



Review article

Use of *Lavandula angustifolia* essential oil as a complementary therapy in adult health care: A scoping review



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ABSTRACT

Background: In addition to its low toxicity risk, Lavender (*Lavandula angustifolia* Mill.) essential oil is recognised worldwide for its sedative, antidepressant, antiseptic, antifungal, relaxing, and antiemetic properties. Thus, the action mechanism of lavender oil has attracted significant attention from researchers interested in improving the physical, emotional, and spiritual well-being of patients.

Objective: To investigate the scope of knowledge regarding the use of *L. angustifolia* essential oil as a complementary therapy in adult health care.

Methods: A scoping review was carried out using a PRISMA-ScR checklist followed by a critical assessment being performed using the Joanna Briggs Institute level of evidence. The following databases were used: SCOPUS, MEDLINE/PubMed, Web of Science, Science Direct, SCIELO, Cochrane Library, LILACS, Wiley Online Library, CAPES, and FIOCRUZ Dissertations.

Results: Eighty-three articles published between 2002 and 2022 were selected for the analysis; More articles came from Iran than from any other country and most articles reported clinical trials. The applicability of lavender essential oil and its route of administration in different clinical situations were the main topics addressed in the articles.

Conclusions: Most studies demonstrate the efficacy of *L. angustifolia* Mill. essential oil in relieving pain and decreasing anxiety. Few studies evaluated the anti-psoriatic, anti-toxoplasmotic, and wound healing properties and the protective actions against cerebral ischemia. One study reported on its safety, specifically the allergenic potential of linalool, the main chemical component of *L. angustifolia* essential oil. However, most studies did not involve the extensive investigations on this topic or report the safe quantities of this oil for human treatment, meaning further research into the safety of this treatment is required.

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Already known information

- The essential oil of *Lavandula angustifolia* Mill. is used to relieve pain, stress, anxiety, and insomnia.
- The essential oil of *Lavandula angustifolia* Mill. can be used as a complementary therapy to ensure holistic and quality care.

Contributions of the study

- Recent research studies have been conducted to show the potential of *Lavandula angustifolia* Mill. oil for treating psoriasis, toxoplasmosis, wound healing, and ischemic brain injury, although it still needs further study.
- Although some studies indicate the absence of adverse effects in the application of this oil, no research to date has clearly addressed the safety of lavender essential oil application.

1. Introduction

There is a growing market trend for medicinal and aromatic plants, where essential oils are the most sought-after due to their vast number of applications, such as in perfumery, food, beverages, cooking, and therapeutics. These oils are derived from distinct parts of a plant, such as the seeds, stems, leaves, petals, flowers, bark, and roots [1].

Several extraction methods are used for essential oils, such as infusion, maceration, and microwave and ultrasonic extraction [2]. The main forms of absorption of essential oils in the human body are inhalation, transdermal application, and oral ingestion [3].

Among the numerous types of essential oils that can be used in clinical practice, lavender essential oil stands out. The genus *Lavandula* belongs to the Lamiaceae family and contains 39 species, of which the most cultivated are *Lavandula angustifolia* (lavender or true lavender), *L. latifolia* Medik. (spike lavender), *L. stoechas* L. (Spanish lavender), and *L. x intermedia* Emeric ex Loisel. (lavandin) [4].

Lavender essential oil can contain more than 100 different components, including terpenoid and phenolic compounds. The main components of lavender oils are the monoterpenoids linalool, linalyl acetate, 1,8-cineole, β -ocimene, terpinen-4-ol, and camphor [5].

With its high linalool and linalyl acetate content and low amount of camphor, the essential oil of *Lavandula angustifolia* Mill. is among the best and most desired lavender oils in the cosmetic and aromatherapy industries. In addition, it is considered a pharmacopoeial raw material native to mountainous areas in southwestern and southern Central Europe [6].

Lavandula angustifolia Mill. oil is recognised for its various pharmacological activities, ranging from healing to sedative, antidepressant, antiseptic, antifungal, relaxing, and antiemetic properties. Some studies have found that it is considered safe as it offers minimal risk of toxicity [7].

The monoterpenes in lavender oil, such as limonene and perillyl alcohol, are strong agents against cancer activity. In addition, their known antibacterial properties are due to the presence of phenolic compounds in their composition, such as carvacrol, eugenol, and thymol, and some terpenes are also useful in preventing cardiovascular diseases [8].

Considering this, lavender is increasingly highlighted in the health care field due to its therapeutic applications and potential, among the various medicinal plants, to improve the quality of life and well-being of those who consume it, offering a positive experience and promoting health.

Thus, aiming to promote the physical, emotional, and spiritual well-being of human beings and considering the therapeutic potential of lavender, there is a growing interest in scientific research on its action mechanism on human health. However, it is perceived that there are still few studies that provide an overview of its applicability and implementation as a complementary therapy in the health care of individuals.

Therefore, this study aimed to map the production of knowledge regarding the use of *Lavandula angustifolia* Mill. essential oil as a complementary therapy in adult health care.

2. Methods

This is a Scoping Review following JBI recommendations and the Checklist Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR). The objectives, inclusion criteria, and methods for this scoping review were specified in advance and documented in the protocol registered in the Open Science Framework.

The scoping review makes it possible to map key concepts, the main sources and types of evidence available on a particular field of interest, and research gaps, applying to different research projects, especially when the research area is complex or has not been previously and comprehensively reviewed. Reviews such as this address broad research questions and do not focus only on the quality of included studies [9].

