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The Neuroscience behind the Smell

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ABSTRACT: Aromatherapy is an alternative treatment utilized in the application of plant essential oils that are derived from flowers, leaves, barks, and roots to improve both physical and psychological well-being. Aromatherapy has its roots in ancient practices in both Indian, Egyptian, and Chinese cultures^{1,36}. It is gaining significant prominence in contemporary medicine as an adjunct to new approaches to stress management, pain control, and overall well-being³¹. The essential oil is used in three different manners: inhalation, external application, or diffusion, in which case it stimulates both limbic interaction in the brain as well as cutaneously induced receptors to manifest different mechanisms of action^{28,34}.

The purpose of this paper is to present information regarding its history, classification, mechanisms of action, and beneficial uses. Essential oil used in aromatherapy, such as lavender oil, eucalyptus oil, sandalwood oil, lemon oil, bergamot oil, and tuberose oil, are also investigated with specific aim at their pharmacological properties in relation to anti-inflammatory, antimicrobial properties, analgesic properties, and anxiolytic properties^{1,25,33}. Recent findings are presented focusing on stress relief, sleep inducement, pain relief, as well as its aid in chronic conditions^{12,13,20}.

Despite its popularity, aromatherapy experiences some challenges in terms of standardization issues, quality of essential oils used in the therapy, and the lack of human studies^{26,30}. Safety issues in the therapy include the potential for allergic reactions and skin sensitization³⁴. It is suggested that the subject needs further studies in the area of human studies in order to qualify its therapeutic uses²⁶. This article asserts the need for the convergence of traditional practices in relation to modern pharmacology³⁶.

Scents may have a significant impact on the emotional experiences and behaviors of individuals. This is called the Proust Effect, identified as a reaction to the experiences expressed by the author Marcel Proust about the ability of certain smells to automatically trigger memories without any intentional mental effort²⁸. Taking advantage of the strong connection between the components of aromatherapy and the physical experiences, this approach to student management can be applied in the classroom to provide a positive and calm environment for increased attention and reduced behavioral problems in students²⁸. It has been discovered that the impact of aromatherapy hand massage can improve academic achievement in nursing students by reducing test anxiety and building self-confidence.

KEYWORDS: Aromatherapy; Essential oils; Complementary and alternative medicine; Limbic system; Lavender oil; Stress management; Anxiety and depression.

I. INTRODUCTION

The term “aromatherapy” was considered in the early 1900s by a French pharmacist named René-Maurice Gattefossé²⁷. Gattefossé realized the treatment offered by lavender essential oil when he applied it topically to a burn on his hand. His observations led to the development of interests in the research of essential oils.

Aromatherapy has long been in practice using aromatic oils from natural resources which stimulate physical, emotional, and intellectual well-being¹. The current elevated use of aromatic oils can mainly be ascribed to their multi-faceted properties of being fragrant and of a natural composition, thus being preferred alternatives to their artificial counterparts²⁴. The key concepts of aromatherapy consist of using these volatile oils through methods similar to inhalation, external application, as well as massage therapies for instigating physiological responses for healing purposes³⁰. These oils are thought to stimulate reactions from the olfactory trembles as well as the limbic system of the brain that controls emotions and desires²⁸.

Such exercise also plays a significant role in relieving stress, coping with anxiety, fighting fatigue, and increasing relaxation and concentration⁶. Both contemporary science and ancient healing practices like Ayurvedic medicine and Traditional Chinese Medicine as well as ancient Egyptian medicinal practices have acknowledged the rejuvenating properties of fragrant oils in rebalancing the body^{1,36}.

