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The Effectiveness of Inhaled Rosemary essential Oil in Improving Hemoglobin Concentration and Reducing Anemia Symptoms Among Pregnant Women

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ABSTRACT

Background: Anemia during pregnancy is a global health concern that affects both maternal and fetal well-being. Iron supplementation is the primary treatment. However, its effectiveness is often hindered by poor adherence due to gastrointestinal side effects. Rosemary (*Rosmarinus officinalis* L.) essential oil has demonstrated antioxidant and hematopoietic potential, suggesting its utility as a complementary therapy. This study aims to evaluate the effectiveness of inhaled rosemary essential oil in improving hemoglobin concentration and reducing anemia releated symptoms among second trimester pregnant women with mild to moderate anemia. **Methods:** A quasi-experimental pretest-posttest control group design was utilized with 60 pregnant women who were randomly assigned to intervention (n=30) and control (n=30) groups. The intervention group inhaled rosemary essential oil for 15 minutes twice day throughout a duration of four weeks, while both groups continued iron supplementation. Hemoglobin levels were measured pre and post intervention using a hematology analyser, and anemia symptoms (fatigue, dizziness and shortness of breath) were assessed using the Visual Analog Scale (VAS). **Results:** The intervention group showed a significantly greater increase in hemoglobin levels compared to the control group (+1,20 g/dL vs. +0,40 g/dL; p<0,001), indicating improvement in clinical symptoms of anemia. **Conclusions:** Inhalation of rosemary essential oil significantly improves hemoglobin concentration and alleviates anemia related symptoms in pregnant women. It offers a safe, natural and non-invasive complementary approach to enhance maternal health during pregnancy.

Keywords: *Rosmarinus*; anemia; hemoglobins; pregnant people; respiratory therapy

1. INTRODUCTION

Anemia during pregnancy remains one of the most pressing global health concerns, affecting approximately 37% of pregnant women worldwide, with the highesst prevalence reported in low- and middle-income countries.[1] According to the World Helath Organization (WHO), anemia in pregnancy is defined as a hemoglobin level below 11 g/dL, with iron deficiency accounting for more than 90% of cases.[2] The second trimester of pregnancy is a particularly vulnerable period because of the physiologic hemodilution that occurs due to increased plasma volume, which can exacerbate the risk of developing anemia.[3] This condition contributes to a range of adverse maternal and fetal outcomes, including preterm birth, intrauterine growth restriction, low birth weight and increased perinatal mortality.[4]

Despite widespread implementation of iron supplementation programs, adherence to oral iron therapy remains suboptimal. Common side effects such as gastrointestinal discomfort, nausea, metallic taste and constipation lead many pregnant women to discontinue or inconsistently use iron tablets.[5] A study by Balarajan et al., emphasized that non-compliance with iron therapy undermines the success of maternal health programs, particularly in under resourced areas.[6] In response to these limitations, the WHO Traditional Medicine Strategy 2014-2023 encourages the integration of complementary and traditional therapies into healthcare systems, particularly those that are safe, effective and culturally acceptable.[7]

One such promising alternative is aromatherapy using rosemary essential oil (*Rosmarinus officinalis* L.). Rosemary is rich in bioactive compounds such as 1,8-cineole, α-pinene, camphor and rosmarinic acid, which have demonstrated significant antioxidant, anti inflammatory and hematopoietic properties.[8] These compounds are known to neutralize reactive oxygen species (ROS), protect red blood cells from oxidative stress and enhance erythropoiesis mechanisms that are highly relevant to the pathogenesis of anemia.[7] Studies have confirmed that oxidative stress impairs hemoglobin synthesis and accelerates erythrocyte destruction, suggesting that antioxidant-based interventions may effectively complement conventional anemia treatments.[9]

