the dorsal horn through descending pathways. Limonene the principal constituent of lemon oil has also been reported to possess analgesic and calming properties. Importantly, this mechanism is sensory-attentional and operates in the moment, so it is entirely coherent that its effect should appear on pain but not on cognitive constructs such as self-efficacy, which are formed over the preceding weeks.

Health Belief Model Counseling as the Driver of Coping Self-Efficacy

The opposite pattern is evident for the psychological outcomes. Coping self-efficacy increased sharply in both counseled groups (Δ +36.2 in A and +31.3 in B) compared with control (Δ +6.4), with no significant difference between A and B ($p=0.38$). Similarly, fear of childbirth and intrapartum anxiety declined to an equivalent degree in both counseled groups. This equivalence between A and

B is itself positive evidence: aromatherapy administered during labor should not be expected to affect self-belief formed during the antenatal phase and indeed it did not.

These findings reinforce Bandura's (1997) self-efficacy framework as applied to childbirth by Lowe (1993), who identified self-belief as the most decisive psychosocial variable explaining variation in active-phase pain, extending the earlier observations of Manning and Wright (1983). Subsequent cross-cultural studies have consistently found an inverse association between coping self-efficacy and reported pain intensity (Huang et al., 2024), and structured antenatal education has been shown to enhance self-efficacy while simultaneously reducing fear of childbirth (Alizadeh-Dibazari et al., 2023; Çankaya & Şimşek, 2021). The HBM proves to be an effective framework for structuring counseling of this kind, extending its application into the domain of childbirth, where its use has hitherto been limited (Alyafei & Easton-Carr, 2024; Şenol et al., 2024).

It must be emphasized that the finding that counseling did not significantly reduce pain does not mean that counseling is without benefit. In the multivariate model, coping self-efficacy remained an independent predictor that reduced pain (β −0.14 per 10 CBSEI points), while anxiety was a predictor that increased it (β +0.21 per 5 STAI-S points). The counseling → self-efficacy → pain pathway therefore does exist; its total effect size, however, is smaller and would probably require a larger sample to be detected as a significant group effect. Moreover, counseling confers benefits that pain scores alone do not capture: birth satisfaction showed a full gradient (A > B > C), and the counseling-only group continued to report a better birth experience than control despite comparable pain intensity. Pain and suffering are not the same thing—a woman who feels able to control the situation may experience equivalent pain yet construe it very differently.

Synergy of the Two Components and Clinical Implications

The combination of the two components produced the best outcomes on almost every indicator: the lowest pain, a 62% lower risk of severe pain than control (aRR 0.38), the shortest active first stage (4.3 hours), the fewest analgesia referrals (8.9%), and the highest satisfaction (8.5/10). The shortening of the first stage is a logical physiological consequence: severe pain and anxiety trigger the release of catecholamines that impair effective uterine contractility, so reducing both simultaneously can improve labor progress (Kissler & Hurt, 2023).

The practical implications are clear for primary midwifery care in Indonesia, where epidural analgesia is unavailable. Both components are inexpensive, non-invasive, easily taught to midwives, and feasible in an independent midwifery practice without any infrastructural investment, and both align with guidance that prioritizes woman-centered, non-pharmacological support during labor (National Institute for Health and Care Excellence, 2023; World Health Organization, 2023). The most important implication of these findings, however, is programmatic: because the two components operate through different pathways, they should not be treated as interchangeable. Removing aromatherapy and providing counseling alone would forfeit most of the analgesic effect; conversely, providing aromatherapy without counseling although not tested directly in this study would be predicted to forfeit the benefits for self-belief, anxiety, and birth satisfaction. It is the complete package, not either component in isolation, that should be recommended.

The safety of the protocol also supports its implementation: no between-group difference in Apgar scores was observed, and only one participant reported mild headache, which resolved after temporary discontinuation of the aromatherapy. This safety profile is consistent with the literature on lemon aromatherapy in labor (Lestari et al., 2022; Sirkeci et al., 2023) and with meta-analytic evidence that aromatherapy in labor does not adversely affect Apgar scores (Karaahmet & Bilgiç, 2023; Kaya et al., 2023).