For the structuring of this study, the Arksey and O'Malley [9] steps improved by Peters et al. [10] were used: 1. Define and align the research objective and question, 2. Develop and align the inclusion criteria with the research objective and question, 3. Describe the planned approach to search for evidence, selection, data extraction, and presentation of evidence, 4. Search for evidence, 5. Select

evidence, 6. Extract data, 7. Analyse data, 8. Present results, and 9. Summarize evidence regarding the research objective, draw conclusions, and observe any implications of findings.

2.1. Research question

To formulate the research question, the PCC mnemonic (Population, Concept, and Context) was used, as indicated by JBI. Therefore, P was defined as adult patients; C: use of *Lavandula angustifolia* essential oil as a complementary therapy; and C: health care. Thus, the following research question was proposed: “What is the production of knowledge on the use of *Lavandula angustifolia* essential oil as a complementary therapy in the health care of adult patients?”

2.2. Search strategy

Ten data sources were used in this search, namely: Elsevier’s SCOPUS, Medical Literature Analysis and Retrieval System Online (MEDLINE)/PubMed, Web of Science, Science Direct, Scientific Electronic Library Online (SCIELO), Cochrane Library, Latin American and the Caribbean Literature in Health Sciences (LILACS), Wiley Online Library, Catalogue of Theses and Dissertations (CAPES), and Oswaldo Cruz Foundation (FIOCRUZ) – Theses. The search strategy was adapted according to the specificities of each source used; however, combinations between descriptors were used, and time and language restriction filters were not adopted (Table 1).

2.3. Selection criteria

In order to select the articles that made up the sample of this review, the following inclusion criteria were adopted: full articles published online, covering articles, dissertations, theses, guidelines, and websites in the area of integrative health practices, without time and languages restrictions and those that presented the theme consistent with the objective of this research. The following were excluded: abstracts, letters to the editor, and studies aimed at the paediatric, adolescent, and/or animal population.

2.4. Data collection

Data collection was carried out from June 22 to July 6, 2022, using the Portal of Periodicals of the Coordination for the Improvement of Higher Education Personnel (CAPES), with remote access through the Federated Academic Community (CAFe) platform.

Descriptors were consulted in the *Descritores em Ciências da Saúde (DeCS)* and Medical Subject Headings (MeSH), aiming to adapt searches to Portuguese and English languages, and the following were respectively established: “Óleos voláteis”, “Óleo Essencial”, “*Lavandula angustifolia*”, “*Lavandula*”, “*Terapias complementares*”, “*Atenção à Saúde*”, “*Enfermagem*”, and “Oils, Volatile”, “Essential oils”, “*Lavandula angustifolia*”, “*Lavandula*”, “Delivery of Health Care”, “Complementary Therapies”, “Nursing”. For the crossing of descriptors, “AND” and “OR” Boolean operators were used.

Table 1
- Search strategies employed in the data sources. Natal, RN, Brazil, 2022.

Sources of data	Search Syntax	Search dates
PUBMED	(((((Oils, Volatile) OR Essential oils) AND Lavandula angustifolia) OR Lavandula) AND Delivery of Health Care) AND Complementary Therapies) AND Nursing)	22 June 2022
Web of Science	(ALL = (Oils, Volatile)) OR ALL = (Essential oils) AND ALL = (Lavandula angustifolia) OR ALL = (Lavandula) AND ALL = (Delivery of Health Care) AND ALL = (Complementary Therapies) AND ALL = (Delivery of Health Care) AND ALL = (Nursing)	22 June 2022
Science Direct	Oils, Volatile OR Essential oils AND Lavandula angustifolia OR Lavandula AND Delivery of Health Care AND Complementary Therapies AND Nursing	23 June 2022
Cochrane Library	Oils, Volatile OR Essential oils AND Lavandula angustifolia OR Lavandula AND Delivery of Health Care AND Complementary Therapies AND Nursing	25 June 2022
MEDLINE/PubMed	(((((Oils, Volatile) OR (Essential oils)) AND (Lavandula angustifolia)) OR (Lavandula)) AND (Delivery of Health Care) AND (Complementary Therapies)) AND (Nursing)	25 June 2022
LILACS	Oils, Volatile OR Essential oils [Words] AND Lavandula angustifolia OR Lavandula AND Delivery of Health Care AND Complementary Therapies AND Nursing [Words]	25 June 2022
Wiley Online Library	“Oils, Volatile OR Essential oils” anywhere and “Lavandula angustifolia OR Lavandula” anywhere and “Delivery of Health Care” anywhere and “Complementary Therapies” anywhere and “Nursing”	25 June 2022
SCIELO	(Oils, Volatile OR Essential oils) AND (Lavandula angustifolia OR Lavandula) AND (Delivery of Health Care) AND (Complementary Therapies) AND (Nursing)	25 June 2022
Oswaldo Cruz Foundation (FIOCRUZ) - Theses	(Volatile Oils OR Essential Oil) AND (Lavandula angustifolia OR Lavender) AND (Complementary Therapies) AND (Health Care) AND (Nursing)	26 June 2022
Theses and Dissertations Catalogue (CAPES)	(Volatile Oils OR Essential Oil) AND (Lavandula angustifolia OR Lavender) AND (Complementary Therapies) AND (Health Care) AND (Nursing)	26 June 2022

Source: survey data, 2022. MEDLINE: Medical Literature Analysis and Retrieval System Online; LILACS: Latin American and Caribbean Literature on Health Sciences; SCIELO: Scientific Electronic Library Online.

In order to identify duplicate studies, a prior search was performed on the following international registry platforms: International Prospective Register of Systematic Reviews (PROSPERO), Open Science Framework (OSF), The Cochrane Library, JBI Clinical Online Network of Evidence for Care and Therapeutics (CONNECT+), and Database of Abstracts of Reviews of Effects (DARE), in which no studies with a theme similar to that of this study were found, reinforcing the importance of carrying out this procedure.