The inhalation route is considered particularly advantageous for pregnant women, as it bypassed the gastrointestinal tract and avoid common adverse effects associated with oral iron supplementation.[7] Inhaled volatile compounds are rapidly absorbed through the olfactory and pulmonary pathways, providing systemic effects without the first-pass metabolism. Furthermore, rosemary aromatherapy has been linked to improvements in subjective symptoms frequently experienced in anemia, such as fatigue, dizziness and reduced cognitive function.[10] Filiptsova e al., found that rosemary aroma significantly improved alertness and memory in human subjects, supporting its neurological and psychological benefits.[11]

Experimental studies on animals have shown that rosemary extract enhances hematologic parameters, including hemoglobin levels, packed cell volume and red blood cell counts.[10] In a study involving iron deficient rats, rosemary significantly improved serum iron and reduced oxidative markers.[12] Another investigation using rosemary oil in fish farming showed improved hematological profiles and immune responses. These findings point to systemic effects of rosemary beyond its traditional use, although translation into human maternal health contexts remains limited.[13]

To date, few clinical trials have assessed the effectiveness of rosemary essential oil on hematologic outcomes in pregnant women. While some studies have demonstrated its potential to relieve psychological stress and fatigue in general adult populations, its role in improving hemoglobin concentration and alleviating clinical symptoms of anemia during pregnancy has not been adequately explored.[14] This presents a clear research gap, particularly given the high burden of anemia in pregnancy and the need for tolerable, non-invasive complementary therapies.

This study is important because it responds to an unmet clinical need by proposing a natural, safe and accessible adjunct to iron therapy. Inhaled rosemary oil could serve not only to enhance iron uptake indirectly through antioxidant pathways but also to relieve anemia related symptoms that impair maternal quality of life. The objective of this study is to evaluate the effectiveness of rosemary essential oil inhalation in increasing hemoglobin levels and reducing fatigue, dizziness and shortness of breath among pregnant women with mild to moderate anemia in the second trimester. The novelty of this research lies in integrating a phytotherapeutic intervention into mainstream antenatal care using a clinical design that assesses both physiological and symtomatic outcomes. The results of this study have the potential to inform future maternal health policies and expand therapeutic options for anemia management in pregnancy, especially in low resource settings.

2. METHODS

2.1 Study Design

This study employed a quasi-experimental, pretest-posttest control group design to evaluate the effectiveness of inhaled rosemary assential oil in improving hemoglobin concentration and reducing anemia related symptoms among second trimester pregnant women diagnosed with mild to moderate anemia. This design was chosen to enable a comparison of outcomes between an intervention and control group while accounting for baseline variability.

2.2 Population

The research was conducted at a community midwifery practice and antenatal care service in Malang, Indonesia, between January – April 2025. The target population comprised pregnant women aged 18 to 35 years, in their second trimester (13-28 weeks gestational age), attending routine antenatal care visits.

2.3 Inclusion and Exclusion Criteria

Participants were included if they met the following criteria: 1) confirmed diagnosis of mild to moderate anemia (hemoglobin level between 8,0 g/dL – 10,9 g/dL, 2) adherence to the national antenatal iron supplementation program (one tablet daily containing 60 mg elemental iron and 400 μg folic acid), and 3) willingness to participate and provide informed consent.

Exclution criteria included: 1) severe anemia (Hb < 8,0 g/dL), 2) history of chronic illness, 3) known hypersensitivity to essential oils, 4) upper respiratory tract infections at the time of study, and 5) concurrent use of other complementary therapies or supplements beyond iron.

2.4 Sample Size and Sampling Technique

A total of 60 eligible participants were recruited using purposive sampling and randomly assigned into two groups: the intervention group (n=30) and the control group (n=30). The minimum sample size was calculated using a two-sample t-test formula with α = 0,05 based on previous studies involving phytotherapeutic interventions.

2.5 Intervention Protocol

Participants in the intervention group were provided with a standardized rosemary essential oil (*Rosmarinus officinalis* L.) and an electric diffuser. They were instructed to inhale the vapor for 15 minutes twice daily (morning and evening) over a four-week period. The essential oil was diffused in a well-ventilated room using 5 drops (approximately 0,25 mL) of oil per session. The control group continued to receive routine antenatal care and oral iron supplementation without any aromatherapy. All participants received counseling on iron rich dietary practice and hydration.