The essential oils which are similar to lavender, eucalyptus, peppermint, and rosemary have been known to share parcels such as anti-inflammatory, antimicrobial, antifungal, antioxidant, and analgesic behaviour^{1,25}. Such medicinal properties help in its efficacy in treating a number of diseases, such as insomnia, headache, respiratory disorders, skin conditions, and mental torture too^{5,31}. Similarly, aromatherapy is also widely in consideration for its medicinal use in treating individuals who are affected in habitual ailments such as Alzheimer's disease, cardiovascular diseases, cancer-related fatigue, as well as childbirth pain in the case of a pregnant woman^{16,18,23}. With the steady increase in the popularity of natural treatments, aromatherapy has become an integral part of holistic healthcare administrations across the world³⁶.

The Science behind the fragrance

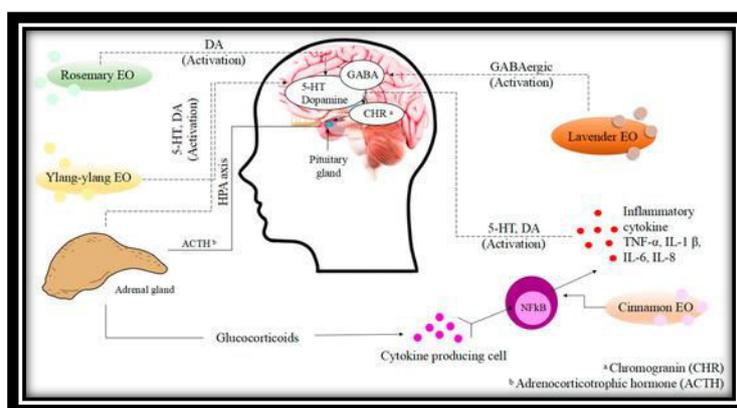


Figure 1. Mechanism actions of essential oils on the Central Nervous System.

Some EOs were suggested to act through an anxiolytic mechanism because of the modulation of the GABAergic system and sodium channels, but also because of the modulation of transient receptor potential channels³⁵. Use of EOs was suggested to be associated with the reduction of pro-inflammatory and anti-inflammatory response to stress¹⁹. It has been suggested that the action of EOs on the Central Nervous System (CNS) is mediated through the activation of different elements of the brain²⁹. In this context, the lavender oil action is anxiolytic antistress, mood elevator, analgesic, and pain reliever through the activation of the GABAergic system, thus suppressing the excitability of the peripheral and central nerve cells and through the inhibition of the voltage-gated calcium channels and the reduction in the serotonergic 5-HT_{1A} receptors^{14,25}. There is an increase in the parasympathetic tone, and this is also participating in the mechanisms associated with the biological action of this AE²⁹. Ylang-Ylang oil has an antidepressant and relaxing action through the activation of the Autonomic Nervous System (ANS) and through the modulation of the DAergic system, the increase of the serotonin levels, and the reduction of the glucocorticoids levels³³.

In addition, this oil acts on the HPA axis by reducing glucocorticoid levels with a sedative effect³³. In vivo experiments have stated that this EO has an anxiolytic effect in male mice because it favours a reduction in the levels of DA in the striatum, as well as a reduction in the concentration of 5-HT in the hippocampus³⁵. Besides, ylang-ylang EO reduces the 5-hydroxyindole acetic acid (5-HIAA)/5-HT ratio. Rosemary EO favoured the activation and secretion of DA, explaining its anxiolytic effect and improving cognitive function³³. Finally, anxiolytic action of cinnamon oil is explained by the downregulation of nuclear factor kappa-light-chain-enhancer, NFκB³³. The biological results in the CNS for lavender, rosemary, cinnamon, and ylang-ylang are presented in Figure a.

How Does Aromatherapy Operate?

Inhalation

The powerful sense of smell is triggered by essential oils, and 10,000 different smells can be detected by humans²⁸. Smells trigger a sensation in the brain as they pass through the nose and come into direct contact with the nerves. When essential oils are inhaled, it sends a signal to the component as well as to the limbic system in the brain, where memory and emotions are stored²⁸. The limbic system in the brain is responsible for triggering reactions in the hypothalamus and pituitary, which play important roles in regulating hormones. The nerves, hormones, temperature, hunger, thirst, digestion, insulin secretion, stress, disgust, and sex drive all respond to these autonomic activities²⁸. It is important to acknowledge that when treating patients, physicians have found that²⁴.

