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# The Role of Perfumes in Surgical Wound Infections and Wound Healing: A Case–Control Study

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## ABSTRACT

A common complication of post-surgical procedures is surgical site infections (SSIs), and wound healing can be gravely affected by these SSIs. Perfumes are known for their use in personal hygiene; however, their role in surgical wound healing and SSIs has not been thoroughly studied. The present study explores the post-operative usage of perfumes in the context of SSIs and wound healing. This was a case–control study conducted in Hail City's Tertiary Care Hospital in Saudi Arabia for 9 months (April–December). The participants were adults undergoing clean elective plastic surgeries. Sixty-three patients were divided into case ( $n = 31$ ) and control ( $n = 32$ ) groups; the former used perfumes continuously post-operation and the latter refrained from them. All patients were observed and followed for three follow-up periods. Data on their demography, characteristics of wounds, patterns of perfume use (Arabic, Western and mixed), and infection outcomes were collected and statistically analysed using SPSS v22 at the significance level of  $< 0.05$ . In the present study, 49.21% of the total participants kept using perfume after their surgeries. The abdomen was the most common operative site in the control (16, 32%) and case (15, 48.38%) groups. The majority of the patients in the control (15, 46.87%) and case (21, 67.74%) groups had wound size  $> 15$  cm ( $p > 0.05$ ). Amongst 31 patients in the case group, most of the patients used mixed (Arabic and Western) perfumes (12, 38.7%,  $p = 0.65$ ). The frequency of perfume application varied, as most participants (11, 35.48%) reported using perfume twice daily ( $p = 0.49$ ). Meanwhile, 22 (71%) used 2–4 sprays per application ( $p < 0.05$ ). During the first follow-up, SSIs were only reported amongst patients in a case group (2, 6.45%,  $p = 0.14$ ). During the second follow-up, SSIs were observed in 3 (9.67%) and 2 (6.25%) patients in the case and control groups, respectively ( $p = 0.61$ ). Meanwhile, in the third follow-up, the SSI pattern was changed, and patients in the control group developed SSIs ( $p = 0.10$ ). Furthermore, a non-significant ( $p > 0.05$ ) association was observed amongst the risk factors, including age, comorbidities, perfume types, operation type, wound site and wound size with infection rates. SSIs are not significantly associated with perfume usage after surgeries, even though the rates were higher amongst the non-perfume users. Future research can explore the biochemical analyses of different perfume types and their psychophysiological effects on wound healing.

## 1 | Introduction

Infections that develop at the site of surgery are termed surgical site infections (SSIs), represent a major public health

challenge, and they are a common and potentially fatal complication of surgery, contributing to increased morbidity, mortality and healthcare costs [1]. They can cause pain, poor or delayed wound healing, extended hospital stays, and high

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### Key Points

- Environmental perfume exposure was evaluated in post-operative plastic surgery patients.
- No statistically significant association was found between perfume use and SSI rates.
- Infection rates were comparable between perfume users and non-users across follow-ups.
- Further research is needed to explore the effects of fragrances in SSI rates.

costs of hospitalisation. The time frame for SSIs to occur is also part of their definition, either within 30 days of the surgery or within 90 days, depending on the procedure [2]. SSIs can affect any part of the body, including the skin, tissues, organs or implants, depending on the depth and other organs where surgical instruments were used [3]. Approximately 0.5% to 3% of patients who underwent surgery experienced SSI or infection at the adjacent site of the surgery, and patients with SSI were usually hospitalised 7–11 days longer than non-SSI patients [4]. However, the prevalence of SSIs varies from country to country, surgical procedures, and quality of healthcare provided post-operation; for instance, in low and middle human development index countries, the prevalence of SSI can reach up to 17.8% [5]. Whilst in developed countries, like Australia, it can be 1.9% [6]. Meanwhile, in Saudi Arabia, SSI prevalence can vary according to the type of surgery; for instance, following caesarean section, prevalence can reach up to 3% [7]. Despite remarkable advances in aseptic techniques, surgical protocols and antibiotic prophylaxis, SSIs remain a threat to the safety and success of surgical interventions. Consequently, a broad range of procedural, patient and environmental factors have been investigated for a better understanding of their potential contributions to post-operative SSIs and wound healing outcomes.

