Lemon Oil Aromatherapy Intervention on Anxiety in Children with Chemotherapy through a Combination Assessment of ZSAS and AI-Based Emotimeter

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ABSTRACT

Each year, 176.000 children are diagnosed with cancer. Chemotherapy is a common treatment. Chemotherapy has both physical and psychological effects. One psychological impact is anxiety. Anxiety in children increases an exaggerated response to painful stimuli and can lead to refusal of treatment, thus impacting the treatment. Anxiety in children can be treated with lemon oil aromatherapy. Lemon oil aromatherapy is a non-pharmacological technique aimed at preventing anxiety in children. The aim of this study was to determine the effect of lemon oil aromatherapy intervention on the anxiety of school-aged children undergoing chemotherapy at a private hospital in Bandung. The study used a quasi-experimental design. The sample consisted of school-aged children. Consecutive sampling was used, with 21 children selected. Data collection involved administering aromatherapy through a diffuser as much as 2 drops of lemon oil dissolved in 100 ml of water, given once before and after chemotherapy for 15 minutes. Anxiety was measured before and after the intervention using the Zung Self-Anxiety Rating Scale (ZSAS) questionnaire, combined with an artificial intelligence based emotimeter to analyze facial expressions more accurately. Data analysis used marginal homogeneity test, found that anxiety before the intervention was mostly severe anxiety (60-74) and after the intervention changed to normal (<45). The statistical test yielded a p-value of 0.001, indicating that the lemon oil aromatherapy intervention had an effect on children's anxiety. Pediatric nurse should provide non-pharmacological interventions, such as aromatherapy, to treat anxiety in children undergoing chemotherapy and using appropriate measurement tools to assess anxiety.

Keywords : aromatherapy, anxiety, artificial intelligence

Introduction

The number of cancer sufferers has increased over time. Cancer can affect all ages, including children. According to data from the Union for International Cancer Control, approximately 176.000 children are diagnosed cancer each year with the majority come from low and middle income countries (UICC, 2025). In high income countries, cancer is the second leading cause of death in children aged 5-14 years. Meanwhile, according to the Indonesian Child Cancer Foundation, based on data from the Global Cancer Observatory in 2020, there were 11.156 cases of childhood cancer annually, and in West Java there were 1.463 cases in 2022 (YKAKI, 2025). The most common types of cancer suffered by children are leukemia and retinoblastoma (Ministry of Health of the Republic of Indonesia, 2025).

Cancer treatment involves medication, surgery, radiotherapy, and chemotherapy. Chemotherapy is a common intervention for children with cancer (Firmana, 2017). Chemotherapy use of cytotoxic drugs in cancer therapy (YKAKI, 2025). While chemotherapy can kill cancer cells, it also harms normal cells. Chemotherapy, as a therapeutic modality in the treatment of malignancies, often causes side effects (Firmansyah, 2017). Side effects of chemotherapy include hair loss, fatigue, nausea, vomiting, diarrhea, mucositis, and bleeding (UICC, 2025). Side effects occur due to changes in normal cells. These side effects can cause discomfort due to physical changes that impact the child's emotional, leading to feelings of anxiety.

Anxiety is a feeling of unease, discomfort, or fear accompanied by an autonomic response with no specific source, a feeling of dread toward something due to anticipation of danger (Yusuf et al., 2015). Children's responses to anxiety, influenced by various factors such as the child's developmental age, gender, length of hospitalization, and previous experiences with illness. Anxiety experienced by children during hospitalization is a very important issue that must be intervened (Hockenberry & Wilson, 2017).

Anxiety problems in children, if untreated, can affect the healing process. This requires early treatment. The impact of delays in managing anxiety in children will increase excessive responses to painful stimuli, children will feel isolated because their activities are hampered, children will refuse treatment. Such condition have a major impact on the process of treatment and recovery of the child (Kyle & Carman, 2015). The worst impact that may occur is the child feels shame, guilt, and fear (Hockenberry & Wilson, 2017).

Efforts are needed to reduce the anxiety experienced by children undergoing chemotherapy by increasing their receptive response to chemotherapy so that they can respond well during chemotherapy. Anxiety in children can be managed with treatments such as distraction, relaxation, guided imagery, and cutaneous stimulation (Ball & Bindler, 2017). Children's limited focus may affect the management of distraction, relaxation, guided imagery, and cutaneous stimulation. Distraction and guided imagery techniques can be used to address anxiety, but the child must be active and focused on the intervention. Relaxation techniques are more appropriate as complementary therapy for children because they do not require the child to be active or focused and do not cause side effects of pain or trauma.

