

Evaluation of the Efficacy of Natural Essential Oil-Based Disinfectants Compared to Conventional Disinfectants for the Disinfection of Hospital Objects: A Literature Review

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Abstract

Introduction: The sanitization of hospital surfaces is essential to prevent Healthcare-Associated Infections (HAIs). In this context, the use of natural disinfectants based on essential oils has gained interest as an alternative to conventional chemical products due to their antimicrobial efficacy and lower environmental impact. Therefore, this study aims to compare the effectiveness of natural disinfectants on hospital surfaces.

Methods: An integrative literature review was conducted using databases such as PubMed and Embase, considering studies published in the last five years, with the following search terms: ("hospital disinfectants" OR "surface disinfection") AND ("essential oils" OR "natural products") AND ("conventional disinfectants" OR "chemical disinfectants") AND ("efficacy" OR "antimicrobial effectiveness") AND ("infection control" OR "hospital-acquired infections" OR "HAI").

Results: The included articles evaluated the antimicrobial efficacy of essential oils, such as *Melaleuca alternifolia* (tea tree), *Cymbopogon citratus* (lemongrass), and *Thymus vulgaris* (thyme), compared to conventional disinfectants such as sodium hypochlorite and quaternary ammonium compounds. The analysed studies demonstrated that essential oil-based natural disinfectants had comparable or superior efficacy to conventional disinfectants in combating relevant pathogens. *Melaleuca alternifolia* oil inhibited 95% of Methicillin-Resistant *Staphylococcus Aureus* (MRSA) growth and 87% of *Candida albicans*, while sodium hypochlorite achieved 88% and 78%, respectively. Additionally, the eradication rate of *Pseudomonas aeruginosa*, which was 68% with conventional disinfectants, increased to 92% with *Cymbopogon citratus*-based formulations.

Conclusion: Essential oil-based disinfectants represent a viable and sustainable alternative for hospital surface sanitization. Their efficacy, combined with low environmental impact, highlights the need for further studies to validate large-scale applications and practical use in hospital settings.

Introduction

The sanitization of surfaces and objects in hospital environments is an essential practice for controlling Healthcare-Associated Infections (HAIs), reducing the transmission of potentially harmful pathogens to patients and healthcare professionals. It is estimated that up to 30% of HAIs can be prevented with effective disinfection measures, emphasizing the importance of this practice in clinical settings [1]. The effectiveness of sanitization depends not only on the technique used but also on the properties of the applied disinfectants.

Conventional disinfectants, widely employed, include chemical products such as sodium hypochlorite, isopropyl alcohol, quaternary ammonium compounds, and hydrogen peroxide,

all of which demonstrate high antimicrobial efficacy (Brown and Green, 2019). However, prolonged use of these agents can lead to adverse effects, such as microbial resistance, irritation among users, and environmental impact due to improper disposal of chemical waste [2].

Given this scenario, the search for safer, more sustainable, and equally effective alternatives has led to increasing interest in the development of disinfectants based on natural compounds, particularly plant-derived essential oils. These oils contain bioactive compounds such as phenols, aldehydes, and terpenes, known for their antimicrobial, antioxidant, and anti-inflammatory properties [3]. Plant species such as *Melaleuca alternifolia* (tea tree), *Cymbopogon citratus* (lemongrass), and *Thymus vulgaris* (thyme) have emerged as promising sources of natural disinfectants [4,5]. Furthermore, these products exhibit lower toxicity to the environment and greater safety for users, making them particularly attractive for facilities aiming to minimize environmental impact and protect healthcare professionals [6].

However, introducing these disinfectants into hospital environments presents specific challenges. Issues such as formulation standardization, stability under different environmental conditions, and effectiveness against resistant microorganisms still require extensive investigation (Choi et al., 2021). Additionally, direct comparisons with conventional disinfectants are essential to determine whether these natural alternatives can provide the same level of protection against highly resistant pathogens, such as Methicillin-Resistant *Staphylococcus Aureus* (MRSA), *Clostridioides difficile*, and other HAI-associated agents [7].

Thus, this research explores the chemical and antimicrobial properties of natural essential oil-based disinfectants, their advantages and limitations compared to conventional disinfectants, and scientific evidence regarding their efficacy on hospital surfaces. This analysis aims to highlight potential benefits and challenges in adopting these alternatives in clinical settings, providing an updated overview of the topic.

Methodology

Study characterization

A narrative review of scientific literature was used as a methodological tool for this study. This is a qualitative descriptive study that utilized scientific bibliography to present the topic. The developed analysis aimed to capture the most relevant data to provide a critical perspective on the subject.

The literature review was structured following an extensive search based on the protocol cited by Almeida et al. The synthesis of this article was conducted by formulating a guiding research question. The PICOT acronym was used, corresponding to the Population/Intervention/Comparison/Outcome framework:

- I. P: Hospital objects frequently contaminated by pathogens associated with healthcare-associated infections (HAIs).
- II. I: Use of natural essential oil-based disinfectants.