The search for data, screening, and inclusion of studies were selected by two independent evaluators, duly trained in terms of the selection criteria for this study, simultaneously and using different electronic devices. Divergences found between reviewers during the selection process were mediated through meetings, and after discussion, it was decided to include or exclude the study from the review. A reverse search was also carried out in the references of selected articles in order to identify possible relevant studies to compose the sample.

3. Results and discussion

Fig. 1 shows the step-by-step procedure, from the identification of the studies in the selected databases to the composition of the final sample of this review (83 articles), after applying the inclusion and exclusion criteria and removing duplicates.

The years of publication ranged from 2002 to 2022. Since 2015, there has been a significant increase in the number of studies on lavender essential oil. In particular, studies published in 2020 stood out, representing 11 (13.2%) of the selected articles.

Furthermore, the countries of origin of the selected articles were Australia, Brazil, Malaysia, Korea, the United States of America (USA), India, Iran, Italy, Japan, the United Kingdom, Switzerland, and Turkey. Among them, Iran prevailed with 40 publications (48.1%), followed by Turkey with 16 publications (19.7%).

Studies with clinical trials were the predominant class in the sample, representing 75 (90.4%) articles, followed by systematic reviews with six (7.2%) articles, and cohort and quasi-experimental studies with one (2.4%) article in each category.

Considering the clinical trials selected in this review, Fig. 2 shows a synthesis of all types of applicability found in the studies on lavender oil. Fig. 3 indicates the types of oil application according to analysis of the 75 clinical trials.

The populations where the lavender oil was applied were heterogeneous. However, the prevalence of research in hemodialyzed, preoperative, and postoperative patients stood out. Finally, it is important to note that in all clinical trials that analysed the application of this oil, there were no adverse effects in patients receiving this intervention.

Due to the extensive number of articles selected and analysed, the authors chose to make the database created during the categorisation of the results available on the research protocol registration link of this review (10.17605/OSF.IO/74UBD); thus, readers will have access to the article titles and other information.

From the selected studies in this review, Iran was the country with the largest number of publications, followed by Turkey. Such prevalence is associated with the fact that Asian countries are precursors in the identification and beneficial use of aromatherapy as a non-pharmacological treatment. However, there is a progression of research on alternative therapies in Western countries [11,12].

Therefore, the use of aromatherapy with essential oils extracted from medicinal plants is considered a treatment for clinical

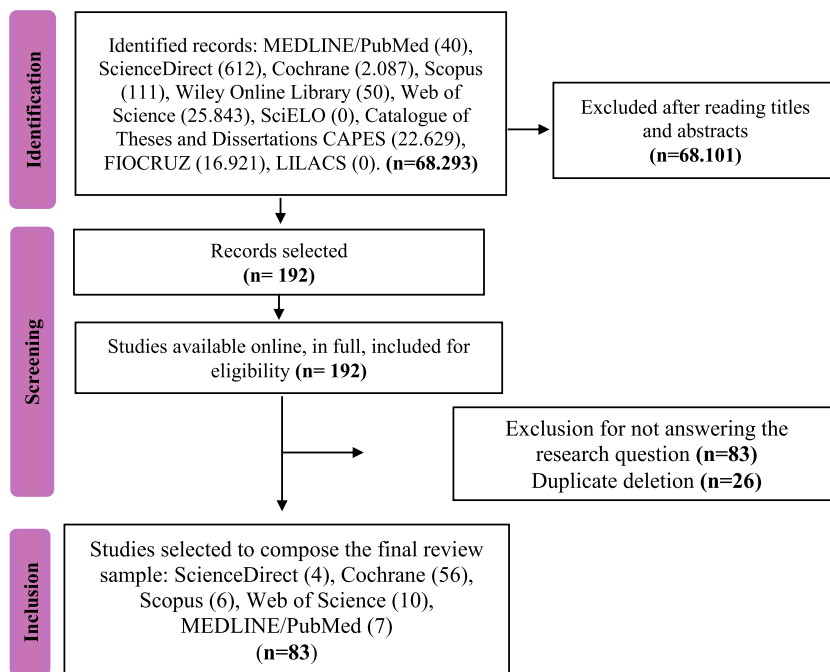


Fig. 1. Search flowchart adapted from the *Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews* (PRISMA ScR). Natal, RN, Brazil, 2022.

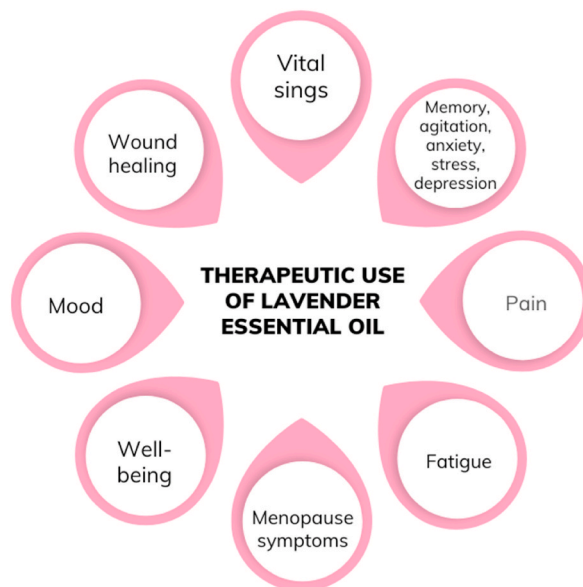


Fig. 2. Schematic presentation showing the therapeutic uses of lavender essential oil reported in selected clinical trials. Natal/RN, Brazil, 2022. An analysis of 75 articles revealed that most experiments were aimed at improving pain relief, improving sleep quality, and decreasing anxiety. Several studies involved the administration of lavender oil to treat anxiety associated with other problems, such as vital signs being outside of the normal range, sleep disturbances, and depression.