Relaxation is the return of muscles to a resting state after contraction. Relaxation techniques can reduce physiological tension. This technique is based on the belief that the body responds the pain through the mind (Yusuf et al., 2015). Relaxation techniques include deep

breathing, meditation, and aromatherapy. According to Nadia et al. (2024), one widely recommended complementary therapy is aromatherapy.

Aromatherapy or inhaling essential oil vapors, is a simple and effective therapy. According to Nadia et al. (2024), aromatherapy is the use of essential oils for therapeutic or medical purposes. Hospital research shows that aromatherapy can reduce the need for medication and improve patients' quality of life and overall sense of well-being (Sharifi et al., 2017). Astuti et al. (2024) explain that aromatherapy is often used in children and adolescents and has been used in pediatric oncology to treat the psychological impacts experienced. In the first published study testing aromatherapy in children with cancer, they tested the effectiveness of citrus aromatherapy in reducing nausea, anxiety, and pain in children undergoing stem cell infusions for the treatment of malignant disorders. Using an aromatherapy diffuser, patients were randomly assigned to citrus aromatherapy. Nausea, pain, and anxiety decreased significantly.

Aromatherapy is one of treatment using fragrances from various flowers and plants. Aromatherapy is a method of treating illness using essential oils (Yadav et al., 2024). Aromatherapy works by stimulating the release of neurotransmitters such as encephalins and endorphins in the body, which have analgesic effects and promote feelings of comfort and relaxation. The main principle of aromatherapy is the use of plant or flower scents to alter emotional, psychological, and spiritual states, and to influence a person's physical condition through relationships, mind, and body (Istianto & Muryati, 2014).

Aromatherapy oils commonly used for complementary therapy include essential oils of lavender, rose, jasmine, chamomile, grass, and orange or various citrus fruits, which can have sedative and calming effects (Rehim et al., 2025). Aromatherapy is effective in improving mood, making patients appear more relaxed and calm. The aromatherapy that the researchers intend to apply is citrus aromatherapy, specifically lemon. Aromatherapy with lemon oil can improve mood, relax the mind and increase concentration (Khadijah, 2023).

The aromatherapy content of lemon essential oil has a calming effect that can reduce children's anxiety. Lemon aromatherapy is also commonly used for children because it has soft scent. Lemon oil also has strong antimicrobial and antioxidant properties that can fight cancer compared to other essential oils. Lemon contains linalool and linalyl acetate which play a role in brain activity. The citrus aroma can stabilize the nervous system, create feelings of calm and happiness, increase appetite, and cure diseases. One of the health benefits of lemon is due to the content of constituent compounds, including limonene to improve blood circulation, relieve sore throats and inhibit cancer cells. Linalool acts as a sedative, linalyl acetate is a sedative,

terpinol is a sedative and citronella is a sedative, so it can reduce anxiety (Istianto & Muryanti, 2014).

When essential oils are inhaled and carried through the nose, an electrochemical message is transmitted to the limbic system and then to the hypothalamus. Hypothalamus as a relay and regulator, generating messages that sent to the brain. The received message then converted into action, namely the release of relaxant compounds (Puteri et al., 2025). This is supported by Kosgey et al. (2015), who found that serotonin secretion can promote relaxation, thereby reducing anxiety.

A private hospital in East Bandung is one of referral hospital for pediatric cancer in West Java. A preliminary study at the hospital revealed that in 2024, 122 children aged 1 to 18 years old suffered from cancer, with the highest number of cases being school-age children (68). Leukemia was the most common type of cancer affecting children, accounting for 87% of cases, with other types of cancer affecting the remainder.

Based on observations and interviews with 10 patients and their families undergoing chemotherapy, all of them experienced anxiety during the chemotherapy period because they were worried about the pain they would experience when chemotherapy began and the side effects that would arise after chemotherapy. This condition causes stress for both children and their families, so they need to intervere with complementary therapies such as aromatherapy to increase the child's comfort. Based on observations and interviews with researchers at the hospital, aromatherapy is rarely used as a nursing intervention to reduce anxiety in school-age children undergoing chemotherapy.