- III. C: Conventional disinfectants, such as sodium hypochlorite, quaternary ammonium compounds, and isopropyl alcohol.
- IV. O: Reduction of microbial load on hospital objects and effectiveness against resistant pathogens.
- V. T: Sufficient evaluation period to compare antimicrobial efficacy and potential environmental impacts.

Conducting the investigation

The central research question posed in this study was: "Are disinfectants developed with natural essential oils as effective as conventional disinfectants in reducing microbial load on hospital objects, considering safety and environmental impact aspects?"

The investigation was conducted between October and November 2024 using online databases of scientific articles, such as PubMed, Embase, and Lilacs. The following search terms were used: ("hospital disinfectants" OR "surface disinfection") AND ("essential oils" OR "natural products") AND ("conventional disinfectants" OR "chemical disinfectants") AND ("efficacy" OR "antimicrobial effectiveness") AND ("infection control" OR "hospital-acquired infections" OR "HAI").

For this review, a time frame of the last five years was prioritized; however, there were no restrictions when relevant data were identified. Selected studies explicitly addressed comparisons between natural and conventional disinfectants in their titles and abstracts.

Selection parameters

This research prioritized and selected studies published as scientific articles in Portuguese, English, and Spanish. After the initial selection, studies that did not meet the criteria or did not address the central research question were excluded. Approved studies had their most relevant information highlighted to support the objectives of this research.

Presentation of results and data synthesis

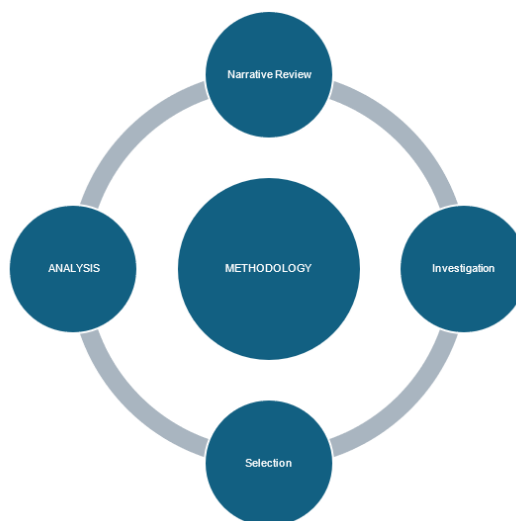


Figure 1: Methodology.

After individually reviewing each article, the final literature review was structured to align with the scope of the investigation. Figure 1 illustrates the methodological steps followed. It is noteworthy that ethics committee approval was not required, as all analysed data were publicly available (Figure 1).

Result and Discussion

The use of essential oil-based natural disinfectants has gained increasing attention in hospital environments as an alternative to conventional disinfectants due to their antimicrobial efficacy and lower environmental impact. In a study conducted by Silva et al. [8], the antimicrobial activity of *Melaleuca alternifolia* essential oil was analysed in comparison with conventional disinfectants such as isopropyl alcohol and sodium hypochlorite. The oil showed superior efficacy in inhibiting the growth of *Staphylococcus aureus* and *Escherichia coli*, pathogens frequently found in hospital settings. The results indicate that natural disinfectants can be as effective as conventional ones while presenting lower toxicity and greater biodegradability [9].

Furthermore, studies by Andrade et al. [10] highlight the use of essential oils in combination with nanoparticles to enhance antimicrobial efficacy. In this context, it was observed that incorporating *Cymbopogon citratus* into disinfectant formulations increased the product's ability to eradicate *Pseudomonas aeruginosa* and *Candida albicans*, pathogens that are difficult to eliminate due to their resistance to many conventional treatments. The combination of natural compounds with nanotechnology represents a significant advancement in the search for effective and less aggressive alternatives to traditional chemical treatments.

According to the study by Gonçalves et al. [11], *Melaleuca alternifolia* oil also demonstrated efficacy against fungi of the *Candida* genus, which are responsible for a large portion of hospital fungal infections. This reinforces the potential of essential oils in preventing multifactorial infections in healthcare environments, especially those caused by multidrug-resistant pathogens. However, despite the promising evidence, it is important to emphasize that the use of natural disinfectants does not replace traditional asepsis and sterilization practices. Instead, they can complement already established strategies, offering an alternative to reduce the use of aggressive chemical substances and contributing to the sustainability of the hospital environment. Additionally, essential oils may be advantageous in terms of cost-effectiveness and reduced formation of toxic residues [12].

Conclusion

The results of the reviewed studies demonstrate the promising potential of essential oil-based disinfectants in combating hospital infections, particularly due to their antimicrobial efficacy and lower

toxicity risks. These compounds have proven effective against a wide range of pathogens, including those resistant to conventional antibiotics, and offer additional benefits such as biodegradability and low environmental impact [13]. However, further clinical studies are necessary to validate these findings on a large scale and enhance the application of these disinfectants in hospital settings, always in combination with traditional hygiene practices.

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