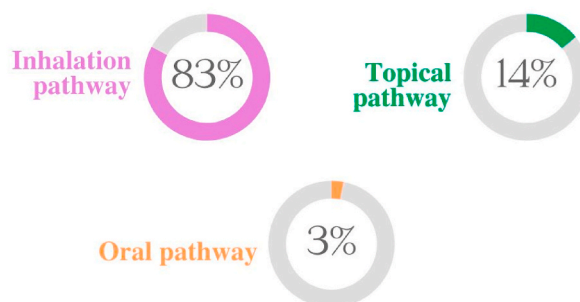


Fig. 3. Administration routes for *L. angustifolia* essential oil according to the analysis of 75 clinical trials. Natal/RN, Brazil, 2022. The inhalation of lavender essential oil was the predominant administration route, especially *via* drops of oil on cotton balls, gauze, fabric, or oxygen masks, in bottles or diffusers, directly in contact with skin, or in bath water. In hospitals, holding a cotton ball close to the patient was the most common technique.

symptoms and can improve the quality of life for individuals. Owing to its chemical components, they enable a low-cost therapy and promote mechanisms to relieve anxiety and stress (e.g., the essential oil of *L. Angustifolia Mill.*) [6].

In this perspective, studies report that lavender oil releases neurochemical substances with sedative and relaxation properties, which activate the central nervous system and contribute to the balance of both the physical and mental well-being of individuals [13].

The oil of *L. angustifolia Mill.* may contain more than 100 different chemical compounds. Table 2 lists the most prevalent chemical compounds of *L. angustifolia Mill.* oil and their respective biological activities.

Thus, the combination of its main constituents, especially linalool and its acetate, produces an anxiolytic and sedative action depending on the inhibition of voltage-dependent calcium channels, reduces the activity of 5HT1A receptors, and stimulates the parasympathetic system [14].

L. angustifolia oil is also associated with the reduction of stress levels. Due to its volatilisation, the receptor cells of the nasal cavity capture the biological signals, followed by their transmission to the limbic system and hypothalamus and the release of neurotransmitters, which act on the parasympathetic system and promote relaxation [15].

The mechanisms of action mentioned above validate the positive results found in the literature regarding the oil of *L. angustifolia Mill.* For example, research showed a significant reduction in anxiety and pain at the time of the puncture of an arteriovenous fistula in patients undergoing haemodialysis when lavender oil aromatherapy was utilized [16–22]. Individuals in this clinical situation were subjected to approximately 320 punctures per year. This resulted in intense pain, discomfort, fear, anguish, and stress, as well as negative effects on the quality of life of these patients. Hence, it is important to offer therapies that alleviate such discomforts [23].

To decrease the pain response, the compound linalool present in the oil acts on muscarinic, opioid, and dopaminergic transmission.

Table 2
Major chemical compounds of *Lavandula angustifolia* essential oil.

Chemical composition	Percentage	Biological activity
Linalyl Acetate	25–46% [2,6]	Anti-inflammatory [2,37] Anti-psoriatic [37] Anxiolytic [23,36] Sedatives [15] Analgesic [24] Prevention of cerebral ischemic injury [39]
Linalool	20–45% [2,6]	Anti-inflammatory [2,37] Anti-psoriatic [37] Antimicrobial [38] Antiviral [38] Antifungal [38] Analgesic [24] Anxiolytic [23,36] Healing [6] Antioxidant [6]
Lavandulol	>0,1% [2,6]	Aroma [38]
Lavandulyl Acetate	>0,2% [2,6]	Aroma [38]
Terpinen-4-ol	0,1–6,0% [2,6]	Antifungal [38]

Source: survey data, 2022.

In this context, the anti-allodynic effects of linalool may be associated with the compound's ability to inhibit nociception by pro-inflammatory cytokines and modulate the glutamatergic NMDA receptor [24].

Thus, current research focuses on aromatherapy using lavender oil for pain relief in different clinical situations. An example of this was a clinical trial performed with 120 women in which the essential oil of *L. angustifolia Mill.* was used for pain relief during childbirth. The results showed a positive response in the group that received lavender oil treatment. This corroborates the results of all articles analysed in this review [16,17,19,21–23,25–35].

Another example of a clinical situation in which lavender oil was used is a study conducted on oncology patients under chemotherapy treatment. The patients reported an intermediate level of anxiety and poor quality of sleep. In this context, three drops of essential oil of *L. angustifolia Mill.* were inhaled at night. The results showed improved quality of sleep and reduced anxiety. Further, no adverse effects on patients were observed [36].

A study conducted by Rai et al. [37] involved *in vivo* tests on the anti-psoriatic activity of oil from *L. angustifolia Mill.* in which its compounds linalool and linalyl acetate significantly reduced the histological changes occurring during psoriasis. Notably, linalool reduced IL-17 and IL-22, and linalyl acetate promoted reductions in the level of Th-1 cytokines. The study also indicated mild and slight skin irritation when lavender oil was used at 10% and 2% concentrations, respectively.

The lavandulol compound and its acetate are responsible for the floral and rosy aroma of lavender oil. Notably, the percentages of the chemical components in lavender oil can vary depending on the species used and the geographical region where these species are being cultivated. Subsequently, its biological activity can vary depending on the proportions of its compounds [38].