Numerous risk factors for SSIs have been established over the years; some of the risk factors for developing SSIs are age, gender, obesity, diabetes, smoking, malnutrition, immunosuppression, surgical technique, dressing or wound care [8, 9]. Likewise, surgical associated risk factors are prolonged duration of surgery, nature of procedure, use of surgical drains or implants and hospital-associated risk factors, including a lack of infection prevention and control protocols and sterilisation practises, which can further increase the chances of SSIs [10]. However, less attention has been given to subtle environmental and behavioural exposures that could disrupt local wound environments or influence immune responses.

One such underexplored factor is the use of aromatherapy, which is the controlled use of plant essences for therapeutic purposes, including infections [11]. Aromatherapy uses fragranced products such as essential oils in the form of perfumes, candles and scented aerosol sprays [12]. These are unexamined elements of personal hygiene and social behaviour that may have biological implications in post-operative settings [12]. Meanwhile, the primary purposes of fragrances, which are used in cosmetics and home items, are to produce odours that are aesthetically

acceptable or to cover up offensive ones [13, 14]. Moreover, the synthetic sandalwood odorant proved to have wound healing properties by activating olfactory receptor OR2ATA [15]. The use of herbal fumigation (Vrana Dhoopan) has significantly reduced foul odour from wounds and has also been helpful in improving SSIs [16]. In addition, skin care products, including perfumes, may also influence the cutaneous microbiome, which plays a critical role in the maintenance of local homeostasis and defending against pathogens [17]. The skin colonising microbiota contributes to maintaining intact skin barrier and also plays a major role in the pathogenesis of numerous skin disorders, including wound healing [18]. However, it is important to understand their potential effects on wound healing. Fragrance has been found to lower stress indicators, such as peripheral pro-inflammatory cytokines and systemic inflammation markers [19]. Another presumed benefit of perfume is improved quality of life. Pleasant scents from perfumes can enhance one's overall quality of life during the wound-healing process [20]. Despite the alleged benefits of perfumes, they can nonetheless result in unpleasant side effects, such as allergic contact dermatitis, irritating contact dermatitis, photosensitivity and acute contact reactions [21].

The lack of definitive clinical evidence linking perfume use to SSIs has contributed to inconsistency in pre-operative instructions, and currently, evidence is sparse. This knowledge gap is clinically relevant, as even a modest increase in infection or delayed healing rates could have a significant impact on post-operative care protocols. Understanding the role of perfumes in the healing of wounds or SSIs could lead to the development of more evidence-based pre-operative guidelines, which could enhance patient safety. Therefore, we evaluated the impact of perfumes on developing SSIs and wound healing outcomes.

## 2 | Methods

### 2.1 | Study Design and Setting

This study employed a case-control design for the assessment of the association between the use of perfumes for hygiene purposes and the occurrence of surgical wound infections and wound healing. This study spanned 9 months from April 2023 to December 2023 amongst patients admitted to the plastic surgery department of a tertiary care hospital in Hail City, Kingdom of Saudi Arabia.

### 2.2 | Ethical Consideration

Ethical approval was obtained from the Hail University's Research Ethics Committee (research number: H-2022-377) and the General Directorate of Health Affairs Institutional Review Board, Hail Region (research number: H-08-L074). The research was performed according to the principles outlined in the Declaration of Helsinki regarding human participants' studies. Patients of this study were recruited during the pre-operative clinic by signing an informed consent after being informed about the study.

## 2.3 | Eligibility Criteria

For the selection of the patients, certain inclusion criteria were set, such as only adult patients aged > 18 years who underwent clean surgical procedures, like breast surgery, abdominoplasty, cyst excision or brachioplasty.

