

Digital Aromatherapy Solutions: Leveraging Lemon Scent Technology to Alleviate Nausea and Vomiting in Pregnant Women

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ABSTRACT

Nausea and vomiting during pregnancy (NVP) are often perceived as normal conditions, yet they can significantly affect a pregnant woman's quality of life. With limited use of pharmacological treatments due to concerns for fetal safety, digital innovation has opened new opportunities for non-invasive maternal care. One emerging approach is digital aromatherapy, which combines the convenience of technology with the benefits of natural therapy to help alleviate common pregnancy-related discomforts. This study aimed to evaluate the effectiveness of a lemon-scented digital aromatherapy intervention in reducing symptoms of NVP. A pre-experimental one-group pretest-posttest design was used, involving 100 pregnant women from Indonesia, Philippines and Malaysia. Participants used a mobile-controlled digital diffuser with lemon essential oil for 20 minutes, twice daily, over a period of seven days. The severity of nausea and vomiting was measured using the Pregnancy-Unique Quantification of Emesis and Nausea (PUQE) scale before and after the intervention. The results showed a statistically significant reduction in PUQE scores post-intervention ($p < 0.001$), indicating a notable decrease in symptom severity. No adverse effects were reported throughout the intervention period. These findings indicate that lemon-based digital aromatherapy is a safe, effective, and accessible complementary approach for managing NVP. This study contributes to the advancement of digital maternal health by introducing a culturally adaptable, user-friendly, and scalable non-pharmacological solution for pregnancy-related symptoms.

Keywords: Digital Aromatherapy, Lemon Scent, Pregnancy, Nausea, Vomiting, Maternal Health



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1. INTRODUCTION

Pregnancy is a dynamic and transformative physiological state that brings about substantial hormonal, emotional, and physical changes (Chandra & Paray, 2024; Gangakhedkar, 2022; Rehbein et al., 2022). While it is often celebrated as a period of anticipation and joy, according to Mortazavi & Ghardashi (2021) and Sahin & Kabakci (2021), many pregnant women experience discomforts that can significantly disrupt their daily lives. Among the most prevalent and distressing symptoms in early pregnancy are nausea and vomiting, commonly referred to as morning sickness (Ashour, 2023; Winter, 2024). These symptoms, although generally considered benign and self-limiting, can be persistent and debilitating for a considerable number of women. Clinically, this condition ranges in severity from mild queasiness to hyperemesis gravidarum, a more severe form that can lead to dehydration, electrolyte

imbalances, weight loss, and hospitalization (Martinez de Tejada et al., 2025; Nelson-Piercy et al., 2024). Even at subclinical levels, nausea and vomiting can negatively impact nutritional intake, sleep quality, mood, and overall well-being, thus compromising both maternal health and pregnancy outcomes (Abbasi et al., 2022; Gu et al., 2021). Recognizing and addressing these symptoms is essential not only for physical health, but also for maintaining psychological resilience and quality of life throughout gestation (Keten Edis & Bal, 2024).

In recent years, digital transformation has redefined the landscape of healthcare delivery, creating new opportunities for personalized, patient-centered care that extends beyond conventional clinical settings. According to Babu et al. (2024), the integration of technology into maternal health has enabled the development of tools that cater to the unique needs of pregnant women, offering both monitoring and supportive interventions. Digital health platforms, mobile applications, and smart devices have become increasingly prevalent in prenatal care, empowering women to actively participate in managing their health (Borges do Nascimento et al., 2025; Hod et al., 2023). However, much of this digital innovation has focused on physiological tracking, such as fetal development or maternal vital signs (Alim & Imtiaz, 2023; L. Liu et al., 2024), while the management of subjective symptoms like nausea, discomfort, and anxiety has received comparatively less attention. Given the limitations in pharmacological treatment during pregnancy due to concerns over teratogenicity and drug safety, there is an urgent need to explore digital non-pharmacological solutions that are safe, effective, and accessible.