2.6 Outcome Measures

The primary outcome was the change in hemoglobin concentration, measured using a calibrated hematology analyzer before and after the intervention. Secondary outcomes included changes in anemia related symptoms specifically fatigue, dizziness, and shortness of breath evaluated using a Visual Analog Scale (VAS) ranging from 0 (no symptom) to 10 (very severe). Baseline demographic characteristics (age, gestational age, parity, BMI) were also recorded.

2.7 Data Collection Procedure

Trained research assistants monitored adherence through weekly follow up calls and home visits. Compliance with the intervention was assessed using a checklist and daily log sheet. Hemoglobin levels were measured at baseline and at the end of the four-week intervention period. Symptom scores were self-reported using the VAS under researcher guidance.

2.8 Ethical Considerations

This study was reviewed and approved by the Research Ethics Committee of LPPM ITSK RS dr Soepraoen Malang No. 017/KEPK/ITSK/I/2025. Written informed consent was obtained from all participants prior to enrollment. All procedures were conducted in acccordance with the Declaration of Helsinki and local health regulations. Participants in the control group were offered aromatherapy after study completion.

2.9 Statistical Analysis

Data were analyzed using SPSS version 26.0. The normality of continuous variables was assessed using the Shapiro–Wilk test. Paired t-tests were used to compare pre- and post-intervention values within groups, and independent t-tests were used for between-group comparisons. Categorical variables were expressed as frequencies and percentages, while continuous variables were reported as means ± standard deviation. A p-value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Participant Characteristics

A total of 60 pregnant women were enrolled and completed the study, with 30 participants in each group. Table 1 summarizes the baseline characteristics of participants. The mean age of participants in the intervention group was 27.5 ± 4.2 years, while that of the control group was 27.1 ± 4.0 years. The mean gestational age was 20.1 ± 3.4 weeks in the interventions group and 20.3 ± 3.5 weeks in the control group. The baseline hemoglobin level was also comparable between groups

(intervention: 9.68 ± 0.59 g/dL vs. 9.72 ± 0.58 g/dL). There were no statistically significant differences in baseline variables between the groups ($p > 0.05$), confirming that the groups were homogenous prior to the intervention.

Table 1. Baseline characteristics of participant

Variable	Intervention group(n=30)	Control group (n=30)	*p*-value
Age	27.5 ± 4.2	27.1 ± 4.0	0.678
Gestational age	20.1 ± 3.4	20.3 ± 3.5	0.744
Baseline Hb (g/dL)	9.68 ± 0.59	9.72 ± 0.58	0.796

3.2 Hemoglobin Concentration

A significant increase in hemoglobin levels was observed in both groups after four weeks. However, the increase was more pronounced in the intervention group. In the intervention group, hemoglobin levels from 9.68 ± 0.59 g/dL to 10.88 ± 0.61 g/dL (mean increase +1.20 g/dL, $p < 0.001$). In the control group, hemoglobin levels increased from 9.72 ± 0.58 g/dL to 10.12 ± 0.62 g/dL (mean increase +0.40 g/dL, $p < 0.001$). Between group comparison revealed a statistically significant difference in the change in hemoglobin levels (Δ = +0.80 g/dL, $p < 0.001$), indicating the effectiveness of rosemary essential oil inhalation.

3.3 Anemia Symptoms

Assessment of clinical symptoms using the Visual Analog Scale (VAS) showed a substantial reduction in fatigue, dizziness and shortness of breath in the intervention group compared to the control group. Fatigue scores decreased from 7.2 ± 1.1 to 3.5 ± 1.0 in the intervention group (mean reduction – 3.7), whereas the control group showed a reduction from 7.1 ± 1.0 to 5.9 ± 1.2 (mean reduction –1.2), with a between group difference of –2.5 ($p < 0.001$).

All outcome measures showed statistically significant improvement in the intervention group compared to the control group. The paired t-test confirmed within group differences, while independent t-test demonstrated that between group differences were also statistically significant ($p < 0.001$ for all comparisons).

