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# Comparison of the effect of surgical site skin preparation with povidone-iodine antiseptic at two different temperatures on the microbial load and surgical site infection in laparotomy patients: A randomised controlled trial

## Abstract

**Background:** Surgical site skin preparation is essential for reducing the skin's microbial load and preventing surgical site infection (SSI). Considering the importance of determining the effect of temperature on the antimicrobial property of povidone-iodine antiseptic, this study investigated the effect of povidone-iodine antiseptic at two different temperatures on microbial load and incidence of SSI in laparotomy patients.

**Method:** This study was a single-blinded, randomised, controlled trial conducted from April to July 2024 at two selected hospitals in Tehran (registration number: IRCT20240212060966N1). Laparotomy patients (N = 126) were randomly assigned to the control group (secondary preparation with 10% povidone-iodine at 22°C) and the intervention group (secondary preparation with 10% povidone-iodine at 35°C). The skin preparation was done in two stages (primary and secondary preparation). Both groups received the same primary preparation (7.5% povidone-iodine). Culture samples were collected before skin preparation, after the primary preparation and after the secondary preparation. A researcher-made checklist was also used to investigate the incidence of SSIs within 24 hours and 30 days after surgery. The data was analysed using Wilcoxon signed rank test, Mann-Whitney U test and Fisher's exact test.

**Results:** The microbial load after secondary skin preparation was significantly reduced in both the control ($p = 0.001$) and intervention ($p=0.003$) groups. However, there was no significant difference in microbial load before and after secondary skin preparation between the two groups ($p = 0.437$). The difference in SSI incidence between the two groups was not significant ($p = 0.164$).

**Conclusion:** Since there were no significant differences in microbial load and SSI between the two groups, it is recommended that povidone-iodine be used at room temperature for skin preparation.

## Introduction

Surgical site skin preparation involves meticulous cleansing and disinfection of the surgical site with antiseptic solutions[1]. It aims to reduce the microbial load on the skin, remove debris and apply antimicrobial agents to inhibit microbial growth during surgery[1,2]. Suboptimal skin preparation with an inappropriate antiseptic solution can lead to a high microbial load remaining on the skin. As a result, the remaining microorganisms on the skin surface enter the body through the surgical incision, which can lead to complications such as infection of the surgical site[3–5].

Surgical site infection (SSI) is the second most common type of health care–associated infection (HAI), accounting for 20–31 per cent of these infections[6–8]. Despite advancements in surgical techniques, SSI remains a prevalent complication following abdominal surgeries, with an incidence rate of 25 per cent[9,10]. SSI can severely impact a patient's physical and mental wellbeing, leading to additional surgeries, increased pain and higher medical costs, while also increasing the risk of other health care–associated infections[11,12]. Depending on its severity, the cost of each SSI case can reach as high as $3000[13]. According to studies, common microorganisms causing SSIs include coagulase-negative *Staphylococcus*, *Staphylococcus aureus* and *Escherichia coli* that are typically found in the skin's natural flora[14]. Hence, safe and effective antiseptic solutions are crucial for controlling and preventing SSIs[3].

Povidone-iodine is a widely used antiseptic for surgical site skin preparation in operating rooms[15]. It has broad-spectrum antimicrobial properties, capable of eliminating a wide range of pathogens responsible for health care–associated infections[15,16]. The effectiveness of antiseptics can vary at different temperatures; however, according to studies, povidone-iodine antiseptic is as effective at 32°C as it is at 25°C[15]. It can be stored at 37°C for up to six months without reducing its available iodine content[17].

Researchers have demonstrated conflicting evidence regarding the effect of the temperature of antiseptic solutions used for surgical site skin preparation on microbial load and the rate of SSI. So, various studies have been conducted to clarify the effect of temperature on the antimicrobial properties of the povidone-iodine solution and the best temperature for its use. In a randomised controlled trial (RCT) conducted by Gezer et al.[18], the effects of chlorhexidine and povidone-iodine antiseptics were compared at two different temperatures (25°C and 37°C). They found that the incidence of SSI was significantly lower in the povidone-iodine at 37°C group compared to the 25°C group[18]. However, no significant difference was observed between the two chlorhexidine antiseptic temperature groups[18]. Hu et al.[5] conducted an RCT comparing the disinfection effect of iodophor at two different temperatures (25°C and 36°C) for surgical site skin preparation. They found that the disinfection effectiveness was higher at the higher temperature (96% at 36°C compared to 81.33% at 25°C)[5].