Likewise, exclusion criteria were also considered before the selection of the patients; paediatric patients aged < 18 years. Patients were excluded from the study if they were exposed to confounding variables, such as inadvertent perfume exposure in the control group or the use of herbal, complementary or alternative treatments during follow-up in the case group. Additionally, patients with pre-existing chronic skin conditions (e.g., eczema, psoriasis), uncontrolled comorbidities (e.g., active infections or immunosuppressive conditions), or those who underwent unplanned or emergency surgical procedures instead of clean elective surgeries were excluded. Further exclusions included patients using medications that could affect wound healing (e.g., high-dose steroids or chemotherapy agents) and those with incomplete or missing data records, such as demographic or wound-specific details.

## 2.4 | Sample Size

The sample size was calculated based on a 95% confidence level (CI), 80% study power and an expected infection rate difference of 15% between users and non-users of perfumes [22]. Convenience sampling was used to recruit eligible patients from a post-operative ward. The relatively small sample size may be due to the eligibility criteria, and patients were selected from a single centre, which may be the reason for the small sample size. Another intention was the identification of a potential association between perfume usage and infection outcomes rather than definite causal relationships. Despite the small sample size, the study ensured balanced representation between case and control groups, allowing meaningful statistical comparisons. After all calculations, 63 patients who underwent surgical procedures were included in the present study, and patients were divided into two groups: case group ( $n = 31$ ) and control group ( $n = 32$ ).

## 2.5 | Perfume Intervention

Perfume exposure was defined as the aerosolized spraying of commercial fragrance products into the air of the patient's room. Case group patients used either Arabic, Western, or mixed perfumes during the post-operation period for hygiene purposes; perfumes were not used directly on the wounds, bed linens or any medical equipment. Instead, it was dispersed into the surrounding room environment. Only spray form perfumes were considered, whilst other forms, like roll-on or cream perfumes, were excluded. No specific brands or fragrance types were standardised, as we aimed to assess the general effect of environmental perfume aerosols rather than a single product. Different frequencies of spraying (1 to > 3)/daily with 2 to > 4 sprays in a single application at a distance of 1–3 m from the bed of patients. Exposure was considered

**TABLE 1** | Demographical characteristics of included study participants.

Study variables	Frequency	Percentage	<i>p</i>
Age (years) (mean ± SD)	34.95 ± 9.99		
Age (years) categories			
< 30	21	33.3	< 0.05
30–50	37	58.7	
> 50	5	7.9	
Gender			
Male	19	30.2	0.002
Female	44	69.8	
Participants type			
Case (perfume used)	31	49.2	0.90
Control (no perfume used)	32	50.8	
Comorbidities			
Smoking/vaping	7	11.1	< 0.05
HTN	2	3.2	
Others (anaemia, asthma, diabetes, hypothyroidism, hyperlipidemia)	8	12.7	
No	46	73	
Medication used			
Levothyroxine	4	6.3	< 0.05
Herbal medication	3	4.8	
Others (multivitamins, metformin, OCP, antihypertensive drugs)	3	4.8	
No medication	53	84.1	
Operation performed			
Abdominoplasty	32	50.8	< 0.05
Brachioplasty	6	9.5	
Breast reduction surgery	12	19	
Breast tissue excision	5	7.9	
Cyst/mass excision	6	9.5	
Back lift	1	1.6	
Thigh lift	1	1.6	

significant if the patient remained in the room for at least 30 min after perfume application. Whilst no perfumes were used in the control groups. All patients were also provided with standard care for wounds.

## 2.6 | Data Collection

Data were collected using a structured questionnaire and clinical forms. Data collection tools used in this study consisted of two Google Form links, and a form was completed for each participant by the data collectors. One form contained the participant's demographic data, including name, age, gender, medical record number, comorbidities, medications used by the patient, and patient type (case or control). If the participant was a case, additional data were collected, including type of perfumes, frequency of usage, and number of sprays. The other form contained wound-specific data, including type of operation, wound site, wound size, number of wounds, day of follow-up, and signs of infection. Matching criteria were used for controls, including similar types of operation and wound-specific characteristics (site, size, and number of wounds).