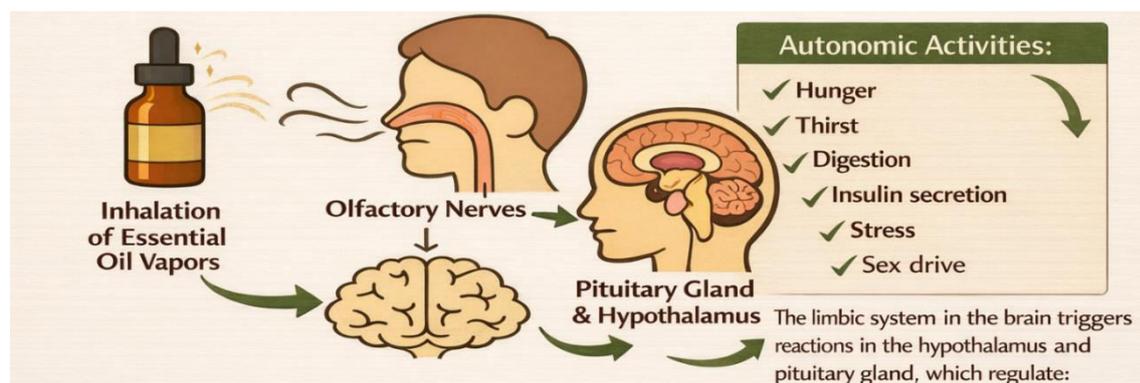


Fig. 2: Process of aromatherapy

Classification of aromatherapy

- Cosmetic aromatherapy
- Massage aromatherapy
- Medical aromatherapy
- Olfactory aromatherapy
- Psycho aromatherapy

Cosmetic Aromatherapy

This strategy involves the use of essential oils in cosmetic formulations that aim to help the skin, hair, facial, and body care²⁴. The products are used owing to the various benefits they present, which include drying, moisturizing, cleaning, as well as toning. Use of essential oils in face cosmetics can lead to healthy skin²⁴. Personally, a foot bath or a whole-body aromatherapy using cosmetics will be one easy and effective way to have fun. Similarly, a few drops of the correct oil are rejuvenating and therapeutic³².

Massage Aromatherapy

This method, often regarded as the "therapeutic touch" in massage therapy practices, has also gained acceptance with the evidence of its effectiveness⁶. Natural vegetable oils including jojoba oil, almond oil, and grapeseed oil used in massage therapy have proved quite effective in hydrating the skin, relieving muscles, and boosting blood circulation³².

Medical Aromatherapy

René Maurice Gattefossé is the developer of modern aromatherapy²⁷. He has utilized the knowledge of medicinal aromatherapy concerning the beneficial properties of essential oils in the promotion and treatment of medically recognized ailments and massage of patients undergoing surgical operations²⁷.

Olfactory aromatherapy

It involves the inhalation of aromas from essential oils²⁸. Inhaling aromas from essential oils improves "emotional well-being, calmness, relaxation, and regeneration processes and includes stress relief and pleasant scents to stimulate your memory associated with smells"²⁸. Essential oils should not be used alone for treatments but should complement them²⁴.

Psycho Aromatherapy

"Psycho aromatherapy" emphasizes the psychological advantages of using essential oils³¹. Inhaling specific fragrances triggers the brain's limbic system²⁸. This has a beneficial effect on emotions. Some of the most commonly used essential oils for anxiety relief, boosting memory power, improving moods, and for enhanced concentration levels are lavender oil, lemon balm oil, and sandalwood^{5, 31, 33}.