Leung et al.[15], conducted a study investigating the effect of temperature on the bactericidal properties of 10% povidone-iodine in two in vivo and in vitro experiment stages. They found no difference in the bactericidal properties of povidone-iodine used at 25°C and 32°C[15]. Kılıç et al.[19], in their RCT, compared the effect of 10% povidone-iodine antiseptic at room temperature and 36°C on hemodynamics and the incidence of SSI and did not find a statistically significant difference in the incidence of SSI between the two groups. A comparative prospective in vitro study by Smock et al.[16] investigated the antimicrobial effect of skin preparation solutions at different concentrations and temperatures used in burn surgeries. They did not find a significant difference in antimicrobial properties between 10% povidone-iodine solution stored at room temperature (25°C) and at 40–42°C[16].

The evidence regarding the effect of the temperature of the antiseptic solution used for surgical site skin preparation on microbial load and SSI is limited. Additionally, it is essential to identify factors that can enhance the effectiveness of the povidone-iodine antiseptic solution, which could help control and reduce SSI. Therefore, the researchers conducted this study to help provide more evidence about how the temperature of the povidone-iodine antiseptic affects the microbial load of surgical site skin and SSI rate.

## Aim

This research aimed to achieve the following objectives:

1. to determine and compare the impact of surgical site skin preparation with povidone-iodine at room temperature and 35°C on the microbial load in patients undergoing a laparotomy
2. to determine and compare the effect of surgical site skin preparation with povidone-iodine at room temperature and 35°C on the SSI rate 24 hours and 30 days after surgery in patients undergoing a laparotomy.

## Methods

This randomised controlled trial study was conducted at Firouzgar and Hazrat Rasul Akram, two medical training centres affiliated with Iran University of Medical Sciences, in Tehran, Iran, from April to July 2024. The study included 126 participants who underwent a laparotomy, which involved making incisions in the abdomen or pelvis. The researchers randomly divided the participants into a control group (n = 63) and an intervention group (n = 63) using a computer-generated table of random numbers. Those with even-numbered assignments were placed in the control group, while those with odd-numbered assignments were placed in the intervention group.

The skin preparation was conducted in two stages – primary preparation, using 7.5% povidone-iodine, and secondary preparation, using 10% povidone-iodine. In the control group, the secondary skin preparation was performed using 10% povidone-iodine at 22°C; in the intervention group, the secondary skin preparation was performed using 10% povidone-iodine at 35°C. In this study, a single-blinding method was used to ensure that the participants were unaware of the antiseptic solution temperature used for them. However, the researcher and the surgical team were aware of the specific temperature of the antiseptic used for each patient.

The required sample size was obtained from the following formula:

$$n_1 = \frac{(r+1)}{r} \times \frac{\sigma^2 (Z_{1-\beta} + Z_{\alpha/2})^2}{(d)^2}$$

With a power analysis of 80 per cent ($Z_{1-\beta}$ = 0.84), the Type I error of 5 per cent ($Z_{\alpha/2}$ = 1.96), a 1:1 ratio of group size (r = 1), and the effect size (d/σ) of 50 per cent, the required sample size for each group ($n_1$) was estimated to be 63 individuals. Therefore, the total sample size across the two groups (intervention and control groups) was 126 individuals.

### Inclusion and exclusion criteria

The inclusion criteria for patient enrolment in this study were individuals aged 18 to 55, willing to participate, possessing at least a diploma as a minimum educational qualification, having a body mass index (BMI) of less than 35 and undergoing elective laparotomy surgery. The patient's level of education affects their understanding and adherence to surgical wound assessment instructions for recording SSI symptoms after discharge. Additional criteria included not having diabetes, no immune system deficiencies, no use of immunosuppressive drugs, no local or systemic infections, no history of allergies to povidone-iodine antiseptic and absence of severe skin rashes or lesions at the surgical site.

Participants who had used broad-spectrum antibiotics within one month before surgery were excluded due to possible effect on microbial load. Participants with urgent or contaminated surgeries, such as gastrointestinal tract perforations or peritonitis, and participants with colostomy, were excluded from the study due to the effect of these cases on the microbial load and the higher risk of infection. Participants who chose not to continue their participation were also not included in the study.