One promising approach lies in the integration of complementary and alternative medicine (CAM) modalities into digital frameworks (Stampini et al., 2024). Aromatherapy, a well-established CAM method, has long been utilized for its therapeutic effects on both body and mind (Caballero-Gallardo et al., 2025). The use of essential oils, particularly citrus-based oils like lemon, is associated with a range of benefits including mood enhancement, stress reduction, and nausea relief (Gonçalves et al., 2025). According to Eddin et al. (2021), lemon essential oil contains limonene, a bioactive compound known to exert antiemetic effects through modulation of the limbic system and olfactory pathways. According to Zhong et al. (2021), the olfactory system's direct neural connections to brain regions involved in emotion and nausea regulation, supporting the rationale for aroma-based interventions. Traditionally administered through manual diffusers or topical application, aromatherapy can now be delivered through digitally controlled devices, enhancing consistency, usability, and precision in dosing. This convergence of traditional healing with modern technology creates a unique therapeutic opportunity for pregnant women seeking non-invasive symptom relief.

Nausea and vomiting in pregnancy (NVP) are influenced by a complex interplay of hormonal, neurochemical, and psychological factors (Geller & Sadowick, 2022; C. Liu et al., 2022). Elevated levels of estrogen, progesterone, and human chorionic gonadotropin (hCG) are strongly implicated in the pathogenesis of these symptoms (Kaňková et al., 2023; Rondanelli et al., 2025). Additionally, heightened sensitivity of the gastrointestinal tract and central nervous system responses contribute to symptom persistence (Heckroth et al., 2021). While pharmacological agents such as antihistamines and antiemetics can be effective, their use during pregnancy is often limited due to potential risks to the fetus and maternal preference for natural approaches. Consequently, there is growing interest in evidence-based, non-pharmacological strategies that align with maternal values and support self-management. Aromatherapy represents one such strategy, with lemon scent in particular showing promise in reducing nausea through olfactory stimulation (Anggraini et al., 2022; Safajou et al., 2020). Nevertheless, to optimize its benefits in contemporary maternal care, a shift from traditional to digital delivery methods is warranted.

The emergence of digital aromatherapy presents a novel paradigm in maternal symptom management, particularly for addressing nausea and vomiting in pregnancy (NVP). By embedding essential oil dispersion such as lemon oil, which is known for its anti-nausea properties, into smart programmable devices, pregnant women can now access aromatherapy in a more controlled, convenient, and personalized manner. This digital interface enhances the user experience while also enabling features such as real-time data tracking, remote medical guidance, and integration into broader maternal health platforms. While traditional aromatherapy has been widely studied for symptom relief in various populations, including its use in reducing NVP symptoms through conventional inhalation methods (Gonçalves et al., 2025; Li et al., 2022; Nassif et al., 2022), these approaches often lack standardization in dosage, timing, and user environment. The novelty of this study lies in introducing a smart, sensor-based aromatherapy system that ensures consistent delivery, remote monitoring, and personalized adjustments, capabilities not addressed in previous analog methods. Recent advancements in digital health technologies have enabled more targeted interventions (Mohamed et al., 2025; Moise et al., 2023; Shahil Feroz et al., 2022), yet few studies have explored their application in maternal care, particularly in symptom relief using essential oils. This research to fill that gap by scientifically evaluating the safety and efficacy of digital aromatherapy for pregnant women experiencing NVP. Despite its promising potential, empirical evidence on digital aromatherapy remains scarce, thus highlighting the need for rigorous validation before its integration into mainstream maternal healthcare systems.

This study aims to evaluate the potential of digital lemon-scented aromatherapy as a supportive intervention for alleviating nausea and vomiting in pregnancy. The findings are expected to inform future innovations in non-pharmacological maternal health interventions and promote integrative care models that are both scientifically grounded and culturally sensitive.

2. METHOD

This study adopted a pre-experimental design utilizing a one-group pretest-posttest approach (Sari et al., 2023) to evaluate the effectiveness of a mobile-controlled digital aromatherapy intervention using lemon essential oil in reducing nausea and vomiting among pregnant women. This design was chosen to enable the observation of changes in symptom severity before and after the intervention within the same participant group, without employing a control group. A total of 100 participants from Indonesia, Philippines and Malaysia were recruited using purposive sampling based on the following inclusion criteria: (1) currently in the first or early second trimester of pregnancy, (2) experiencing mild to moderate nausea and vomiting as measured by the Pregnancy-Unique Quantification of Emesis and Nausea (PUQE) scale (Hada et al., 2021), (3) not receiving pharmacological antiemetic treatment, and (4) possessing access to and the ability to operate a mobile-controlled digital aromatherapy device.