II. SOME PLANTS USED IN AROMATHERAPY

A wide range of plants have been utilized in aromatherapy, owing to the presence of volatile or essential oils in various plant parts, including the flowers, bark, stem, leaves, roots, and fruits¹. Some of the plants used in aromatherapy are summarized as essential oils parts of the plant. Bergamot, lemon, sweet orange, tangerine, mandarin Fruit peel, Cinnamon Bark Citronella, lemongrass, petitgrain, patchouli leaves, Geranium, lavender, rosemary, lavender, Ginger, Jasmine, neroli (orange blossom), rose, ylang flowers^{1, 11}.

1. Lemon

The fruit that is most abundant in India and is cheapest. Lemons *Citrus limon* Linn. (*C. limon*) are of the Rutaceae family. Taller trees of *C. limon* grow to 15 feet and are markedly aromatic with lemons. Fruiting is done throughout the year. The oil components have appreciable amounts of terpenes. d-Limonene is found in abundant quantities. Even further, it has been recognized that there is phellandrene, pinene, and sesquiterpenes⁹.

It should be noted, however, that clary sage is not to be confused with common sage (*Salvia officinalis*), as it has larger leaves and a distinctive purple tint to them, together with bluish-white flowers blooming during late summer months, as opposed to the current species which has smaller leaves and white flowers. The essential oil of clary sage is constituted by a number of primary ingredients, which include linalool, linalyl acetate, alpha-terpineol, germacrene D, and geranyl³⁰. The essential oil is prized for its health benefits, especially among women²⁴.

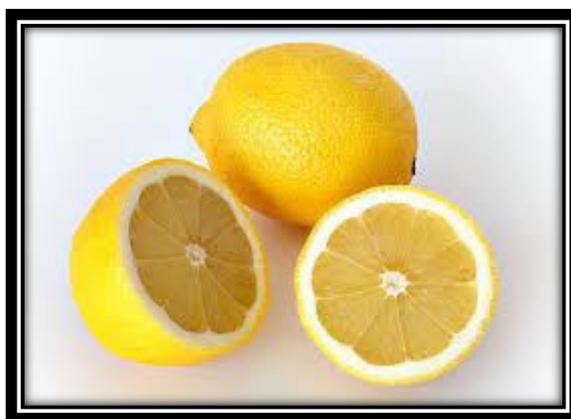


Fig. 3: Citrus Lemon.

It is also commonly employed to treat the symptoms of menstruation, relieve stress, and calm muscle spasms²⁴. Besides the health advantages, clary sage is also widely cherished for promoting emotional health, managing stress, and displaying aphrodisiac properties³¹. In general, clary sage is an herb with a remarkable history of being used medicinally³⁰.

2. Eucalyptus

Eucalyptus, also known as *Eucalyptus globulus*, is a large evergreen tree, which in certain instances can reach a height of up to 250 feet. This rare species has long been celebrated for the presence of its essential oil, whose chief active component constitutes cineole (70-85%), together with other components such as limonene, terpinene, cymene, phellandrene, aromadendrene, and pinene¹⁹.

It is well known that eucalyptus oil has some medical uses regarding the number of body systems. It can be very helpful for the nervous system, relieving headache, general weakness, and neuralgia¹⁹. It acts effectively against all diseases like chickenpox, measles, flu, and common cold due to its immune system stimulate¹⁹. Eucalyptus oil is well known for its diverse uses in medicine. With respect to the genitourinary system, it has been shown to be effective in the management of conditions like leucorrhea and cystitis¹⁹. This is attributed to its natural properties of being antimicrobial and anti-inflammatory¹. On the part of respiratory issues, it is especially beneficial when used to relieve sinusitis, bronchitis, asthma, coughs, catarrh, and sore throat¹⁹. This is why it is so common in inhalers and chest rubs¹⁹.



Fig. 4: Eucalyptus globulus

Moreover, it may also act to ease the condition of muscle/joint pain, such as that experienced by people suffering from rheumatoid arthritis¹⁹. Evidence has pointed out the antibacterial, anti-inflammatory, anti-proliferative, and antioxidant abilities of the oil^{1, 19}. Such qualities prove the efficiency of the oil against many infectious diseases and metabolic problems. The results showcase the immense benefits of eucalyptus oil for many health-related concerns¹⁹.