Table 2. Change in hemoglobin concentration before and after the intervention

Group	Pre-intervention Hb (g/dL)	Post-intervention Hb (g/dL)	Mean Increase (g/dL)	*p*-value*
Intervention group	9.68 ± 0.59	10.88 ± 0.61	+1.20	<0.001
Control group	9.72 ± 0.58	10.12 ± 0.62	+0.40	<0.001
Between-group comparison	-	-	Δ = 0.80	<0.001

*p-value <0.001

4. DISCUSSION

This study evaluated the effectiveness of inhaled rosemary essential oil in improving hemoglobin concentration and alleviating anemia related symptoms among pregnant women in the second trimester with mild to moderate anemia. The findings demonstrated a statistically significant increase in hemoglobin levels in the intervention group compared to the control group (Δ = +0.80 g/dL, $p < 0.001$). In addition, the intervention group experienced substantial reductions in fatigue, dizziness and shortness of breath as measured by the Visual Analog scale (VAS), with all between group differences reaching statistically significant ($p < 0.001$). These result support the hypothesis that rosemary essential oil inhalation serves as a beneficial complementary therapy in managing gestational anemia.

The observed increase in hemoglobin levels is consistent with previous experimental studies suggesting that *Rosmarinus officinalis* L. has hematopoietic and antioxidant properties.[15] Animal studies have shown that rosemary estract can stimulate erythropoiesis, enhance serum iron levels and reduce oxidative stress markers through upregulation of endogenous antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx).[16] These enzymes play a crucial role in preserving red blood cell integrity and promoting hemoglobin synthesis under oxidative stress conditions commonly observed in anemia. In the present study, the non-invasive nature of inhalation delivery likely enhanced the bioavailability of rosemary's active

compounds, allowing for systematic effects without the limitations of gastrointestinal absorption.[17]

In line with this, Ciliberti et al. (2024) reported that rosemary essential oil has immunomodulatory and antioxidant effects in human and animal models, which may indirectly contribute to better iron metabolism and red blood cell production.[18] Furthermore, studies in aquaculture and veterinary medicine have consistently demonstrated improved red blood cell indices in species receiving rosemary supplementation, suggesting conserved mechanisms across biological systems.[19] Although human studies remain limited, our results provide one of the first clinical evidences demonstrating a significant hematologic benefit from rosemary inhalation during pregnancy.[20]