Data collection occurred in two stages. In the first stage, baseline measurements of nausea and vomiting severity were obtained using the PUQE scale prior to the intervention (pretest). In the second stage, participants used a mobile-controlled digital diffuser containing lemon essential oil for 20 minutes, twice daily (morning and evening), over a period of seven consecutive days. After completing the intervention period, participants were assessed again using the same PUQE scale (posttest). The diffuser was pre-programmed to ensure consistent usage, and participants received written guidelines along with remote monitoring and support to promote adherence to the intervention protocol.

Data were analyzed using appropriate statistical tests depending on the distribution of the data, as assessed by the Shapiro-Wilk normality test. Differences between pretest and posttest PUQE scores were examined using the paired t-test for normally distributed data or the Wilcoxon signed-rank test for non-normal data. A p-value of less than 0.05 was considered statistically significant. Hypothesis: H_0 : There is no significant difference in the level of nausea and vomiting among pregnant women before and after the digital lemon aromatherapy intervention delivered via a mobile-controlled diffuser. H_1 : There is a significant difference in the level of nausea and vomiting among pregnant women before and after the digital lemon aromatherapy intervention delivered via a mobile-controlled diffuser. Ethical approval was obtained, and informed consent was secured from all participants. Confidentiality and data privacy were maintained throughout the research process in accordance with health research ethical standards.

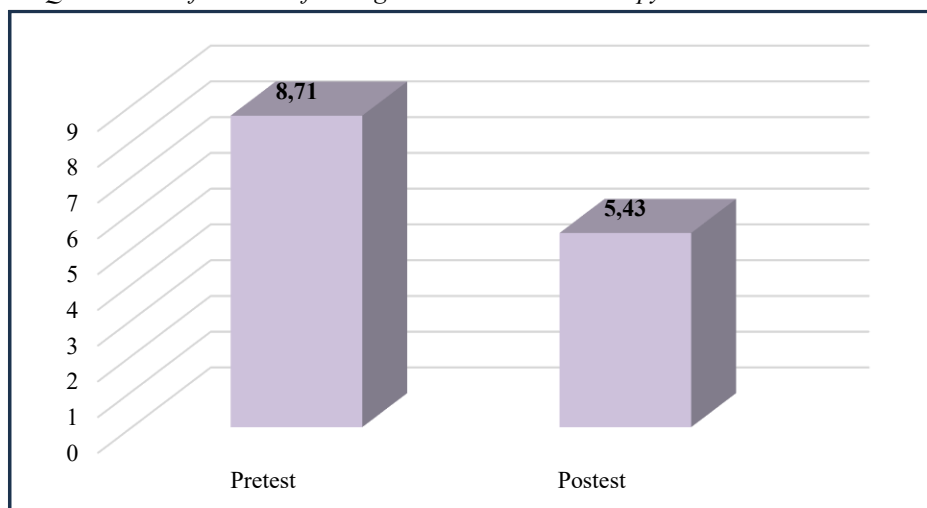
3. RESULTS AND DISCUSSION

3.1. Results

Figure 1 illustrates this reduction in mean PUQE scores using a bar graph. The figure clearly depicts the downward trend from pre- to post-intervention, with visible error bars representing the standard deviation. The marked decrease reinforces the statistical findings and highlights the potential impact of digitally delivered lemon aromatherapy as a supportive approach in maternal care.

Figure 1

PUQE Scores Before dan After Digital Lemon Aromatherapy Intervention



Descriptive and inferential analyses were conducted to evaluate the effect of the digital lemon aromatherapy intervention on nausea and vomiting severity among pregnant women. The results are summarized below.

Table 1

Descriptive Statistics, Normality Test, and Paired t-test Results for PUQE Scores (n = 100)

Variable	Mean ± SD	Min–Max	Shapiro-Wilk	Distribution	Test	Test Value	p-value
PUQE Score – Pretest	8.71 ± 1.18	6–11	0.1469	Normal	Paired t-test	t = 16.26	0.000
PUQE Score – Posttest	5.43 ± 1.32	3–9	0.083	Normal			

Normality testing using the Shapiro-Wilk method confirmed that both pretest and posttest PUQE scores were normally distributed ($p > 0.05$). Therefore, a paired t-test was appropriate to compare the scores before and after the intervention. The analysis showed a statistically significant decrease in PUQE scores following the 7-day intervention using a mobile-controlled digital diffuser with lemon essential oil. The mean PUQE score dropped from 8.71 (SD = 1.18) at pretest to 5.43 (SD = 1.32) at posttest. The paired t-test revealed a t-value of 16.26 with a p-value of < 0.001 , indicating a significant difference. These findings support the rejection of the null hypothesis and confirm that the digital lemon aromatherapy intervention was effective in reducing the severity of nausea and vomiting during pregnancy.