The antimicrobial action of the compounds of *L. angustifolia Mill.* oil, as indicated in Table 2, is mainly due to their affinity with the lipidic structures of cells, destroying the cell wall of bacteria, particularly in Gram-positive bacteria and fungi, causing the extravasation and coagulation of the cytoplasm. In addition, lavender oils inhibit RNA, DNA, protein synthesis, and polysaccharides in bacteria and inhibit the enzyme production of fungi [38].

Recently published research was performed on murine and human brain cells, and the results suggested that linalyl acetate may be a novel protective agent against ischemic brain injury. This is because this compound could protect against calcium-related ischemic injury that can damage neurovascular unit cells and indirectly maintain normal blood-brain barrier function, indicating future benefits for patients in a clinical environment [39].

Among the various research studies conducted on the actions of Lavandula oil, the *in vitro* study on the use of *L. angustifolia Mill.* essential oil against *Toxoplasma gondii* infection may be the most important. This study demonstrated the anti-toxoplasma activity of *L. angustifolia Mill.* by inhibiting *T. gondii*, preventing its invasion and growth through the alteration of its cell membrane. However, the authors state that further research should be conducted so that *L. angustifolia* could be a candidate for the production of an anti-toxoplasma drug in the future [40].

Camphor is generally formed in low percentages in lavender essential oil, and its presence confers an important parameter in evaluating the quality of this oil, i.e., high-quality lavender oils have low camphor content in their composition and high linalool and linalyl acetate content [2].

Essential oils are increasingly used worldwide, especially in the field of nursing, where new knowledge is being acquired about integrative and complementary treatment practices, thereby strengthening nursing as a science and art [27]. This therapy is considered an easy and non-pharmacological method of intervention in providing palliative care and physical and psychological health promotion (Rajai et al., 2016).

The application of aromatherapy using lavender oil as a complementary therapy before invasive procedures, such as endoscopy,

Table 3

- Evidence discussed in this research. Natal, RN, Brazil, 2022.

Evidence	Description
Chemical compounds Innovation	Responsible for most of the biological activities of lavender oil are linalool and linalyl acetate [2,6,15,23,24,37–39] Research of <i>Lavandula angustifolia</i> oil in clinical situations such as psoriasis [37]; toxoplasmosis [40]; ischemic brain injury [39]; wound healing [6].
Prevalent biological activities	Anxiolytic action: inhibition of voltage-dependent calcium channels, decreased activity of 5HT1A receptors, and stimulation of the parasympathetic system [23,36] Stress reduction: acting on the limbic system and hypothalamus [15]. Pain reduction: inhibition of nociception by pro-inflammatory cytokines and modulation of the glutamatergic NMDA receptor [24].
Safety	The 0.1% concentration of lavender oil is the safest so far. However, the literature indicates allergenic potential of its linalool compound. There is a need for future research to further explore this topic [6,45].
Public studied	The most studied were women in childbirth [16,17,19,21–23,25–35] and haemodialysis patients [16–22].

Source: survey data, 2022. NMDA: N-methyl-D-aspartate; 5HT1A: 5-hydroxytryptamine subtype.

was shown to help decrease systolic-diastolic blood pressure, heart rate, anxiety, and pain levels, while oxygen saturation values increased [27].

In addition to the inhalation route of application, the topical route was the second most commonly used strategy found in the studies analysed in this review (14%). Massage therapy is the most efficient method related to topical application due to the high blood flow in the epidermis, which enables higher absorption of the chemical constituents of the oil by the bloodstream. Consequently, access to organs and tissues is facilitated, promoting the relief of muscle tension and reducing the physiological effects of pain [41–44].

Another important aspect of lavender oil as a non-pharmacological therapy is its positive role in wound healing. The active ingredients present in lavender oil have demonstrated its healing potential by promoting collagen synthesis, differentiating fibroblasts, and reducing the perilesional area of wounds [43].

The action of *L. angustifolia* Mill. is linked to the induction of interleukin-6 expression, a cytokine responsible for the tissue-healing reaction. In addition, studies have found the association of lavender essential oil in increasing the production of vascular endothelial growth factor, which can accelerate wound closure by promoting granular tissue formation and improving the mechanical properties of the healed area [6].

Regarding the safety of using *L. angustifolia* Mill. essential oil, a study conducted by Miastkowska et al. [6] indicated that a 0.1% concentration of the essential oil was the safest for all preparations evaluated. However, some studies indicated that exposure to linalool, a major compound of essential oils, especially that of *Lavandula angustifolia*, may result in allergic reactions. Therefore, the 7th Amendment of the European Cosmetics Legislation (2003) requires natural products, including linalool, to be labelled as potentially allergenic [45].

Considering this, it is possible to understand the growing number of research studies, especially clinical trials, regarding the use of lavender essential oil in improving the health of adult patients in various clinical settings and conditions.

Table 3 summarizes the evidence discussed in the text with their respective descriptions.

3.1. Limitations

The limitations of this review are as follows. The sample size was small because only the adult population was considered in this review. Further, a few articles had to be excluded because they were inaccessible. Another limitation was the lack of standardisation in the dosage of *L. angustifolia* Mill. essential oil used in articles that involved human participants. Reports with vague terms and without a deeper discussion were identified, limiting the interpretation of the concentration of the oil used.

4. Conclusion

Studies on the applicability of the essential oil of *L. angustifolia* Mill. for human health are increasingly growing, particularly in clinical trials attempting to prove its effectiveness. The essential oil of *L. angustifolia* Mill. showed its main activity in relieving pain, stress, and anxiety through linalool compounds and linalyl acetate.