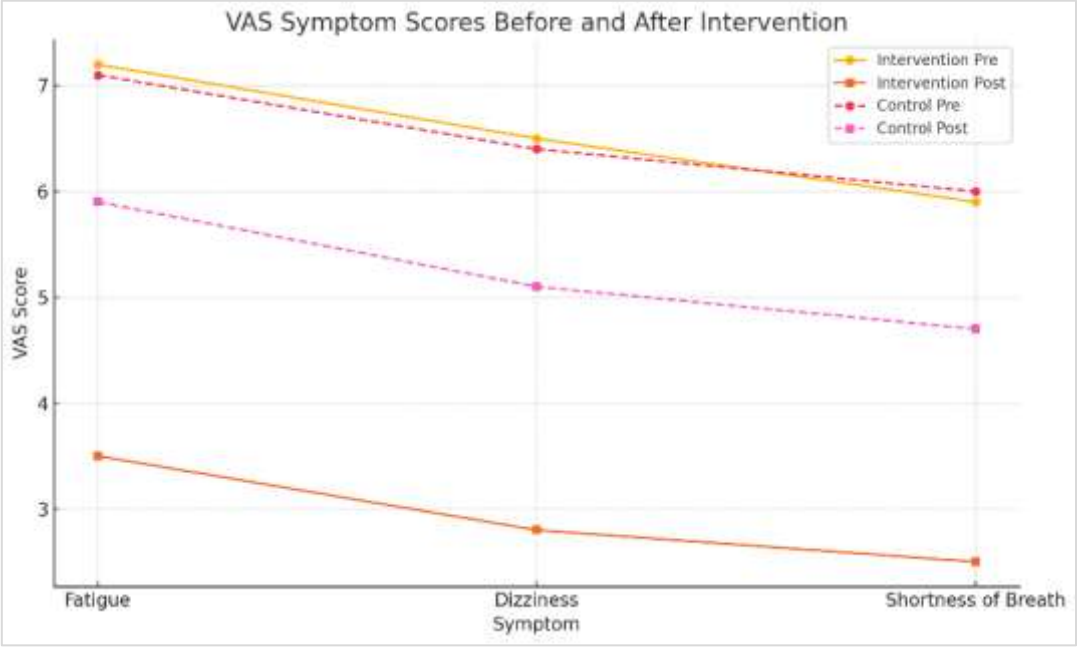

Figure 1. Change in anemia symptoms based on VAS scores

Regarding symptom improvement, the significant reductions in fatigue, dizziness and shortness of breath align with earlier findings that rosemary aromatherapy improves cognitive performance, alertness and energy perception. These neuropsychological benefits may explain the reduced perception of anemia related fatigue in the intervention group.[21] Additionally, rosemary is known to stimulate peripheral circulation, potentially improving oxygen delivery to tissues and reducing symptoms such as dyspnea.

The novelty of this study lies in its integration of phytotherapeutic aromatherapy into maternal care, an area with limited clinical exploration. While oral iron therapy remains the primary treatment for gestational anemia, adherence challenges due to gastrointestinal side effects often reduce its effectiveness. Inhalation of rosemary oil offers an accessible, tolerable and culturally acceptable adjunct that does not interfere with existing treatment protocols. This makes it particularly valuable in resource limited settings, where non-compliance with oral supplements is a common barrier to effective anemia management.[8]

Importantly, the intervention demonstrated a favorable safety profile. No adverse events or allergic reactions were reported throughout the four-week period, and adherence to the inhalation protocol was high (>95%). These findings support the feasibility of implementing rosemary inhalation in antenatal care programs as a complementary intervention, especially when supported by community-based education and monitoring.

Nevertheless, the study contributes significantly to the emerging body of evidence supporting complementary and integrative therapies in maternal health. It underscores the potential of rosemary essential oil inhalation as an evidence-based, non-pharmacological adjunct to conventional iron supplementation, capable of addressing both the biochemical and symptomatic dimensions of anemia. This dual benefit enhances maternal quality of life and

may improve antenatal care outcomes, especially in settings where standard treatments are underutilized.

This study has several limitations that warrant consideration. The relatively short duration of the intervention (four weeks) may not fully capture the long-term hematologic and clinical effects of rosemary essential oil inhalation. Additionally, the absence of iron-related biomarkers such as serum ferritin or transferrin saturation limits the depth of physiological interpretation. The lack of blinding and placebo control may introduce bias, particularly in subjective symptom reporting. Moreover, the sample was limited in size and scope, reducing the generalizability of findings. Future research should include larger, multicenter, placebo-controlled trials with comprehensive biomarker assessments and extended follow up.

5. CONCLUSION

Inhaling rosemary essential oil has been demonstrated to significantly elevate hemoglobin levels and mitigate anemia-related symptoms, including fatigue, dizziness, and dyspnea, in second-trimester pregnant women with mild to moderate anemia. The effects are ascribed to the antioxidant and anti-inflammatory characteristics of rosemary's active components, together with its circulatory stimulation by inhalation. Rosemary presents a promising, safe, and natural complementary therapy that may enhance maternal well-being. Its integration as an adjuvant intervention for pregnancy-related anemia is particularly valuable in settings with limited access to conventional pharmacological treatments.

Ethical Approval

This study was reviewed and approved by the Research Ethics Committee of LPPM ITSK RS dr Soepraoen Malang No. 017/KEPK/ITSK/I/2025.

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Competing Interests

All the authors declare that there are no conflicts of interest.

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Underlying Data

Derived data supporting the findings of this study are available from the corresponding author on request.

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