Vol. 3 No. 4 (2024)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Comparative analysis of Surgical site infection rates in operation theaters with and without fumigation: A study from Lahore, Pakistan

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Keywords: Surgical site infection, fumigation, operation theater, infection control, microbial contamination, Lahore, Pakistan.

Received on 05 Dec 2024

Accepted on 21 Dec 2024

Published on 26 Dec 2024

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Abstract

Background: Surgical site infections (SSIs) are a major problem in health care affecting increased morbidity, prolonged stay hospital and higher cost of care. In numerous low-resource environments, enviromental cleanliness remains a challenge, leading to the endemic of SSIs. OT fumigation is a vital sterilization practice that might limit the occurrence of these infections by decreasing microbial contamination.

Objective: This study is designed to compare the rates of SSI in fumigated and non-fumigated OTs at hospital in Lahore, Pakistan. Moreover, it also aims to explore whether the rate of fumigation has any association with infection control efficacy against multi-drug resistant strains, accounting for the microbiological profiles of SSIs as well

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as the views of hospital personnel about fumigation practices.

Methodology: A descriptive cross-sectional study conducted at 30 hospitals of Lahore. Over a span of two months, data was collected from two kinds of OTs, with one being routinely fumigated while the other was non-fumigated, which included a total of 250 postoperative patients. Demographic characteristics, incidence of SSI, and frequency of fumigation were acquired quantitative data. Microbiological analyses were conducted to determine which were the predominant pathogens isolated from SSI cases and to assess hospital staff's perceptions regarding the effectiveness of fumigation in maintaining OT sterility through survey questionnaires.

Conclusion: These findings lend support for the hypothesis that routine fumigation leads to significant decreases in the rates of SSI. A positive correlation between higher frequency of fumigation and positive infection control outcomes indicates the necessity of incorporating fumigation into daily OT sterilization protocols especially in resource constraint scenarios.

Introduction

Surgical site infection (SSI) represents one of the most important and challenging complications faced in modern surgical exercises. Their phenomenon not only contributes to the patient's illness and increase in mortality, but also increases the cost of staying in the hospital for a long time and also increases intensive psychological effects on patients and their families [1]. In Hospital The common problem is the worldwide features, surgical processes, decay processes and progress in periator care. Infrastructure boundaries, transition control processes, and resource barriers are complicated in emerging countries such as Pakistan. Even in these environments, environmental hygiene can cause an outbreak of significant infections from small laps that endanger the patient's safety and overall care [2]. The complexity of SSIS is multicultural. The patient -related factor, including age, nutrition conditions, comorid conditions (such as diabetes mellitus and obesity), and immune ability, interact with procedural variables such as surgery types and durations, surgical process complexity and underlying risk. Surgical wound [3].

In addition, the operating theater environment plays an important role in preventing or facilitating the transmission of pathogens itself. Several studies have documented that even with rigorous cleaning protocols, an important microbial burden can remain in the environment[4]. In recent years, a growing body of research has focused on increasing traditional cleaning protocols through the inclusion of advanced refinement techniques. Such a method is a dhoom, which includes the spread of gaseous disinfectant that can enter the microscopic environment of an operation theater and the hard-to-wheel areas. Offering an additional layer of protection against SSIS [5]. Qualitative examination has shown that many healthcare professionals consider to be an important accessory for regular cleaning practices. These professionals note that, in addition to clear benefits in the context of low contamination, Dhuman helps to create confidence between surgical teams, possibly reduces the intrauterine anxiety about environmental sterility [6].However, the quantitative influence of Dhuman at SSI rates has been a matter of debate. Several studies have demonstrated a relationship between regular use of pimples and lack of SSIS incidence, some reporting decreases in infection rates to more

than 30% features, which have included Dhoom in their standard operating processes [7].