3. Lavendar

The family name Lamiaceae encompasses the beautiful lavender plant, scientifically known as *Lavandula officinalis*, commonly found in gardens. The herb is valued for its essential oil that contains major compounds such as 1, 8-cineole, camphor, terpinen-4-ol, linalool, linalyl acetate, and beta-ocimene²⁵. Due to the following effects it exhibits on the central nervous system, it has become renowned for having excellent skin penetration during massage and also for inducing relaxation²⁹. Due to the relaxing properties associated with it, linalyl acetate is employed in relaxing treatments for anxiety and insomnia¹⁴.



Fig. 5: Lavender officinalis

Disorders, whereas linalool is known for its sedative qualities²⁵. Lavender is a well-liked option for improving mental clarity, lowering anxiety and anger, and improving well-being because of these qualities^{2,29}. In order to enhance the quality of sleep, lavender's calming scent is frequently used in pillows and aromatherapy⁷.

4. Geranium

Pelargonium graveolens is commonly referred to as geranium. It is a robust perennial shrub and is part of the Geraniaceae family. Geranium is a native plant of South Africa. It has adapted so easily to environments in other areas of the world like Central America, Egypt, Japan, Congo, France, Italy, and Spain. Geranium grows to a height of one meter and is significant not only for aesthetic reasons but for the fragrant leaves and medicinal properties as well³⁰.



Fig. 6: *Pelargonium graveolens*

The chemical composition of its essential oil consists of healthy compounds like eugenol, geranic acid, citronellol, geraniol, linalool, citronellyl formate, citral, myrten³⁰. This plant is highly valued for its fragrance. Perfume manufacturers also make use of geranium oil due to its renowned fragrance¹¹. This unique quality helps it combine well with both soap and detergent without being affected by their alkaline properties. Geranium oil helps in emotional control through aromatherapy³¹. It promotes balance and harmony. This scented oil has long been a preferred component in many therapies due to its uplifting and soothing nature³¹.

5. Sandalwood

Sandalwood oil is very popular for its luxurious aroma. It is ranked amongst the most expensive essential oils. It has a soft, sweet, warm, woody, and balsamic aroma. Due to its properties, it is widely used in perfumes and aromatherapy¹⁷. Sandalwood Essential Oil that is most conventional and regarded highly comes from a *Santalum album* tree, which is indigenous to East India. It is a very slow-growing plant, and as a result of increasing demand for it over the years, it has become scarce. In order to safeguard this plant, its cultivation is now regulated. This essential oil is sourced from NDA only after it is ensured that it comes from authorized suppliers who adhere to government auctions held in India. As an alternative option, Australian Sandalwood oil, sourced from the *Santalum spicatum* tree, has received popularity due to its resemblance to the scent of the East Indian Sandalwood¹¹. It is known to promote the attributes of mental acuity, emotional harmony, and tranquility³³.



Fig. 7: Santalum album

This oil is also used to relieve stress, reduce feelings of anxiety, promote relaxation and improve sleep, as well as improve concentration³³. It is also used to promote spiritual relaxation and thus is a great addition during meditation. Sandalwood oil is also known to relieve common bodily symptoms such as headaches, digestion problems, coughs, and colds, replacing them with ease and relaxation¹. The distinct aroma properties and benefits of this oil are primarily because of its key components, which are the alcohol isomers α -Santalol and β -Santalol, as well as other sesquiterpene alcohols¹⁷. The presence of Santalol in this oil is not only responsible for its distinct aroma properties but also a determining factor of its purity, whereby the higher percentage of Santalol, the more costly or better oil it is¹⁷.