These aforementioned chemical compounds also demonstrated their potential in activities such as anti-psoriatic, anti-toxoplasmosis, wound healing, and preventing cerebral ischemia. However, previous studies on these topics are considerably recent and were performed *in vitro* using muscarinic and human cells. Therefore, there is a need for the advancement of these research studies to prove and, consequently, use the oil of *L. angustifolia* Mill. in these clinical situations.

The inhaled form of application has proven to be the most widely used for pain relief and anxiety reduction in haemodialysis, preoperative, postoperative, and intensive care unit patients, during exams such as colonoscopy, endoscopy, and dental procedures, as well as several other clinical conditions found in the articles in this review.

The oil from *L. angustifolia* Mill. did not show adverse effects during its use in the studies analysed in this review. However, this oil has many natural chemical components, and only the linalool and its acetate were evaluated for cytotoxicity due to their allergenic potential depending on the oil concentration. Therefore, there is a need for further studies on its safety.

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] K. Shady, J. Nair, C. Crannell, Lavender Aromatherapy Examining the effects of lavender oil patches on patients in the hematology-oncology setting, *Clin. J. Oncol. Nurs.* 23 (5) (2019) 502–508, <https://doi.org/10.1188/19.cjon.502-508>.
- [2] Dobros, N., Zawada, K. D., Paradowska, K. Phytochemical Profiling, Antioxidant and Anti-Inflammatory Activity of Plants Belonging to the Lavandula Genus. *Molecules.*, 28(1), 256. <https://doi.org/10.3390/molecules28010256>.
- [3] L.M. Lowring, Using therapeutic essential oils to support the management of anxiety, *J. Am. Assoc. Nurse Pract.* 31 (10) (2019) 558–561, <https://doi.org/10.1097/JXX.000000000000227>. <https://pubmed.ncbi.nlm.nih.gov/31169787/>.
- [4] I. Crisan, A. Ona, D. Varban, L. Muntean, R. Varban, A. Stoie, T. Mihaiescu, A. Morea, Current trends for lavender (*lavandula angustifolia* Mill.) crops and products with emphasis on essential oil quality, *Plants* 12 (2) (2023) 357, <https://doi.org/10.3390/plants12020357>.
- [5] L. Sharma, C. Meghna, P. Ajmera, Health benefits of lavender (*Lavandula angustifolia*), *Int. J. Physiol., Nutr. Phys. Educ.* 4 (1) (2019) 1274–1277. <https://www.journalofsports.com/archives/2019/vol4/issue1/4-1-317>.
- [6] M. Miastkowska, T. Kantyka, E. Bielecka, U. Kalucka, M. Kaminska, M. Kucharska, A. Anna Kilanowicz, D. Cudzik, K. Cudzik, Enhanced biological activity of a novel preparation of *lavandula angustifolia* essential oil, *Molecules* 26 (9) (2021) 2458, <https://doi.org/10.3390/molecules26092458>.
- [7] H.B. Darzi, A. Azimi, S. Ghasemi, A. Ebadi, T. Sathyapalan, A. Sahebkar, The effect of aromatherapy with rose and lavender on anxiety, surgical site pain, and extubation time after open-heart surgery: a double-center randomized controlled trial, *Phytother. Res.* 34 (10) (2020) 2675–2684, <https://doi.org/10.1002/ptr.6698>.
- [8] S. Panda, S. Sahoo, K. Tripathy, Y.D. Singh, M.K. Sarma, P.J. Babu, M.C. Singh, Essential oils and their pharmacotherapeutics applications in human diseases, *Adv. Tradit. Med.* 22 (1) (2020) 1–15, <https://doi.org/10.1007/s13596-020-00477-z>.
- [9] H. Arksey, L. O'Malley, Scoping studies: towards a methodological framework, *Int. J. Soc. Res. Methodol.* 8 (1) (2005) 19–32, <https://doi.org/10.1080/1364557032000119616>.
- [10] M.D.J. Peters, C. Marnie, A.C. Tricco, D. Pollock, Z. Munn, L. Alexander, P. McInerney, A.M. Godfrey, H. Khalil, Updated methodological guidance for the conduct of scoping reviews, *JBI Evid. Synth.* 18 (10) (2020) 2119–2126, <https://doi.org/10.11124/JBIES-20-00167>.
- [11] Paviani, B. A., Trigueiro, T. H., Gessner, R. The use of essential oils in labor and childbirth: scope review. *REME Rev. Min. Enferm.*, 23, e-1262, 1-8. <https://cdn.publisher.gn1.link/remee.org.br/pdf/e1262.pdf>. DOI: 10.5935/1415-2762.20190110.
- [12] C. Tesser, D. Dallegrave, Complementary and alternative medicine and social medicalization: lack of definitions, risks, and potentials in primary healthcare, *Cad. Saúde Pública* 36 (9) (2020), e00231519, <https://doi.org/10.1590/0102-311X00231519>.
- [13] L.S. Nunes, J.C. Branco, S.S. Nedel, J.S. Martins, Efeitos do óleo essencial de *lavandula angustifolia* associado a massagem com auxílio de pedras quentes na redução de ansiedade e perda de peso em mulheres obesas, *Rev. Bras. Obes., Nutr. Emagrecimento.* 15 (93) (2021) 187–195. <http://www.rbone.com.br/index.php/rbone/article/view/1649>.