### Data collection tools

Data collection tools comprised a demographic characteristics form, which gathered information on the following variables: age, gender, marital status, education level, BMI and household income. The microbial load registration form included the results of microbial cultures from the skin of the surgical site before skin preparation, after primary preparation (7.5% povidone-iodine) and finally after secondary preparation (10% povidone-iodine at room temperature or 35°C). The form for recording the symptoms of SSI (based on symptoms by the Centers for Disease Control and Prevention) was designed by Amiri et al.[14] and consisted of presence or absence of a high fever (above 38.5°C / 101.3°F), chills, pain, redness, swelling at the incision site and pus with an unpleasant odour discharging from the surgical wound.

The data collection forms were edited based on the evaluations and corrective comments of ten faculty members and experts in the field, and the validity of the forms was examined. To verify the reliability of the SSI symptoms form, the researcher and one of her colleagues independently observed the surgical sites of ten participants who underwent laparotomy after the surgery. They recorded the symptoms of SSI in the mentioned form. Then, the results were compared for reliability verification, and the similarity of the results was approved.

### Microbiological culture sampling

The researcher who performed skin preparation and sampling wore a sterile disposable surgical gown and gloves. The microbial culture samples were obtained from an approximately 10 cm x 10 cm surface of the skin of the abdomen at the surgical incision site and periphery. Microbial culture samples were collected at three stages: before

surgical site skin preparation, after the primary preparation and after the secondary preparation.

Sterile swabs were moistened with sterile normal saline and rubbed on the skin for 15 seconds in a circular motion to collect samples. Immediately, the swab was drawn over the entire surface of a sterile blood agar plate supplemented with sheep blood (5%). The microbial culture samples were kept cold and immediately transferred to the laboratory. The blood agar cultures were then incubated at 37°C for 24 hours. If no bacterial growth was observed, they were incubated for another 24 hours. After incubation, the bacterial colonies were counted under adequate illumination to ensure optimal visibility. Bacterial growth was quantified in terms of colony-forming units per unit of area (CFU/cm$^2$).

## Interventions

In both groups, a baseline bacterial sample was obtained from the skin at the surgical site before initiating the surgical site skin preparation. This work involved swabbing the skin with a sterile, saline-moistened swab and then drawing the swab over a blood agar culture medium, as previously described.

In both control and intervention groups, the surgical site skin preparation process was performed with povidone-iodine antiseptic after induction of anesthesia and proper positioning. The equipment used for skin preparation included sterile gowns and gloves, a sterile preparation set containing sponge forceps and gallipot, and simple sterile gauze pads (without radiopaque lines). The operating room temperature was 24°C.

The skin preparation process had two stages – primary and secondary. In both the control and intervention groups both stages of skin preparation were performed using a standard concentric circular technique, beginning at the centre of the proposed surgical incision site and progressing outward to the periphery with three separate simple sterile gauze pads. According to the Association of Surgical Technologists' recommendation[20] and in concordance with the manufacturer's instructions, the antiseptic solution was wiped away using a sterile dry cloth after five minutes.

The primary skin preparation consisted of applying 7.5% povidone-iodine solution at room temperature in both groups. After the primary skin preparation, a second bacterial sample was taken from the surgical site in both groups using the same method as was used for taking the baseline bacterial sample.

The secondary skin preparation consisted of applying 10% povidone-iodine solution. In the control group, the solution was applied at room temperature. In the intervention group the solution was applied at 35°C after the unopened plastic bottle of solution had been warmed in an electric thermostatic water bath for 30 minutes. The temperature of the pre-warmed solution was measured with a laser thermometer before use.

Finally, the third bacterial sample was obtained from the surgical site using the same method in both groups. The surgical site was then draped, and the surgical procedure was commenced. The culture samples taken from both groups were immediately transported to the laboratory for microbial load determination.

Twenty-four hours after surgery, the researcher and doctor changed the dressing on the surgical site for the first time. They carefully examined the surgical area for any signs of SSI and recorded their observations on the SSI symptoms form to document the symptoms.

Following the surgery, the patient received guidance on assessing and observing the surgical site. They, or their caregivers, were given the SSI symptoms form to track any potential signs of SSI that could appear within the first month (30 days) after surgery. This form enabled the patient to routinely check the surgical site and record any symptoms or issues of concern. The researcher followed up on the patient's condition for 30 days. At the end of 30 days, the researcher collected the form by making phone calls to participants, contacting the participants or their caregivers through messaging apps or visiting the clinics in person to meet participants at outpatient visits.

Finally, the microbial load and incidence of SSI of the control and intervention groups were compared. In this research, there was no missing data and all samples were present until the end of the follow-up process (see Figure 1).

## Statistical analysis

Data analysis was performed using SPSS version 16.0. Descriptive statistics were calculated to describe the characteristics of the participants, including mean, standard deviation, median, frequency, quartiles and percentages. The Kolmogorov-Smirnov test was used to evaluate the normality of the data.