## 2.7 | Follow-Up Protocol

After the operation, patients were followed up by two plastic surgery specialists and one plastic surgery consultant. Follow-up started from day one post-operative and a minimum of three follow-up visits from the operation date.

## 2.8 | Statistical Analysis

SPSS version 22 was used for all statistical analyses. To summarise participants' characteristics, descriptive statistics were used to summarise participant characteristics, including frequency and percentage distributions for categorical variables such as perfume type, frequency of use and amount per application. To assess the association between perfume type and infection occurrence, a chi-squared test ( $\chi^2$  test) was performed, depending on expected cell

counts, to determine statistical significance. A  $p$ -value  $<0.05$  was considered statistically significant.

## 3 | Results

### 3.1 | Demographic and Clinical Characteristics of Patients

A total of 63 patients (32 in control and 31 in case group) were included in the study, with a mean age of  $34.95 \pm 9.99$  years and majority (37, 58.7%) aged between 30 and 50 years, followed by  $<30$  years (21, 33.3%) and minimal number of patients (5, 7.9%) were  $>50$  years, with a significant difference ( $p < 0.05$ ). Female patients predominated (44, 69.8%) than males (19, 30.2%), with a significant difference ( $p = 0.002$ ). Amongst the participants, 17 (26.98%) had one or more comorbidities, and 46 (73.02%) did not report any comorbidities ( $p < 0.05$ ). In addition, approximately 7 (11.1%) of participants reported smoking or vaping. Most patients significantly ( $p < 0.05$ ) did not use any medication (53, 84.1%), though a small proportion of the patients used levothyroxine (4, 6.3%), herbal medications (3, 4.8%) and 3 (4.8%) patients did use other drugs, including multivitamins, metformin, oral contraceptives (OCP), antihypertensive drugs (Table 1). The most common surgical procedures performed were abdominoplasty (32, 50.8%), followed by breast reduction (12, 19%), whilst least number of patients performed back (1, 1.6%) and thigh lifts (1, 1.6%), with a significant difference ( $p < 0.05$ ), as described in Table 1.

### 3.2 | Surgical Characteristics

The most common operative site was the abdomen in the control (16, 32%) and case (15, 48.38%) groups, followed by the breast (8, 25%; 8, 25.80%), upper arm (2, 6.25%; 3, 9.67%) and other sites including chest, arms, hands, thigh, wrist and back (3, 9.37%; 5, 16.12%), with a non-significant difference ( $p = 0.44$ ). The distribution of wound size also did not demonstrate any significant difference ( $p = 0.14$ ) amongst the control and case group patients. Meanwhile, the majority of the patients in both

**TABLE 2** | Characteristics of the surgical wound site and size amongst case and control groups.

Study variables	Control	Case	Total	$p$
Wound site				
Abdomen	16 (32%)	15 (48.38%)	31 (49.20%)	0.44
Breast	8 (25%)	8 (25.80%)	16 (25.39%)	
Forehead	3 (9.37%)	0 (0%)	3 (4.76%)	
Upper arm	2 (6.25%)	3 (9.67%)	5 (7.93%)	
Others (chest, arms, hand, thigh, wrist, back)	3 (9.37%)	5 (16.12%)	8 (12.69%)	
Wound size (cm)				
3–8	4 (12.5%)	4 (12.90%)	8 (12.69%)	0.14
9–12	4 (12.5%)	4 (12.90%)	8 (12.69%)	
13–15	9 (28.12%)	2 (6.45%)	11 (17.46%)	
$> 15$	15 (46.87%)	21 (67.74%)	36 (57.14%)	

control (15, 46.87%) and case (21, 67.74%) groups had wound size > 15 cm (Table 2).