- [14] A.S. Malta, L.M.A. Lemos, The use of essential oils in the treatment of stress, *Id Line Rev. Mult. Psic.* 13 (48) (2019) 54–65, <https://doi.org/10.14295/online.v13i48.2140>.
- [15] J. Montibeler, T.S. Domingos, L.M. Braga, J.R. Gnatta, L.F.S. Kurebayashi, A.K. Kurebayashi, Effectiveness of aromatherapy massage on the stress of the surgical center nursing team: a pilot study, *Rev. Esc. Enferm. USP* 52 (2018), 03348, <https://doi.org/10.1590/S1980-220X2017038303348>.
- [16] H. Bagheri, T. Salmami, J. Nourian, S. Mirrezaie, A. Abbasi, A. Mardani, Z. Vlaisavljevic, The effects of inhalation aromatherapy using lavender essential oil on postoperative pain of inguinal Hernia: a randomized controlled trial, *J. Perianesth. Nurs.* 35 (6) (2020) 642–648, <https://doi.org/10.1016/j.jopan.2020.03.003>.
- [17] A. Ghods, N. Abforosh, R. Ghorbani, M. Asgari, The effect of topical application of lavender essential oil on the intensity of pain caused by the insertion of dialysis needles in hemodialysis patients: a randomized clinical trial, *Compl. Ther. Med.* 23 (3) (2015) 325–330, <https://doi.org/10.1016/j.ctim.2015.03.001>.
- [18] M. Nesami, F. Espahbodi, A. Nikkhal, S. Shorofi, J. Charati, The effects of lavender aromatherapy on pain following needle insertion into a fistula in hemodialysis patients, *Compl. Ther. Clin. Pract.* 20 (1) (2013) 1–4, <https://doi.org/10.1016/j.ctcp.2013.11.005>.
- [19] M. Bagheri-Nesami, S. Shorofi, A. Nikkhal, F. Espahbodi, The effects of lavender essential oil aromatherapy on anxiety and depression in haemodialysis patients, *Int. J. Pharm. Biomed. Res.* 3 (1) (2017) 8–13, <https://doi.org/10.18869/acadpub.pbr.3.1.8>.
- [20] A. Senturk, P. Kartın, The effect of lavender oil application via inhalation pathway on hemodialysis Patients' Anxiety level and sleep quality, *Holist. Nurs. Pract.* 32 (6) (2018) 324–335, <https://doi.org/10.1097/hnp.0000000000000292>.
- [21] E. Taşan, O. Ovayolub, N. Ovayoluc, The effect of diluted lavender oil inhalation on pain development during vascular access among patients undergoing haemodialysis, *Compl. Ther. Clin. Pract.* 35 (2019) 177–182, <https://doi.org/10.1016/j.ctcp.2019.02.010>.
- [22] M. Mesri, S. Hosseini, R. Heydarifar, M. Mirizadeh, M. Forozanmehr, Effect of lavender aromatherapy on anxiety and Hemodynamic changes: a randomized clinical trial, *Qom Univ. Med. Sci.* 10 (12) (2017) 69–76. <https://journal.muq.ac.ir/article-1-826-fa.html>.
- [23] S. Sahin, B. Tokgöz, G. Demir, Effect of lavender aromatherapy on arteriovenous fistula puncture pain and the level of state and trait anxiety in hemodialysis patients: a randomized controlled trial, *Pain, Manag. Nurs.* 22 (4) (2021) 509–515, <https://doi.org/10.1016/j.pmn.2021.01.009>.
- [24] P.A. Batista, M.F.P. Werner, E.C. Oliveira, L. Burgos, P. Pereira, L.F.S. Brum, G.M. Story, A.R.S. Santos, The antinociceptive effect of (-)-Linalool in models of chronic inflammatory and neuropathic Hypersensitivity in mice, *J. Pain* 11 (11) (2010) 1222–1229, <https://doi.org/10.1016/j.jpain.2010.02.022>.
- [25] M. Yazdkhasti, A. Pirak, The effect of aromatherapy with lavender essence on severity of labor pain and duration of labor in primiparous women, *Compl. Ther. Clin. Pract.* 25 (2016) 81–86, <https://doi.org/10.1016/j.ctcp.2016.08.008>.
- [26] R. Shammass, C. Marks, G. Broadwater, E. Le, A. Glenner, A. Sergesketter, R. Cason, K. Rezak, B. Phillips, S. Hollenbeck, The effect of lavender oil on perioperative pain, anxiety, depression, and sleep after microvascular breast reconstruction: a prospective, single-blinded, randomized, controlled trial, *J. Reconstr. Microsurg.* 37 (6) (2021) 530–540, <https://doi.org/10.1055/s-0041-1724465>.
- [27] S. Saritas, Z. Buyukbayram, E. Serin, Y. Bilgic, Effects of lavender oil intervention before endoscopic retrograde cholangiopancreatography on patients' vital signs, pain and anxiety: a randomized controlled study, *Explore* 17 (5) (2019) 446–450, <https://doi.org/10.1016/j.explore.2020.07.011>.
- [28] H. Sapmaz, M. Uysal, U. Taş, M. Esen, M. Barut, B. Somuk, T. Alatlı, S. Ayan, The effect of lavender oil in patients with renal colic: a prospective controlled study using objective and subjective outcome measurements, *J. Alternative Compl. Med.* 21 (10) (2015) 617–622, <https://doi.org/10.1089/acm.2015.0112>.