Strengths and Limitations

This study has several strengths. First, the three-arm design with an active comparator (Group B) permits the aromatherapy effect to be separated from the counseling effect something structurally impossible in a two-group design and never previously accomplished in the labor pain literature. Second, pain was measured repeatedly according to cervical dilatation rather than at a single time point, so that the pain trajectory could be modeled with GEE. Third, pain scores at 4 cm of dilatation before aromatherapy was administered were shown to be equivalent across groups, which rules out the alternative explanation of differing initial pain thresholds. Fourth, the simultaneous evaluation of sensory (pain), cognitive (self-efficacy), affective (anxiety, fear), physiological (labor duration), and experiential (satisfaction) outcomes allowed the dual mechanistic pathways to be traced. Fifth, the assessors of intrapartum pain were not involved in delivering the intervention and were not informed of the study hypotheses.

Several limitations must be acknowledged candidly. First, group allocation was not randomized but was based on consecutive recruitment periods. This decision was taken because the scent of lemon disperses readily within the birthing area, so that individual randomization within the same period would have produced contamination; the consequence, however, is a potential for temporal confounding (seasonal change, staff turnover, or evolution of care practice between phases) that is not fully eliminated even after covariate adjustment. A cluster randomized controlled trial with randomization at the facility or period level would be a stronger next step.

Second, and most important for interpretation: blinding of participants was not possible because the scent of lemon is recognizable, and this study did not include a scent placebo group (for example, a neutral oil or distilled water). Consequently, part of the analgesic effect observed in Group A may represent a placebo or expectancy effect rather than a pharmacological effect of lemon alone. A four-arm design incorporating a scent placebo group is strongly recommended for future research. Third, this study also did not include an aromatherapy-without-counseling group, so it cannot be determined whether the aromatherapy effect depends on prior counseling or is independent of it; a 2×2 factorial design would answer this question definitively.

Fourth, the sample size was powered for the primary contrast (A versus C), so statistical power for the smaller incremental contrasts is limited. The conclusion that counseling did not significantly reduce pain must therefore be read with caution: absence of evidence of an effect is not evidence of absence of an effect, and a small but real counseling effect may have gone undetected. Fifth, pain was measured with a subjective self-report instrument; although the NRS is a widely validated standard, the addition of physiological indicators (cortisol levels, hemodynamic parameters) would strengthen the measurement. Sixth, the study was conducted in a single independent midwifery practice among low-risk women, so generalization to referral facilities, high-risk births, or different sociocultural contexts requires caution. Seventh, standardizing the quality and concentration of the essential oil across participants is a practical challenge that requires tighter control.

Conclusion

This three-arm quasi-experimental design demonstrates that Health Belief Model counseling and lemon aromatherapy operate through different but complementary pathways in labor. Inhaled lemon aromatherapy is the principal driver of pain relief: the contrast between the combination group and the counseling-only group yielded a difference of 1.3 NRS points at 8 cm of dilatation ($p<0.001$), whereas counseling alone did not differ significantly from control in the adjusted pain trajectory (β −0.18; $p=0.12$). Conversely, HBM counseling is the principal driver of childbirth coping self-efficacy and of the reduction in anxiety, with the two counseled groups equivalent to each other and far surpassing control. Their combination produced the best outcomes: a 62% lower risk of

severe pain than control (adjusted RR 0.38; 95% CI 0.22–0.66), the shortest active first stage (4.3 hours), the lowest rate of analgesia referral (8.9%), and the highest birth satisfaction (8.5/10), with no difference in neonatal outcomes and with minimal adverse effects.

Because the two components operate through different pathways, they cannot substitute for each other and should be integrated as a single package of non-pharmacological midwifery care in independent midwifery practices and primary health services. Given the limitations of the design in particular the absence of randomization, the absence of a scent placebo group, and the limited power for the incremental contrasts a 2×2 factorial randomized controlled trial with a scent placebo and a larger sample is recommended in order to confirm the magnitude of the effect of each component and to separate the pharmacological effect from the expectancy effect.

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Conflict of Interest

The authors declare that there is no conflict of interest with respect to the research and the publication of this article.

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Author Contributions

ERT: conceptualization, methodology, data analysis, drafting of the original manuscript, and correspondence. SNFS: methodology, data collection, and manuscript editing. AB: supervision of intervention delivery and data validation. AFT: data curation and statistical analysis. PN and JA: field data collection and preparation of the tables. All authors have read and approved the final manuscript.

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