Due to the non-normality of the microbial load data, the Wilcoxon signed-rank test was used to compare the microbial load between skin preparation stages in each group. The Mann-Whitney U test was

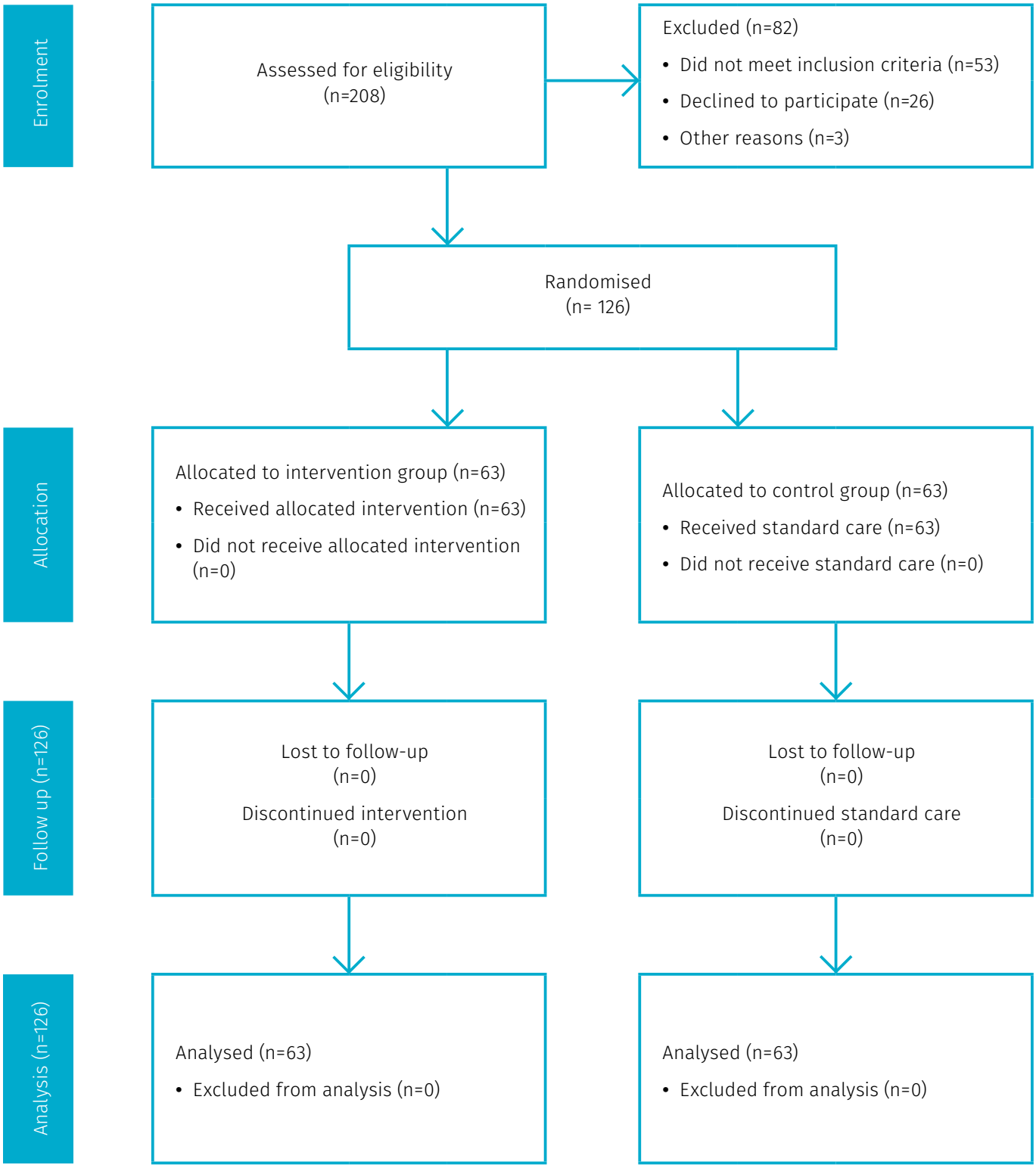


**Figure 1: CONSORT research flow diagram**

used to compare the microbial load of skin preparation stages between groups. Bonferroni correction was applied to the Wilcoxon and Mann-Whitney U tests and the significance level in these two tests was $p < 0.016$. Additionally, the microbial load results are presented in the tables as the median (first quartile and third quartile) due to the non-normality of the data. Fisher's exact test was used to compare the SSI rates between the control and intervention groups. The threshold for statistical significance in this test was $p < 0.05$.