- [29] S. Kim, H. Kim, J. Yeo, S. Hong, J. Lee, Y. Jeon, The effect of lavender oil on stress, bispectral index values, and needle insertion pain in volunteers, *J. Alternative Compl. Med.* 17 (9) (2011) 823–826, <https://doi.org/10.1089/acm.2010.0644>.
- [30] M. Cerezer, S. Nedel, M. Christmann, L. Nunes, I. Vieira, M. Badke, Lavander essential oil for spinal pain in obese women: a clinical trial, *Coluna/Columna* 20 (3) (2021) 192–196, <https://doi.org/10.1590/S1808-185120212003243743>.
- [31] M. Shahnazi, R. Nikjoo, P. Yavarikia, S. Mohammad-Alizadeh-Charandabi, Inhaled lavender effect on anxiety and pain caused from intrauterine device insertion, *J. Caring Sci.* 1 (4) (2012) 255–261. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4161086/>.
- [32] A. Olapour, K. Behaen, R. Akhondzadeh, F. Soltani, F. al Sadat Razavi, R. Bekhradi, The effect of inhalation of aromatherapy blend containing lavender essential oil on cesarean postoperative pain, *Anesthesiol. Pain Med.* 3 (1) (2013) 203–207, <https://doi.org/10.5812/aapm.9570>.
- [33] T. Karaman, S. Karaman, S. Dogru, H. Tapar, A. Sahin, M. Suren, S. Arici, Z. Kaya, Evaluating the efficacy of lavender aromatherapy on peripheral venous cannulation pain and anxiety: a prospective, randomized study. *Complement, Ther. Clin. Pract.* 23 (2016) 64–68, <https://doi.org/10.1016/j.ctcp.2016.03.008>.
- [34] Z. Seifi, A. Bikmoradi, M. Bazrafshan, J. Poorolajal, M. Araghchian, S. Kashfi, E. Kavi, M. Jokar, The effect of inhalation aromatherapy with lavender essential oil on pain severity of patients after coronary artery bypass surgery: a single-blind randomised clinical trial, *J. Clin. Diagn. Res.* 12 (7) (2018) LC01–LC05, <https://doi.org/10.7860/JCDR/2018/34865.11721>.
- [35] L. Welden, P. Leatherland, M. Schitter, A. Givens, J. Stallings, Abdominal surgical patients randomized to aromatherapy for pain management, *J. Perianesth. Nurs.* 36 (3) (2021) 291–299, <https://doi.org/10.1016/j.jopan.2020.08.005>.
- [36] A. Ozkaraman, O. Dugum, H.O. Yilmaz, O.U. Yesilbalkan, Aromatherapy: the effect of lavender on anxiety and sleep quality in patients treated with chemotherapy, *Clin. J. Oncol. Nurs.* 22 (2) (2018) 203–210, <https://doi.org/10.1188/18.CJON.203-210>.
- [37] V.K. Rai, P. Sinha, K.S. Yadav, A. Shukla, A. Saxena, D.U. Bawankule, T. Sudeep, F. Khan, C.S. Chanotiya, N.P. Yadav, Anti-psoriatic effect of *Lavandula angustifolia* essential oil and its major components linalool and linalyl acetate, *J. Ethnopharmacol.* 261 (1) (2020), 113127, <https://doi.org/10.1016/j.jep.2020.113127>.
- [38] M. Bialon, T. Krzyzko-Lupicka, E. Nowakowska-Bogdan, P.P. Wiczorek, Chemical composition of two different lavender essential oils and their effect on facial skin microbiota, *Molecules* 24 (18) (2019) 3270, <https://doi.org/10.3390/molecules24183270>.
- [39] Y.S. Hsieh, Y.K. Shin, G.H. Seol, Protection of the neurovascular unit from calcium-related ischemic injury by linalyl acetate, *Chin. J. Physiol.* 64 (2) (2023) 88–96. <https://pubmed.ncbi.nlm.nih.gov/33938819/>.
- [40] N. Yao, J.K. He, M. Pan, Z.F. Hou, J.J. Xu, Y. Yang, J.P. Tao, S.Y. Huang, In vitro evaluation of *lavandula angustifolia* essential oil on anti-toxoplasma activity, *Front. Cell. Infect. Microbiol.* 11 (2021), 755715, <https://doi.org/10.3389/fcimb.2021.755715>.
- [41] M. Aragão, S. Correia, S. Gomes, A. Pereira, K. Azevedo, W. Lima, S. Dias, Use of essential oils associated with physiotherapy for pain relief in dysmenorrhea: a systematic review, *Res., Soc. Dev.* 10 (11) (2021), e30101119308, <https://doi.org/10.33448/rsd-v10i11.19308>.
- [42] I.N.A.S.B. Borges, L.A. Reis, J.B. Ferreira, E.P. Grisi, F.R. Brito, A.B. Ferreira, Effect of aromatherapy massage with lavender essential oil: integrative review, *Id Line Rev. M. Psic.* 14 (51) (2020) 121–131, <https://doi.org/10.14295/idonline.v14i51.2558>.
- [43] H. Cardoso, D. Marin, N. Barros, C. Lugtenburg, *Lavandula angustifolia*: in the use of aromatherapy by massage with essential lavender oil in various pathologies, *Braz. J. Dev.* 7 (5) (2021) 46320–46340. <https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/29507>.
- [44] A.S. Nascimento, R.S.S. Tamiasso, S.F.M. Morais, J.R. Gnatta, R.N.T. Turrini, A.L.S.C. Calache, V.B. Poveda, Essential oils for healing and/or preventing infection of surgical wounds: a systematic review, *Rev. Esc. Enferm. USP* 56 (2022), e20210442, <https://doi.org/10.1590/1980-220X-REEUSP-2021-0442en> (spe).
- [45] G. Woronuk, Z. Demissie, M. Rheault, S. Mahmoud, Biosynthesis and therapeutic properties of *lavandula* essential oil constituents, *Planta Med.* 77 (1) (2011) 7–15, <https://doi.org/10.1055/s-0030-1250136>.