6. Bergamot

Bergamot is a citrus fruit that comes from the family of Rutaceae, which is mainly cultivated in areas such as Italy as well as Morocco⁹. The essential oil, which is mainly sourced from the peel of the bergamot fruit, is widely known for its ability to relieve for its potential calming and soothing properties⁹. It has been suggested to help reduce irritability and promote restful sleep⁹.



Fig. 8: Citrus bergamia.

The major components of bergamot essential oil are bergapten (5-methoxypsoralen), linalool, and linalyl acetate⁹. A study of the biological properties of bergamot essential oil suggests that it has the capacity to increase the concentration of melatonin within human blood and that 5-methoxypsoralen is mainly responsible for this function⁹. Melatonin has immense applications within the human body in terms of managing its biological clock. An increase in melatonin is likely to help a human being sleep peacefully⁷.

Prior literature has identified how postpartum depression and lack of sleep can play a crucial role in women's overall well-being¹³. Experiments involving animals have produced evidence that suggests active ingredients in bergamot oil

have a positive effect on treating symptoms associated with depression, relaxation, and improvements to one's sleep³⁵. Despite this information, there is a current absence of authoritative clinical studies that explore a specific connection to how bergamot essential oil affects postpartum women²⁶. This information has yet to be explored within a clinical setting through experiment methods such as a controlled study²⁶.

7. Amber

Amber oil is not a true essential oil because it is not produced through steam distillation, but it is taken from Baltic amber resin of *Pinus succinifera* trees¹¹. Amber oil is a fossilized oil, which has great aromatic as well as spiritual value because of its distinctive properties. Historically, amber has been revered across various cultures for its protective, healing, and spiritually uplifting qualities¹¹.



Fig. 9: *Pinus succinifera*

Well beyond its intoxicating scent, the odour of amber oil also possesses an extensive meaning related to spiritual wellness and energetic balance¹¹. Many practitioners of energy work feel that amber oil is very grounding and balancing. The warmth of amber oil is also known to have benefits in terms of calming down the mind and ensuring that emotional energy is well balanced and free to flow¹¹. In energy works, amber oil is used to remove any kind of energy obstruction toward ensuring that there is free energy flow in the body. Due to its capacity to remove or clean any negative energy, it is also used in some spiritual clearing practices¹¹. This is expected to clean any negative energy present in the surrounding, as well as serve as some form of protection against any kind of negative energy¹¹.

Essential oils & pharmacological actions

Essential oils have been researched for their diverse uses¹. The major health uses of these essential oils are listed below. The following section discusses some of the therapeutic uses of essential oils. These herbs work to reduce the risk associated with the following diseases: eucalyptus, lemon, lavender, basil, sweet orange, ginger, pine, and peppermint^{1, 5, 19}. Stress, anxiety, agitation, difficult behaviour, insomnia, and mental fatigue: memory loss and pain management^{12, 31}.



Fig. 10: Pharmacological Effects of Essential Oils.

Essential Oils with Antimicrobial Properties

Essential oils may be categorized depending on antibacterial properties into two groups:

- Those acting on gram-positive bacteria and
- Those acting upon gram-negative bacteria¹.

In many of the essential oils outlined above, antifungal properties are also evident¹. Though the antibacterial properties of essential oils have received extensive attention, studies have found evidence for the efficiency of essential oils against particular bacteria such as Salmonella¹. These essential oils have the potency to act as a substitute for existing antibiotics. Among the essential oils noted in this regard is basil oil. Basil oil has the strongest bactericide attribute¹. That makes basil oil capable of killing bacteria. A number of studies have found basil oil to have immense antimicrobial powers¹. That makes basil oil the most widely sought essential oil due to its health benefits¹.

Antifungal properties

Antifungal agents can be defined as the ones that either prevent the growth of the fungus or totally eliminate it³⁰. One major example is in the handling and control of ringworms using antifungal creams on the affected skin. Preliminary clinical findings suggest that Cuminum cyminum (commonly known as cumin) exhibits promising antifungal properties¹. If these results are verified, cumin may become an efficient alternative for antifungal therapy, which relies on numerous medications that are underutilized due to the risk of systemic toxicity³⁰.