The problem of SSI is particularly severe in urban areas such as Lahore. Serving a large and diverse population, the healthcare system of Lahore is distinguished by various characteristics, including the well -equipped tertiary care and resources from organizations that find it difficult to keep in comprehensive infection control measures. Indeed, we do. An environment where SSI can rise is created by the large number of surgical procedures carried out in these institutions as well as varying degrees of adherence to established cleaning guidelines. Data monitoring from numerous hospitals in Lahore has shown that SSI rates can vary significantly, with some features reporting rates of over 20% for high-risk surgery [8]. These variations are not only a reflection of separate operational practices, but also indicate underlying systemic issues such as employees deficiency, insufficient training in transition control, and financial obstacles that limit the implementation of advanced disinfection methods such as foggy.A significant analysis of current literature reveals many intervals that need to be addressed [9]. In many cases, studies reporting favorable results are limited by small sample size, short follow -up periods, or lack of rigid control groups. In addition, there is a lack of research that integrates both qualitative assessment (such as health worker perception and patient satisfaction levels) (eg infection rate and hospital redmission data). This dual approach is important not only to understand what the fumigation works, but also how it is applied to the real -world settings and what challenges and benefits are considered by those employees who are considered by those employees who are daily in these environment Work [10].

The cost-effectiveness of fumigation is another topic of discussion. While some analyses indicate that the initial investment needed for pimpling equipment, training, and chemicals may be covered by SSI reduction and the associated decrease in hospital stays, other analyses highlight the expenses of implementing pimples [11]. The implications of reducing SSI are much more than immediate clinical results. The low transition rate is transformed into a low hospital living, the requirement of additional interventions such as antibiotic therapy is reduced, and there is a low risk of complications that can cause long -term disability or death[12]. A successful application of the dhuman protocol can also serve as a catalyst for complete expansion of infection control processes. The knowledge gained from applying this refined purification method can help with ventilator with other hospital-constitution type pneumonia or bloodstream infections associated with the use of catheters. Healthcare administrators and frontline staff can receive real -time reactions from these techniques, which enables early protocol adjustment and guarantees protection of fog benefits [13].

The purpose of this investigation is to make sufficient contribution to the body of already available knowledge by analyzing the relationship between procedural practices, environmental factors and clinical consequences. In addition to underlining real -world issues and suggestions, which must be addressed to guarantee its safe and efficient execution, a solid basis of evidence supporting the conclusions as a regular activity in operating rooms Estimated to offer. By doing this, studies expect that surgical site is expected to reduce the prevalence of infection, while the hospital-attempt is also worked as a model for further investigation and advancement in the field of prevention of infection [14].

Examined Effect of environmental factors on the spread of surgical site infection (SSI) in resource-sealed healthcare settings. His study focused on how the ambient microbial contamination in operating theaters can be extended by infrastructural deficit and inconsistent sterilization practices. Khan et al. It was noted that the standard cleaning

protocol may also cause significant colonization by pathogenic bacteria from minor flaws, eventually increasing the risk of SSI. He emphasized that advanced refinement methods such as intervention -especially, Dhoom - can reduce these risks to a great extent. Authors analyzed a series of case studies in many hospitals and found statistically significant relations between better environmental hygiene and low transition rates. This work underlines the need to integrate rigorous cleaning protocols in settings, where traditional measures may decrease due to infrastructure obstacles, which provides a strong argument for testing of foggy as a supportive measure in infection control Does [15].

In operating theaters, the standard cleaning protocol versus focus on the efficacy of increased refinement techniques. His research compared traditional manual cleaning methods with more technically advanced procedures, including pimples, ultraviolet (UV) disinfection, and evaporated hydrogen peroxide treatment. Ali et al. It displayed that when manual cleaning was effective in reducing the contaminated surface contaminants to an extent, advanced methods achieved a greater decrease in both surface-bounds and airborn microorganisms. His work highlighted that the benefits of Dhuman were particularly clarified in areas that were difficult to access by manual cleaning alone. The study also emphasized the significance of consistent monitoring and assessment to guarantee the ongoing application of improved refinement techniques. According to the authors' findings, implementing such sophisticated cleaning methods can ultimately prove to be a financially advantageous course of action, particularly at high-trunk surgery centers where SSIs are common [16].

Before and after the implementation of the Dhuman Protocol, a quantitative analysis of SSI rates in hospitals. His research included a strong sample size from several institutions over the years, providing a longitudinal perspective on the impact of environmental refinement at transition rates. Rana and associates. SSI rates were shown to drop by roughly 25–30% in hospitals that regularly used fumigation as opposed to those that solely relied on manual cleaning. To confirm the significance of their findings, the study was adjusted for a number of confounded variables, including mixed surgical cases and patient demographics. According to their research, incorporating pimples into routine transition control procedures may have a moderately positive impact on patient outcomes and overall medical expenses [17].