### 3.3 | Perfume Usage Amongst Cases

Amongst 31 patients who used perfumes, amongst these patients, most of the patients used mixed (Arabic and Western) perfumes (12, 38.7%), followed by Western perfumes (11, 35.5%) and Arabic perfumes (8, 25.8%), with a non-significant difference ( $p=0.65$ ). The frequency of perfume application varied as most participants (11, 35.48%) reported using perfume twice daily, and 8 (25.8%) reported using it once per day ( $p=0.49$ ). In terms of the number of

**TABLE 3** | Perfume usage pattern amongst the participants in case group ( $N=31$ ).

Study variables	Frequency	Percentage	<i>p</i>
Types of perfume			
Arabic	8	25.8	0.65
Western	11	35.5	
Mixed	12	38.7	
Frequency of perfume used/day			
1	8	25.8	0.49
2	11	35.5	
3	7	22.6	
> 3	5	16.1	
Amount of perfume per time (sprays)			
< 2 sprays	1	3.2	< 0.05
2–4 sprays	22	71	
> 4 sprays	8	25.8	

sprays, 22 (71%) used 2–4 sprays per application and 8 (25.8%) used > 4 sprays per day ( $p<0.05$ ), as described in Table 3.

### 3.4 | Infection Outcomes Across Patients

During the first follow-up, infection was only reported amongst patients in a case group (2, 6.45%,  $p=0.14$ ). During the second follow-up, infection-related complications, like wound dehiscence, discharge, fever, pain, redness, swelling, tenderness and localised breast collection were observed in 3 (9.67%) and 2 (6.25%) patients in case and control groups, respectively. However, the difference was statistically non-significant ( $p=0.61$ ). Meanwhile, in the third follow-up, infection pattern was changed, and patients in the control group developed infection, such as red streaks from the wound, redness and discharge, wound dehiscence, abdominal seroma, mild left seroma, open wound, wound site pain, necrosis and generalised swelling, with a non-significant difference ( $p=0.10$ ). Overall, the infection rates in the first, second and third follow-up appointments showed an increasing trend, with rates of 3.17%, 7.93% and 17.46%, respectively; however, the difference between both groups was non-significant ( $p>0.05$ ) (Table 4).

### 3.5 | Association Between Demographic, Perfume Use, Wound Site, Wound Size and Infection Outcomes

Infection was more frequent amongst patients aged 30–50 years (7, 11.11%), whilst no infection was observed in patients aged > 50 years, with a statistically non-significant difference ( $p=0.56$ ). Regarding the comorbidities, most of the patients without any comorbidities (8, 12.69%) had infection, followed by smokers/vapers (2, 3.1%), with a non-significant difference ( $p=0.76$ ). Amongst perfume users, infection incidence was low and comparable across the types of perfumes: mixed (2, 6.45%), Western (1, 3.22%), whilst no infection was observed with Arabic perfumes ( $p=0.32$ ). Infection was more prevalent after abdominoplasty (6, 9.52%), breast reduction surgery (3, 4.76%) and breast tissue excision (2, 3.17%), with

**TABLE 4** | Summary of infection associated outcomes during follow-ups amongst case and control group patients.

Study variables	Control	Case	Total	<i>p</i>
Follow-up 1				
Infection	0 (0%)	2 (6.45%)	2 (3.17%)	0.14
No infection	32 (100%)	29 (93.54%)	61 (96.82%)	
Follow-up 2				
Infection (wound dehiscence, wound discharge, fever, wound site pain, redness, swelling, tenderness, discharge, left breast collection)	2 (6.25%)	3 (9.67%)	5 (7.93%)	0.61
No infection	30 (93.75%)	28 (90.32%)	58 (92.06%)	
Follow-up 3				
Infection (red streaks from the wound, redness, redness and discharge, wound dehiscence, abdomen seroma, mild left seroma, open wound, wound site pain, necrosis, generalised swelling)	8 (25%)	3 (9.67%)	11 (17.46%)	0.10
No infection	24 (75%)	28 (90.32%)	52 (82.53%)	

a non-significant difference ( $p=0.51$ ). Likewise, breast (5, 7.93%) and abdomen (5, 7.93%) sites were the most common sites of infection ( $p=0.40$ ). Concerning the wound size, most infections occurred in wounds  $>15$  cm (8, 12.69%), whilst smaller wounds (3–8 cm) had only one case with infection (0.71), as indicated in Table 5.