Materials and Methods

The research design used a quasi-experimental. The sample consisted of school-aged children. Consecutive sampling was used, with 21 children selected. Data collection involved administering aromatherapy through a diffuser as much as 2 drops of lemon oil dissolved in 100 ml of water, given once before chemotherapy for 15 minutes. Anxiety was measured before and after the intervention using the Zung Self-Anxiety Rating Scale (ZSAS) questionnaire, with indications of normal (<45), mild anxiety (45-59), severe anxiety (60-74) and extreme anxiety (>75), combined with an artificial intelligence-based emotimeter application to analyze facial expressions for more accurate assessments, with the categories of neutral expressions (normal), surprised and sad (mild anxiety), afraid and angry (severe anxiety), and tantrum (extreme). Data analysis used bivariate analysis with a marginal homogeneity test to determine the effect of the dependent variable on the independent variable with more than two categories.

The research was conducted from April until June, in the childrens's ward of a private hospital in Bandung.

Results and Discussion

1. Anxiety Prior to Lemon Oil Aromatherapy Intervention

Table 1. Anxiety Before Lemon Oil Aromatherapy Intervention

Variable	Frequency	Percentage (%)
Mild Anxiety	8	38.1
Severe Anxiety	12	57.1
Ekstreme	1	4.8
Total	21	100

Based on anxiety measurements, it was found that before chemotherapy, 12 of the 21 children experienced severe anxiety. The anxiety assessment identified children as frequently feeling anxious, fearful for no apparent reason, trembling, feeling weak, having a rapid heartbeat, frequent urination, and feeling upset stomach. Furthermore, children also experienced headaches, dizziness, and difficulty sleeping. They sometimes even experienced nightmares with facial expressions of sadness and fear.

The anxiety measurements in this study also identified eight children experiencing mild anxiety. The symptoms displayed were fewer than those mentioned above, including restlessness, palpitations, and upset stomach. These results align with research by Yadav et al. (2024) that found anxiety in children during medication administration in the hospital.

The emergence of anxiety in children is influenced by age, gender, and individual experience (Ball & Bindler, 2017). Age or developmental level is known to increase anxiety levels and the more constructive coping strategies a person employs to address challenges. The respondents in this study were elementary school-aged children, aged 7 to 12, with an average age of 10. School-age children already possess a body awareness, and social development is centered around the body and its abilities (Hockenberry & Wilson, 2017). Coping mechanisms in children include problem-solving through communication, calm, denial, regression, or formation reactions. Therefore, most children experienced mild anxiety, with none experiencing severe anxiety.

In addition to age, anxiety is also influenced by gender; males exhibit higher levels of anxiety than females. This is evidenced by free fatty acid (FFA) tests, which showed higher values in males compared to females. In this study, the majority of respondents were female.

Furthermore, individual experience significantly influences anxiety responses because it can be used as a learning experience in dealing with stressors or problems. All respondents in this study were children who had previously undergone chemotherapy.

Anxiety in children undergoing chemotherapy will affect the chemotherapy administration process. Chemotherapy is the use of antineoplastic drugs to kill malignant cells by disrupting cellular reproductive function (UICC, 2025). The chemotherapy program given repeatedly over six treatment cycles with a 21-day interval between cycles. Patients will enter a rest period between cycles to allow healthy cells recovery (Firmana, 2017). Despite this repeated intervention, most children still experience anxiety during the chemotherapy program. Anxiety problems in children, if untreated, can affect the healing process. This requires early treatment. The impact of delay managing anxiety in children can increase excessive responses to pain stimuli, children will feel isolated because their activities are hampered, children will refuse treatment. This conditions significantly affect the recovery process (Kyle & Carman, 2015). Therefore, nursing interventions are needed to anticipate the emergence of anxiety in children. There needs an efforts to reduce the anxiety by increasing the child's response to chemotherapy so that the child can give a good response during chemotherapy (Hockenberry & Wilson, 2017).

Anxiety measurement using the Zung Self Anxiety Rating Scale, validated with an artificial intelligence-based emotimeter, which analyzes facial expressions into categories of neutral (normal), sad and surprised (mild anxiety), fear and anger (severe anxiety), and tantrums (extreme). The emotimeter application facilitates nurses' anxiety assessment because it can be done quickly and accurately through an assessment of the child's facial expressions. Accurate assessment results can assist nurses in determining appropriate interventions for the child.