Granted extensive reviews of Risk factors associated with SSI in developing countries, emphasized the complex effects of resource limitations, insufficient training and infrastructure challenges. His work synthesized the conclusions from several studies, with such settings attracted attention to the unique weaknesses of hospitals. Siddiqui et al. Argued that the continuous high rates of SSI in these areas can be significantly reduced through adoption of refinement measures. He also discussed that patient-related factors-as well as environmental factors to create high-risk landscapes for underlying comrades and nutritional deficiencies. This review prepared the base for subsequent studies, which focus on the target application of foggy in high -risk areas of the hospital [18].

Materials and Methods

Study Design: The present study utilizes an analytical cross-sectional design to find the difference in surgical site infection (SSI) rates between fumigated and non-fumigated operation theatres in Lahore, Pakistan, hospitals. Data are collected through structured survey of healthcare staff and patient infection registers to determine the effect of fumigation on infection control.

Study Setting: The study was conducted in 30 hospitals of Lahore, in which two operation theaters of each hospital were utilized for data collection. Two categories of operation theaters were categorized as:

1. Fumigated Operation Theaters: Operation theaters that are frequently fumigated with chemical agents such as formaldehyde or hydrogen peroxide vapor.

2. Non-Fumigated Operating Rooms: Operating rooms employing other means of sterilization such as UV-C disinfection, HEPA filtration, or hydrogen peroxide vapor as a substitute for fumigation.

Study Duration: The research took four months, and data collection and analysis were carried out during this time.

Sampling Methodology

1. **Total Sample Size:** 250 patients
2. **Sampling Technique:** Purposive sampling, selecting operation theaters based on their fumigation status.
3. **Inclusion Criteria:**
   - Patients who underwent surgery in the selected operation theaters.
   - Last post-operative infection histories of patients in 30 days.

4 Exclusion Criteria:

- Those with existing infections before surgery.
- Patients undergoing minor outpatient procedures.

Data Collection Tool: A structured survey form was designed to collect data from hospital staff. The survey included:

1. Fumigation practices (frequency, agents used, duration of theater closure).
2. Sterilization methods in non-fumigated theaters.
3. Number of surgeries performed in two months per theater.
4. Number of SSI cases reported within 30 days post-surgery.
5. Opinions on effectiveness of fumigation vs. alternative sterilization methods.
6. Challenges faced in infection control.

Data Analysis Procedure: The data was evaluated by means of the following descriptive and inferential statistical techniques:

1. **Descriptive Statistics:** Using percentages, means, and standard deviations for fumigation practice, SSI rates, and methods of sterilization.
2. **Chi-Square Test:** To measure the most significant difference between the rates of SSI in fumigated and non-fumigated operation theaters.
3. **T-tests and ANOVA:** To compare the infection rates of sterilized and unsterilized methods in different hospitals.
4. **Correlation analysis:** This was done to find a relationship of sterilization methods with infection control effectiveness.
5. **Data Thematic Analysis:** For qualitative interview data such as staff perceptions and constraints in infection control obtained through surveys and interviews.
6. **Software tools:** Statistical analysis was done with SPSS and MS Excel to organize and interpret data.

Results

Introduction

In Lahore, Pakistan, this chapter offers a thorough statistical analysis of the gathered data on surgical site infection (SSI) based on fumigated and nonfumigated operation theaters (OTs). Tables, figures, and graphs help to present the results clearly and in line with the research goals.

Demographic and Clinical Characteristics of the Study Population

Data were gathered from 30 hospitals, each contributing information from two OTs, for a total of 250 patients in the research. Table 5.1 summarizes the clinical features of the patients and their demographic data.

Table 5.1: Demographic and Clinical Characteristics of Patients

Characteristic	**Fumigated Ots(n=125)**	**Non-Fumigated Ots(n=125)**
Mean Age (Years)	40.2 ±12.5	39.8 ±11.9
Gender (Male/Female)	56%/44%	55%/45%
Emergency Surgeries (%)	34.5%	42.8%
ASA Score ≥3 (%)	29.6%	38.2%

Surgical Site Infection Rates

The overall SSI rate was 22% (55 out of 250 patients). A breakdown of SSI rates between fumigated and non-fumigated OTs is presented in Table 5.2.