Antiviral property

This project hypothesized the potential for certain components within Essential Oils to bind with core protein targets related to the outbreak of severe acute respiratory syndrome from Coronavirus in 2019¹. The commonest examples of essential oils that have antiviral properties include lemongrass, lavender, and cinnamon oils¹.

Insect or Mosquito Repellent Action

Nepeta parnassica essential oils presented positive data regarding toxicity or repelling properties against Culex pipiens molestus¹. Various extracts were separated on the proper helium gas, which is substantially better at relieving the contractile overactivity of the ileum, underpinning the entire problem of the digestive system³⁵. Every synthetic and natural chemical has its individual impact on the hormonal levels of the body; geraniol, neral, and geraniol display the widest coverage regarding the impact on the body's hormonal balance³⁰. These were found to promote the estrogenic response, unlike the previously known impact of eugenol on estrogen³⁰. Citra, a combination of geraniol, neral, and eugenol, is more effective at replacing beta³⁰.

III. THE FUTURE OF AROMATHERAPY IN ALTERNATIVE MEDICINE

The increasing application of aromatic plants in complementary and alternative medicine practice emphasizes their considerable value in medicine³⁶. A considerable number of aromatic plants with established medical uses exist;

nonetheless, intensive research is required to identify their healing properties, toxicity, and modes of action²⁶. The steadily growing practice of inhalation aromatherapy and EO massage therapy in medicine calls for more intensive in vitro and in vivo studies to prove their beneficial properties²⁶.

The appeal of EOs can be attributed to the belief that natural products have fewer side effects than conventional drugs²⁶. There could be selection bias introduced by the positive expectations of individuals using EOs²⁶. Moreover, the pleasurable feelings that aromatherapy provides can make it effective²⁸. One could question the affective or placebo effect introduced when research results could be biased²⁶. Thus, in order to eliminate such biases, it is recommended that future studies focus on in-depth research regarding the therapeutic values of aromatic plants utilizing appropriate study designs, for example, randomized controlled trials²⁶.

IV. SAFETY AND LIMITATIONS

Ideally, essential oils having the comfort of coming home from a hard, trying day at work, knowing that the scent of a preferred essential oil will chase the stressors away from a busy, trying day is a reassuring thought²⁴. Taking an uplifted bubble bath with essential oils helps individuals feel like a new, rejuvenated being³². Conversely, essential oils can be poisonous, resulting in chemical burns or death³⁴. Aromatherapy is on the rise in popularity, but the misuse of aromatherapy essential oils can be perilously dangerous due to a lack of understanding³⁴. The foremost ethical principle is beneficence, where the nurse makes positive efforts to avoid harming the patient⁶. Secondly, the ethical principle is nonmaleficence, where there is the duty or obligation not to cause any form of damage or injury to a patient⁶. Legal repercussions might follow should any damage or injury come to a patient because of negligence related to the use of aromatherapy³⁴. In conclusion, the major takeaway is that nurses should educate themselves regarding the essential oils used in aromatherapy, poisoning, or life-threatening complications^{6, 34}.

V. CONCLUSION

Though aromatherapy shows great potential in its therapeutic applications, more research is required to determine standard guidelines for its usage as a therapeutic aid²⁶. There is also a great need for large-scale studies to confirm the efficacy of essential oils in certain medical conditions like anxieties, sleep disorders, pain, and palliative oncology^{12, 13, 18, 20}. Standardization of procedures in the extraction process and administration of essential oils is required for rigorous studies and to make them safe for use as therapeutic agents^{30, 34}. There is also scope for crossover research work between pharmacology, neuroscience, and medical practices that could help explain the therapeutic procedures in greater detail and widen the applications of aromatherapy as therapeutic medicine³⁶.

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