3.2. Discussion

3.2.1. Effectiveness of Digital Aromatherapy in Reducing Nausea and Vomiting Symptoms

The findings of this study demonstrate that digital aromatherapy utilizing lemon scent significantly reduced the severity of nausea and vomiting symptoms in pregnant women. The average PUQE score decreased from 8.71 to 5.43 after seven days of intervention, reflecting a clinically meaningful shift from moderate to mild symptom intensity. This reduction was statistically significant, as shown by the paired t-test ($p < 0.001$), indicating that the change was not due to random variation. Beyond statistical relevance, this result highlights the potential of digital aromatherapy to improve maternal comfort and daily functioning during early pregnancy.

From a clinical perspective, nausea and vomiting during pregnancy, if left unmanaged, may negatively affect maternal nutrition, hydration, and psychological well-being (De Bonis et al., 2025; Lowe & Steinweg, 2022). In such cases, According to Gergő et al. (2025), non-pharmacological approaches that are both effective and safe become essential, especially when pharmacologic options are limited due to potential risks to fetal development. Digital aromatherapy provides a user-friendly, non-invasive solution that minimizes systemic exposure while addressing a common and often underestimated maternal health issue. The application of this intervention aligns with the Self-Care Deficit Nursing Theory by Dorothea Orem (Hartweg & Metcalfe, 2022; Tanaka, 2022), which emphasizes the role of nursing interventions in supporting individuals who are temporarily unable to care for themselves, such as pregnant women experiencing debilitating nausea. Additionally, from a health technology perspective, the use of a mobile-controlled diffuser exemplifies the principles of the Technology Acceptance Model (AlQudah et al., 2021), which posits that perceived usefulness and ease of use are key determinants in the adoption of health technologies. In this context, the positive user engagement and adherence observed in the study underscore the model's relevance, as the digital aromatherapy device was both practical and effective in meeting users' self-care needs.

The integration of digital technology allows for more precise and consistent use of aromatherapy, as participants were able to schedule their sessions during times when symptoms typically occurred. Supported by Religioni et al. (2025) and Marzban et al. (2022), this level of personalization contributes to greater adherence and therapeutic effectiveness. The ability to deliver symptom relief through a mobile-controlled diffuser reflects a shift toward more adaptive and accessible forms of maternal support. Therefore, digital aromatherapy offers a promising innovation that combines traditional therapeutic benefits with modern convenience, promoting safer and more comfortable pregnancy experiences.

3.2.2. Lemon as an Evidence-Based Natural Therapeutic Agent

Lemon essential oil has long been recognized for its therapeutic properties, particularly in the management of nausea (Gonçalves et al., 2025; Kreye et al., 2022). Its efficacy is primarily attributed to active volatile compounds such as limonene, citral, and β -pinene, which have been shown to interact with the olfactory system and influence neurophysiological responses (Masuo et al., 2021). When inhaled, these aromatic molecules stimulate olfactory receptors that transmit signals to brain regions involved in emotion and nausea regulation, particularly the limbic system and the chemoreceptor trigger zone. This

olfactory pathway provides a non-invasive and rapid mechanism of action, making lemon oil a suitable intervention for pregnancy-related nausea and vomiting. The underlying mechanism of action can be understood through the lens of Jean Watson's Theory of Human Caring (Curcio et al., 2024; Montana-Rhodes et al., 2024), which emphasizes holistic healing environments and the therapeutic use of natural modalities to support both physical and emotional well-being. Aromatherapy with lemon oil, by engaging sensory and emotional dimensions, exemplifies a caring intervention that aligns with this theory's focus on individualized, compassionate care.