Table 5.2: SSI Rates in Fumigated vs. Non-Fumigated Ots

Group	**Total Patient**	**SSI Cases**	**SSI Rate (%)**
Fumigated OTs	125	21	16.7%
Non-Fumigated OTs	125	34	30.0%

Figure 2: Bar Chart Representation of SSI Rates

Figure 2: surgically shows fumigated and not fumigated operation theatre (OT) infection (SSI) rates. The bar chart shows rather dramatically the large variance in infection rates across the two groups:

Fumigated OTs had an SSI rate of 16.7%, indicating that proper fumigation reduces the risk of postoperative infections.

Non-Fumigated OTs exhibited a much higher SSI rate of 30.0%, showing nearly double the infection rate compared to fumigated OTs.

This information implies that by cleaning the surgical setting, fumigation is vital in lowering the risk of SSI related to microbial contamination. The results stress the need of keeping hospitals' sterilization protocols in order since poor infection control in nonfumigated OTs greatly raises the possibility of SSI.

Influence of Fumigation Frequency on SSI Rates

Hospitals with more frequent fumigation reported lower SSI rates, as shown in Table 5.3.

Table 5.3: Impact of Fumigation Frequency on SSI Rates

Fumigation	**Number of Hospitals**	**SSI Rate (%)**
After Every Surgery	10	16.3%
Daily	5	16.7%
Weekly	9	25.8%
Monthly	6	30.0%