#### 4 | Discussion

This study explored the potential influence of perfume use on SSIs and wound healing outcomes in patients undergoing clean elective plastic surgery procedures. The findings showed after the last follow-up a higher rate of infection was observed amongst patients who did not use perfumes post-operatively; however, the difference was found to be statistically non-significant ( $p=0.10$ ). Moreover, the study found a non-significant association between age, comorbidities, the type of perfume used, type of operation, wound site, wound size and infection outcomes.

This non-significance may be due to the clean elective plastic surgeries, which inherently carry a low baseline risk of infection, thereby reducing observable differences attributable to the perfume intervention. Moreover, the low rate of infection may also be due to the strict aseptic surgical protocols and post-operative wound care, which reduced infection variability amongst the patients (both control and case), masking any minor effects of perfume exposure in the environment. Interestingly, none of the participants who used Arabic perfumes developed infections. Although this suggests a potentially safer profile for certain types of perfumes, the small sample size makes it difficult to draw definitive conclusions. Additionally, it is possible that the chemical composition of Arabic perfumes, often oil-based and containing fewer synthetic chemicals, may pose a lower risk of irritation compared to alcohol-based Western perfumes [20].

Furthermore, chemical and microbiological analysis would be necessary to substantiate this hypothesis. Besides perfume usage, surprisingly, patients with no comorbidities had higher SSIs than patients with smoking or other comorbidity conditions, and SSIs were found to be non-significantly associated. These unexpected findings may be due to the small sample size, which limits the statistical comparison. Moreover, patients with comorbidities, like diabetes, hypertension or smoking history, often receive closer post-operative monitoring and provide strict care, including more vigilant wound assessment and early antibiotic use, which may reduce the chances of SSI. On the contrary, in patients with no comorbidities might have been considered as lower risk, resulting in relatively less intensive care, which may result in the development of SSIs. In contrast, another study identified smoking as a risk factor and identified it as a major modifiable risk factor for poor wound healing because smoking impairs oxygen delivery to tissues, inhibits collagen synthesis and disrupts inflammatory and reparative processes essential for wound repair [23, 24]. Other factors, such as age, wound size, location and number, were not significantly associated with infection rates. These findings suggest that, under controlled surgical conditions, these variables might have less impact on outcomes than behavioural and environmental exposures, such as smoking and, potentially, fragrances. However, another cross-sectional study indicated that age had a significant association with SSIs

**TABLE 5** | Association between last follow-up infection outcomes with comorbidities, perfume used, surgical procedures, wound site and size.

Study variables	Infection	No infection	<i>p</i>
Age (years)			
< 30	4 (6.34%)	17 (26.98%)	0.56
30–50	7 (11.11%)	30 (47.61%)	
> 50	0 (0%)	5 (7.93%)	
Comorbidities			
Smoking/vaping	2 (3.17%)	5 (7.93%)	0.76
HTN	0 (0%)	2 (3.17%)	
Others (anaemia, asthma, diabetes, hypothyroidism, hyperlipidemia)	1 (1.58%)	7 (11.11%)	
No comorbidities	8 (12.69%)	38 (60.31%)	
Perfume used ( <i>N</i> = 31)			
Arabic	0 (0%)	8 (25.80%)	0.32
Western	1 (3.22%)	10 (32.25%)	
Mixed	2 (6.45%)	10 (32.25%)	
Operation types			
Abdominoplasty	6 (9.52%)	26 (41.26%)	0.51
Brachioplasty	0 (0%)	6 (9.52%)	
Breast reduction surgery	3 (4.76%)	9 (14.28%)	
Breast tissue excision	2 (3.17%)	3 (4.76%)	
Cyst/mass excision	0 (0%)	6 (9.52%)	
Back lift	0 (0%)	1 (1.58%)	
Thigh lift	0 (0%)	1 (1.58%)	
Wound site			
Abdomen	5 (7.93%)	26 (41.26%)	0.40
Upper arm	0 (0%)	5 (7.93%)	
Breast	5 (7.93%)	11 (17.46%)	
Forehead	0 (0%)	3 (4.76%)	
Others (chest, arms, hand, thigh, wrist, back)	1 (1.58%)	7 (11.11%)	
Wound size			
3–8 cm	1 (1.58%)	7 (11.11%)	0.71
9–12 cm	1 (1.58%)	7 (11.11%)	
13–15 cm	1 (1.58%)	10 (15.87%)	
> 15 cm	8 (12.69%)	28 (44.44%)	