2. Anxiety After Lemon Oil Aromatherapy Intervention

Table 2. Anxiety After Lemon Oil Aromatherapy Intervention

Variable	Frequency	Persentage (%)
Normal	11	52,4
Mild Anxiety	7	33,3
Severe Anxiety	3	14.3
Total	21	100

The range of anxiety levels after lemon oil aromatherapy intervention was that most children responded normally. Of the 21 children, three still experienced severe anxiety. In mild

anxiety, children were identified as still experiencing anxiety, as indicated by physiological and behavioral responses across almost all systems, but not all symptoms were experienced. Symptoms that appeared included frequent restlessness, unexplained fear, trembling, feeling weak, a rapid heartbeat, stomach upset, and frequent urination. This is in line with research by Rehim et al. (2025) which showed a decrease in anxiety after aromatherapy.

In children with normal response, show physiological and behavioral responses that are still acceptable (Yusuf et al, 2015). Anxiety that arises from physiological responses is primarily felt in the cardiovascular system, namely responses in the form of palpitations, then in the gastrointestinal system, responses such as loss of appetite and abdominal discomfort appear, and in the urinary tract, responses such as frequent urination appear. Anxiety seen from behavioral responses, which often occurs in children is the emergence of feelings of restlessness, and in the cognitive system, impaired attention and poor concentration, then in the affective system, children feel afraid and nervous.

Research on anxiety levels after intervention revealed that not all children became less anxious, but most did not experience anxiety. Most children showed a decrease in symptoms, from frequent to occasional or never. This change in anxiety levels can be significantly beneficial for children and for healthcare providers. Various studies have shown that children who are less anxious communicate more easily, making the chemotherapy program much easier to administer. Furthermore, children become calmer, making it easier to adapt to chemotherapy.

The persistence of children experiencing mild to severe anxiety, despite lemon oil aromatherapy intervention, is due to their age and experience. The respondents were elementary school-aged children, at this level still have unstable emotions, making them prone to anxiety about all invasive procedures in hospitals. Furthermore, health status is a factor. In this case, the respondent was a sick child, and the disease was a chronic and malignant cancer, which can be life threatening.

Cancer impacts children's quality of life, especially when they experience unpleasant side effects from treatment. Quality of life is an individual's evaluation of their functioning and well-being across various life domains, according to their culture, values, and expectations. School-age children with cancer find that their diagnosis, treatment, and prognosis influence their development. Another impact on children's psychosocial development that children struggle to overcome fears of loss of control and death. Cancer is also a significant experience for school-age children because it causes separation from friends, school, and previously normal activities. Several emotional reactions are common in school-age children, such as

mood swings, feeling different from others, thoughts of death, and even regressive behavior (Kyle & Carman, 2015). This poor quality of life impacts physical, emotional, social, psychological, school, and cognitive functioning, disrupting children's growth and development. Nurses strive to improve children's quality of life with support from their family, so that children can continue to learn and interact with each other (Khadijah et al., 2023).

3. The Effect of Lemon Oil Aromatherapy Intervention on Anxiety

Table 3 Differences in Children's Anxiety Before and After Lemon Oil Aromatherapy Intervention

Variable		Anxiety after intervention				Total	*p Value*
		Normal	Mild Anxiety	Severe Anxiety	Ekstreme		
Anxiety before intervention	Normal	0	0	0	0	0	0,001
	Mild Anxiety	11	1	0	0	12	
	Severe Anxiety	0	6	2	0	8	
	Extreme	0	0	1	0	1	
Total		11	7	3	0	21	

The study found that before the intervention, most school-age children experienced severe anxiety, and after the intervention, most children response normally. This finding aligns with several studies demonstrating the effectiveness of aromatherapy in reducing anxiety (Dos Santos et al., 2022). School-age children with cancer undergoing chemotherapy, who were included in this study, tended to have a realistic and relatively shallow understanding of their disease. The study used two instruments to measure anxiety: a subjective questionnaire and an objective assessment of facial expressions. The results showed that the assessment of facial expressions strenghten the results based on the subjective questionnaire (Zafar et al., 2024).