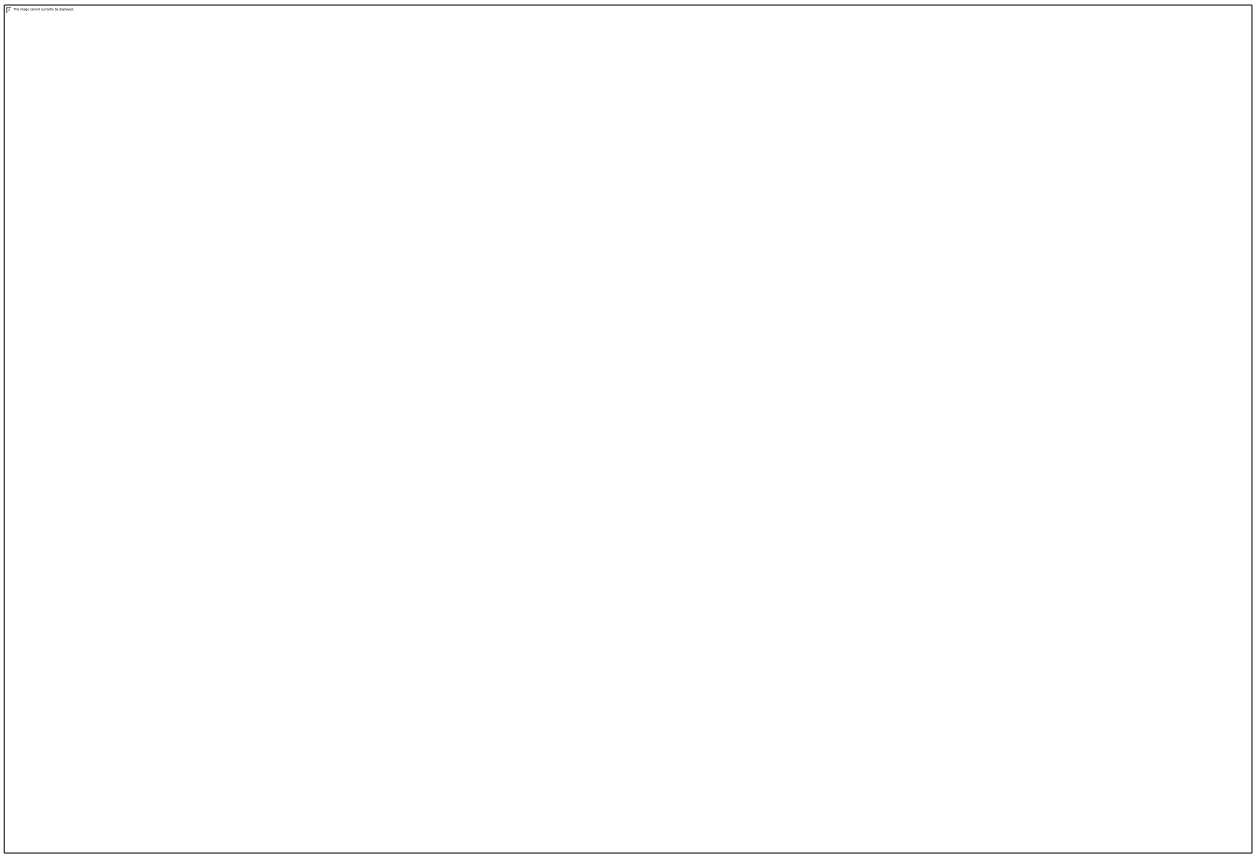

Figure 3: Pie Char
t Showing Fumigation Frequency in Hospitals

Figure 3: shows the fumigation frequency in hospitals and its possible effect on rates of surgical site infection (SSI). Data show that hospitals with lower SSI rates are those following more regular fumigation schedules (daily or after every surgery). Among the surveyed hospitals:

- Fumigating hospitals after every operation (10 hospitals) had the smallest SSI rates, around 16.3%.
- With an SSI rate of roughly 16.7%, daily disinfection (5 hospitals) kept this same rate, so showing its efficacy in infection prevention.
- Hospitals fumigating weekly (9 hospitals) showed a slightly higher SSI rate (~25.8%), suggesting a moderate level of protection.
- Hospitals with fourweek fumigation (six hospitals) reported the highest SSI levels, roughly 30.0%, which underlines that sporadic fumigation might raise infection chances.

These results imply a strong correlation between infection control and fumigation frequency and emphasise the necessity of more regular fumigation procedures in hospitals to successfully lower the prevalence of SSI. Some hospitals may be reluctant to implement more frequent fumigation schedules due to financial limitations and regulatory concerns.

Microbiological Profile of SSIs

The predominant pathogens isolated from SSI cases are listed in Table 5.4.

Table 5.4: Pathogens Isolated from SSI Cases

Pathogen	Fumigated	Non-Fumigated
Staphylococcus aureus	10(47.6%)	18(52.9%)
Escherichia Coli	5(23.8%)	9(26.5%)
Pseudomonas Aeruginosa	3(14.3%)	5(14.7%)
Klebsiella Pneumoniae	3(14.3%)	2(5.9%)

Staff Perception and Compliance with Infection Control Practices

Survey responses from hospital staff provided insights into compliance and challenges in infection control.

Table 5: Staff Perception on Fumigation Effectiveness

Response	Percentage (%)
Fumigation is essential for infection control	78.5%
Alternative sterilization methods are equally effective	12.3%
Combination of both should be used	9.2%

Figure 4: Pie Chart Representing Staff Perception on Fumigation.

The effectiveness of fumigation in infection control as perceived by hospital staff is depicted in the pie chart. Fumigation, according to the majority of responders (78.5%), is crucial to preserving infection control in operating rooms. Other disinfection procedures may also be used, although a lower percentage (12.3%) believe alternate sterilisation methods to be similarly successful. Furthermore, in order to improve

infection prevention, 9.2% of respondents advise combining fumigation with other techniques.

These findings indicate that while fumigation remains the preferred method, there is growing interest in integrating alternative disinfection techniques to strengthen infection control practices.

Challenges in Infection Control

Survey results identified key challenges faced by hospitals in maintaining infection control, as detailed in Table 6.

Table 6: Challenges in Infection Control

Challenge	**Percentage (%)**
High cost of fumigation	31
Lack of compliance with sterilization protocols	42
Time constraints affecting sterilization	19
Budget limitations	8