Several experimental and clinical studies support the antiemetic effects of lemon aroma. Research by Kreye et al. (2022), Panchal et al. (2024) and Rambod et al. (2023) demonstrated that exposure to lemon scent can reduce gastric dysrhythmia, and induce a calming effect that may indirectly mitigate nausea. These findings align with the broader understanding of aromatherapy as a complementary treatment modality that engages sensory pathways to produce physiological and psychological benefits. The inhalation route, in particular, allows for fast onset of action without the need for metabolic processing, which is a critical advantage in pregnant populations where pharmacological interventions may pose teratogenic risks. Additionally, the effectiveness of lemon oil in influencing autonomic regulation and emotional states is consistent with principles of the Psychoneuroimmunology (PNI) framework (Fransson, 2021), which posits that psychological interventions can modulate physiological outcomes through neural and hormonal pathways.

Furthermore, the natural origin of lemon essential oil adds to its appeal as a safe and accessible therapeutic option. Compared to synthetic antiemetic drugs, lemon oil does not carry significant systemic side effects, and its use is generally well tolerated. The growing body of evidence supporting its efficacy reinforces the relevance of incorporating natural therapies into modern health practices, especially in maternal care contexts. By grounding its use in both traditional practices and scientific validation, lemon essential oil stands out as a credible and effective agent in the realm of integrative medicine.

3.2.3. Technological Innovation in Non-Pharmacological Pregnancy Care

The integration of digital technology into non-pharmacological care strategies has opened new avenues for enhancing maternal health (Ladyman et al., 2022), particularly during early pregnancy. One such advancement is the development of mobile-controlled digital diffusers, which allow for more precise and user-friendly delivery of aromatherapy interventions. Compared to conventional methods that rely on manual application such as applying essential oils to cotton or diffusing them through heat-based devices, digital diffusers provide a more consistent and controlled release of therapeutic scents. This innovation offers greater efficiency in administering treatment and ensures a more stable sensory experience for users. The increased reliability and precision of this delivery system can also be understood through the lens of the Technology Acceptance Model (TAM) (AlQudah et al., 2021), which posits that perceived usefulness and ease of use are critical factors influencing user adoption of technology. In this context, digital diffusers enhance the perceived value of aromatherapy by simplifying and optimizing its application in daily maternal care routines.

Digital aromatherapy systems enhance therapeutic adherence by allowing pregnant women to schedule and control the timing and intensity of scent diffusion through mobile applications. This level of personalization not only empowers users but also accommodates individual variations in symptom patterns, such as the common morning or evening peaks of nausea. Convenience and automation reduce the cognitive and physical effort typically required to use traditional aromatherapy, which can be particularly beneficial for women experiencing fatigue or discomfort. From the perspective of Self-Determination Theory (Y. Liu et al., 2022), such autonomy and personal control in managing health symptoms contribute to increased intrinsic motivation and better compliance. By enabling pregnant women to self-regulate their aromatherapy interventions based on individual needs and daily rhythms, this technology supports a more engaged and empowered user experience, aligning digital health innovation with psychological theories of motivation and well-being.

Moreover, digital aromatherapy aligns well with the growing demand for personalized, non-invasive, and evidence-based maternal health solutions. According to Amabie et al. (2023), by combining natural remedies with modern technological interfaces, this approach bridges the gap between traditional holistic practices and contemporary digital healthcare. It provides a platform for safe self-management of common pregnancy symptoms while minimizing the need for pharmacological solutions. This integration of technology also reflects the principles of Person-Centered Care, which emphasizes tailoring interventions to the values, preferences, and needs of individuals. In doing so, it not only supports maternal autonomy but also reflects a broader trend toward integrative and digitally supported wellness in obstetric care. As maternal health increasingly embraces digital transformation, innovations like lemon-scent digital aromatherapy represent a practical and theoretically grounded advancement in supportive care.

3.2.4. Integrating Digital Innovation and Holistic Care

This study presents an original contribution to maternal health by combining digital technology with complementary therapy in the management of pregnancy-related nausea and vomiting. Traditionally, according to Caballero-Gallardo et al. (2025), holistic approaches such as aromatherapy have been viewed as separate from modern medical systems. However, the integration of digital aromatherapy into healthcare offers a new model (Ng et al., 2024) that blends the benefits of natural remedies with the precision and adaptability of digital health tools. This synergy represents a shift toward more holistic, patient-centered care models that respect both scientific rigor and individual well-being. This transformation aligns with the Integrative Health Care Model (Venkatesan et al., 2021), which emphasizes the coordination of conventional and complementary treatments to address the full range of physical, emotional, and spiritual health needs of patients. Digital aromatherapy, in this sense, functions as a bridge, connecting ancient wellness traditions with contemporary digital infrastructure.