Regular chemotherapy can disrupt a child's daily routine, reducing their opportunities to play or interact with peers. This can lead to anxiety, compounded by the side effects of chemotherapy. These side effects are caused by the nonspecific effects of cytotoxic drugs, which inhibit the proliferation of not only malignant cells but also normal cells. Side effects of chemotherapy include nausea and vomiting, anorexia, taste changes, weight loss, oral mucositis, diarrhea, and constipation. Controlling nausea and vomiting is crucial for maintaining patient adherence to treatment. Among the most feared side effects, uncontrolled

nausea and vomiting affects approximately 60% of chemotherapy recipients and can lead to anorexia, malnutrition, dehydration, and decreased immunity (Astuti et al., 2024).

Anorexia and weight loss occur as a result of the disease process and treatment. Stomatitis or oral mucotitis is a term used to describe inflammation of the oral mucosa. Diarrhea and constipation can be caused by damage to the digestive mucosa secondary to treatment. Alopecia, or hair loss, is a common side effect of antineoplastic agents. The extent of hair loss depends on the drug and dosage. Alopecia generally begins in the second or third week after the first course of therapy and is temporary (Firmana, 2017). All physical responses experienced by chemotherapy can contribute to anxiety in children.

Changes in anxiety levels experienced by children in this study were achieved through the intervention of lemon oil aromatherapy given to them. Aromatherapy can be described as the art of self-care using pure oil extracts or essential oils. Aromatherapy is also a complementary therapy alongside pharmacological therapy. Aromatherapy liquids are obtained through various processing methods known as essential oils (Nadia et al., 2024).

Accessing aromatherapy through inhalation is a much faster route than other methods, as the human sense of smell is highly sensitive. This sense of smell can be up to 10,000 times stronger than the sense of taste. Therefore, inhalation therapy of the active ingredients has a strong effect on the sensory organs.

Aromatherapy works by stimulating the release of neurotransmitters such as encephalin and endorphins, which have analgesic effects and promote feelings of comfort and relaxation. Lemons contain compounds such as limonene, linalool, and linalyl acetate, which improve blood circulation, so the sore throats, inhibit cancer cells, induce feelings of calm and pleasure, and also produce a sedative effect that promotes relaxation (Istianto & Muryati, 2014). Linalool functions as an anxiolytic or a substance that can reduce anxiety. The main activity is to increase immunity and improve circulation and increase cell excitation responses, thereby helping to overcome nausea and vomiting (Astuti et al., 2024). The main principle of aromatherapy is the use of the scent of plants or flowers to change the emotional, psychological, and spiritual state and influence a person's physical condition through relationships, mind, and body (Nadia et al., 2024). The fragrant aroma from aromatherapy is transmitted through two pathways: the first pathway through the limbic system to the hypothalamus and then to the pituitary. The second pathway is transmitted through the olfactory cortex to the hypothalamus and then to the neurocortex. Through these two pathways, aromatherapy will be processed until it creates an individual's perception (Kosgey et al., 2025).

The aromatherapy content of lemon essential oil has a calming effect that can reduce children's anxiety, lemon aromatherapy is also commonly used for children because it has a soft scent, lemon oil also has strong antimicrobial and antioxidant properties that can fight cancer compared to other essential oils. Lemon contains linalool and linalyl acetate which play a role in brain activity. The aroma of citrus can stabilize the nervous system, create feelings of calm and happiness, increase appetite, and cure diseases. Linalool acts as a sedative, linalyl acetate is a sedative, terpinol is a sedative and citronella is a sedative, so it can reduce anxiety (Istianto & Muryanti, 2014).

Consistent efforts are needed to reduce the anxiety experienced by children undergoing chemotherapy by increasing their acceptance of chemotherapy, ensuring a positive response during the treatment. Aromatherapy, or inhaling essential oil vapors, is a simple and effective therapy. Aromatherapy is the use of essential oils for therapeutic or medical purposes. Aromatherapy with lemon oil can reduce the need for medication and improve patients' quality of life and overall sense of well-being.

Conclusion

Anxiety experienced by school-age children aged 7 to 12 years, while undergoing chemotherapy in the hospital before being given lemon oil aromatherapy intervention, the majority experienced severe anxiety were 12 children out of 21 children. The level of anxiety after being given lemon oil aromatherapy intervention was mostly changed to normally in 11 children. Giving lemon oil aromatherapy can be a routine intervention in the chemotherapy room, because the process is easy and inexpensive, with anxiety evaluation using a simple and fast measuring tool through an artificial intelligence-based application.

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