[25]. Meanwhile, the concept that perfumes may improve quality of life and reduce stress, both of which could theoretically aid in healing, is supported by earlier evidence showing that pleasant odours can modulate emotional states and reduce systemic markers of inflammation [19, 26]. A case report also demonstrated that when the patient was supplemented with essential oil, the patient did not develop any infection [27]. Moreover, these perfumes are not only helpful in healing wounds, but they are also helpful in reducing pre-operative anxiety. In a randomised study, lavender essential oil was used as a perfume and inhaled by patients in addition to a standard of care, after inhaling, patients had significantly lower anxiety [28]. Aromatherapy with lavender essential oil also significantly reduced the daily intake of medication for post-operative pain [29]. Furthermore, essential oil from the tree (*Melaleuca alternifolia*) proved to have a promising efficacy in the healing of wounds [30]. A systematic review of five studies concluded that use of lavender oil as an aroma can be helpful in the healing of post-surgical wounds [31]. Meanwhile, when essential oils were used as a topical application for the healing of post-surgical wounds. This topical application improved the wound at the surgical site without any signs of infection [32]. Moreover, topical application of essential oils successfully decreased the wound surface area, and physicians were also satisfied with the wound appearance [33].

However, no psychometric or biomarker assessments were included in this study to validate such claims. A future randomised controlled trial focused on stress and cytokine level assessments could better address the interplay between psychological well-being, perfume use and wound healing. Finally, the limited scope of the study, including its single-centre design and small sample size, restricts generalizability. Additionally, exposure was determined from patient reports, nursing documentation and ward observations rather than through objective environmental monitoring, which could lead to misclassification and reporting bias. Furthermore, direct measurement of airborne fragrance compounds was not performed, which limits the ability to quantify true exposure levels. Moreover, variability in the perfumes brands, their chemical composition, room size and visitor behaviour was not accounted for, which may influence the concentration and persistence of perfume aerosols in the room. Due to reliance on self-reporting for perfume usage, bias is possible, especially in estimating the proximity of fragrance application to the wound site. The exclusion of patients using herbal or complementary treatments strengthens internal validity but limits the ability to assess potential synergistic or antagonistic interactions with perfumes. Future studies should employ a prospective or experimental design incorporating standardised exposure protocols, chemical analysis, and environmental monitoring to more accurately characterise exposure and firmly identify the causal relationship between SSIs and environmental perfume aerosols.

## 5 | Conclusion

This study found no statistically significant relationship between perfume usage and an increase in the risk of SSI in clean elective surgeries, although a higher infection rate was observed amongst non-perfume users. Surprisingly, patients with no comorbidities had increased infection risk; however, there was a

statistically non-significant difference. Future research should explore the chemical profiles of different perfume types and assess psychophysiological outcomes to further elucidate the potential dual role of perfumes in both enhancing quality of life and modulating wound healing.

## Declaration

The study was conducted in accordance with the Declaration of Helsinki.

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## Ethics Statement

This study was approved by the University of Hail's Research Ethics Committee (Ref: H-2022-377) and the General Directorate of Health Affairs Institutional Review Board, Hail Region (Ref: H-08-L074).

## Consent

All participants provided written informed consent prior to inclusion in the study.

## Conflicts of Interest

The authors declare no conflicts of interest.

## Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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