The use of a mobile-controlled digital diffuser in this context not only enhances the practical aspects of aromatherapy but also aligns with the growing emphasis on personalized and technology-enabled care. By delivering a consistent and customizable therapeutic experience, digital aromatherapy supports emotional and physical comfort during early pregnancy while avoiding pharmaceutical risks. This method respects the holistic philosophy of addressing the person as a whole and adds value through technological responsiveness to symptom patterns, environmental conditions, and user preferences. From a behavioral standpoint, this can also be examined through the Technology Acceptance Model (TAM) (AlQudah et al., 2021), which suggests that the perceived usefulness and ease of use of a digital diffuser may positively influence a pregnant woman's willingness to adopt it as part of her self-care routine. The integration of mobile features supports higher user engagement and reinforces the therapeutic continuity that is often challenging in traditional complementary practices (Ng et al., 2024).

As a novel intervention, this study reflects the broader potential of integrating complementary therapies into mainstream healthcare using digital platforms. The results reinforce the viability of such approaches in prenatal care and open possibilities for future applications in other domains of women's health. Ultimately, the research encourages continued exploration of how digital innovation can expand access to safe, holistic, and evidence-informed solutions that meet the evolving needs of pregnant individuals in both clinical and community settings.

3.2.5. Clinical Implications for Maternal Nursing and Health

The integration of digital aromatherapy into maternal nursing practice presents a meaningful advancement in non-pharmacological care for pregnant women. Given the limitations of conventional pharmacologic treatments during pregnancy due to concerns about fetal safety, there is an increasing need for alternative interventions that are both effective and safe. Digital aromatherapy using lemon essential oil offers a promising solution that aligns with the principles of evidence-based nursing and holistic maternal care. Its implementation in clinical settings could provide immediate symptom relief, enhance maternal comfort, and support emotional well-being without introducing medication-related risks.

From a nursing perspective, the use of technology-assisted aromatherapy strengthens the role of nurses in delivering individualized and responsive care. Nurses can educate and guide patients in the proper use of digital diffusers, monitor their response to therapy, and integrate this modality as part of a broader, patient-centered care plan (Altmiller & Pepe, 2022; Swami et al., 2021). This approach not only empowers patients to manage their symptoms independently but also fosters greater trust in non-invasive and supportive interventions. It provides nursing professionals with additional tools to address common but often overlooked discomforts of early pregnancy, such as nausea and vomiting.

The scalability and ease of use of digital aromatherapy systems make them particularly suited for integration into home-based maternal care programs. As healthcare shifts increasingly toward remote and preventive models, technologies like mobile-controlled diffusers can extend care beyond clinical environments while maintaining safety and effectiveness. This innovation aligns with the goals of sustainable maternal health services by reducing reliance on pharmaceuticals, supporting patient autonomy, and promoting well-being through accessible, natural interventions guided by professional care.

4. CONCLUSION

This study demonstrated that digital aromatherapy using lemon essential oil significantly reduced the severity of nausea and vomiting in pregnant women, as evidenced by a substantial decline in PUQE scores after a seven-day intervention. The findings provide empirical support for the efficacy of non-pharmacological, technology-enhanced therapies in addressing common discomforts during early pregnancy. These results highlight the potential of combining natural remedies with digital innovation to deliver safe, effective, and patient-centered care for maternal health.

Despite the promising outcomes, this research has several limitations. The study employed a pre-experimental design without a control group, which may affect the ability to generalize findings or fully rule out external influences. Additionally, the intervention duration was limited to one week, and

subjective measures such as symptom diaries or self-reported adherence were not included. Future studies should adopt randomized controlled trial designs, explore long-term effects, and consider integrating biometric tracking or real-time symptom monitoring to strengthen data accuracy and explore broader applications of digital aromatherapy.

The primary contribution of this study lies in its integration of digital health technology with evidence-based complementary therapy, offering a novel model for sustainable, non-invasive prenatal care. By advancing the use of mobile-controlled aromatherapy as a viable clinical tool, this research opens pathways for further innovations in digital maternal care solutions and enriches the dialogue on holistic, tech-enabled interventions that align with the evolving landscape of healthcare for pregnant populations.

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