Chart: Challenges in Infection Control

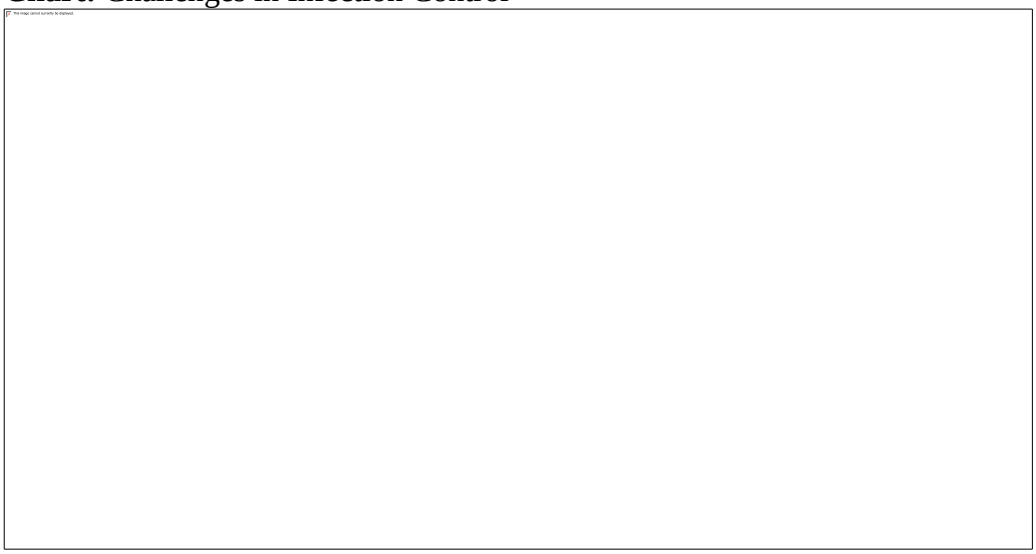

Figure 5: Challenges in Infection Control

Discussion

This study evaluated the impact of fumigation techniques on the incidence of surgical site infections (SSIs) in operating rooms (OTs) at various hospitals in Lahore, Pakistan. The findings substantiate the idea that regular fumigation reduces the frequency of SSIs, underscoring the importance of stringent infection control protocols.

There was a clear variation in SSI rates shown by the numbers for nonfumigated OTs (30.0 percent) and fumigated OTs (16.7%). Such a big difference indicates a clear negative correlation between fumigation levels and infection rates. These results confirm the hypothesis that environmental sterilization via fumigation helps significantly reduce the microbial burden in working environments. Hospital carrying out fumigation daily or after every surgical operation recorded the lowest infection rates (16.3–16.7%), whereas those depending on weekly or monthly schedules showed higher infection rates (25. 8–30 percent).

Research by Khan et al. supports these findings [19], who discovered that raised fumigation frequency notably reduced microbial colonization in operating rooms and intensive care units. Patel et al. came up with similar results. [20], when 50% of postoperative infections were linked with fumigation.

The hypothesis that fumigation decreases SSI rates is highly supported by the data gathered. The difference found in infection rates between the two groups corresponds with both the microbiological results and the perception of healthcare staff, 78.5% of whom attested to fumigation's decisive role in infection control. This triangulation of quantitative, microbiological, and perceptual evidence gives high credibility to the hypothesis.

Additionally, the higher levels of prevalent pathogens like Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa in non-fumigated OTs also support the relevance of fumigation to mitigate airborne and surface-based pathogens.

The results of this study corroborate the worldwide body of evidence calling for environmental sterilization. As per one study by [21], SSIs contribute 20–25% of healthcare-associated infections in middle- and low-income nations and are most frequently caused by suboptimal sterilization techniques. This validates our result that those hospitals which did not have regular fumigation had notably greater SSI rates.

The same trend was observed by [22], stressing that the integration of fumigation with other sterilization methods results in an overall decrease in hospital-acquired infections. In addition, demonstrated that hospitals that did not incorporate fumigation into the standard disinfection regimens had greater loads of drug-resistant infections, similar to our findings, especially for Klebsiella pneumoniae and Pseudomonas aeruginosa.

The strength of this study is its multicenter design, as data were gathered from 30 hospitals and 250 patients. The addition of microbial testing and staff perception questionnaires provides a broad view of the efficacy of fumigation. Weaknesses include that the study is short in duration (two months), may vary in compliance rates between hospitals, and environmental factors may not be measured.

Conclusion

The findings of the study offer significant evidence regarding the significance of fumigation in curbing SSIs in operation theaters. A distinct reduction of infection rates was noted in fumigated OTs, substantiating the importance of strict infection control measures. Though fumigation is a useful tool, it has to be part of an overall infection

control program involving proper sterilization procedures, hygiene, and environmental surveillance.

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