## Ethical considerations

Ethical approval for this study was granted by the Research Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (code: IR.IUMS.REC.1402.1008). The study was also registered with the Iranian Registry of Clinical Trials Registration Centre (number: IRCT20240212060966N1). Before participation, participants received a clear explanation of the study's purpose and provided written informed consent. They were assured of their right to voluntary participation and withdrawal at any time. The research complied with the ethical standards outlined in the Declaration of Helsinki that guides medical research involving human subjects[21]. In the data analysis sheets, participants were assigned numerical labels ranging from 1 to 126; thus, participant information remained confidential. Archived data collection forms were securely stored offline only.

# Results

## Demographic characteristics

Table 1 shows the demographic characteristics of the 126 participants. Just over half of them (50.8%) were women, most (60.3%) were aged between 45 and 55 years, most (77.8%) were married, close to half (48.8%) had diploma degrees and most (78.6%) stated that they had enough income. The BMI of nearly half the participants (44.4%) was between 18 and 22 kg/m$^2$ and the average BMI of all participants was 28.4±3.72 kg/m$^2$.

## Microbial load

Bacteria grew in 62 (98.41%) of 63 cultures of samples taken before skin preparation in both the control group and the intervention group.

**Table 1: Demographic characteristics of participants in the control and intervention groups (N=126)**

| Characteristic | | Control (n = 63) | Intervention (n = 63) | Total (N = 126) |
|---|---|---|---|---|
| Age (in years) | mean±SD<br>median (min–max) | 42.08±10.35<br>43 (21–55) | 46.97±10.71<br>52 (18–55) | 44.52±10.77<br>47 (18–55) |
| Gender (frequency and percentage) | female | 33 (52.4%) | 31 (49.2%) | 64 (50.8%) |
| | male | 30 (47.6%) | 32 (50.8%) | 62 (49.2%) |
| Marital status (frequency and percentage) | married | 47 (74.6%) | 51 (81%) | 98 (77.8%) |
| | single | 16 (25.4%) | 12 (19%) | 28 (22.2%) |
| Education level (frequency and percentage) | diploma | 29 (46%) | 32 (50.8%) | 61 (48.4%) |
| | associate degree | 8 (12.7%) | 12 (19%) | 20 (15.9%) |
| | bachelor degree | 24 (38.1%) | 16 (25.4%) | 40 (31.7%) |
| | master's degree | 2 (3.2%) | 3 (4.8%) | 5 (4%) |
| Income (frequency and percentage) | sufficient | 51 (81%) | 48 (76.2%) | 99 (78.6%) |
| | insufficient | 12 (19%) | 15 (23.8%) | 27 (21.4%) |
| BMI (kg/m2) | mean±SD<br>median (min–max) | 25.3±3.99<br>25 (19–34) | 24.3±3.38<br>24 (19–34) | 28.4±3.72<br>24 (19–34) |

SD = standard deviation

Of the samples taken after the secondary stage of skin preparation, bacteria grew on nine of 63 (14.28%) cultures in the control group and six of 63 (9.52%) cultures in the intervention group. Eleven culture samples (six from the control group and five from the intervention group) were incubated for an additional 24 hours to detect bacterial growth not evident after the initial incubation.

The normal microbial load of skin can vary according to body region and skin type[22]. Bacterial counts can also differ depending on ecological and individual factors[22,23]. Approximately $4 \times 10^4$ CFU/cm$^2$ is the average bacterial count on human abdominal skin[24,25]. This study compared the microbial load present at three stages – before skin preparation, after primary skin preparation (with 7.5% povidone-iodine solution) and after secondary skin preparation (with 10% povidone-iodine at two different temperatures – room temperature and 35°C). Table 2 summarises these comparisons.

## Comparison of microbial load at skin preparation stages

In the control group, the median of the microbial load before skin preparation was 200, with a first quartile (Q1) of 50, a third quartile (Q3) of 1000 and a range of 2000 (min = 0, max = 2000). The median of the microbial load after primary skin preparation was zero, with Q1 of zero, Q3 of one and a range of 50 (min = 0, max = 50). After the secondary skin preparation using the solution at room temperature, the median of the microbial load was zero, with Q1 of zero, Q3 of zero and a range of 40 (min = 0, max = 40).

The microbial load in the control group after primary skin preparation was significantly reduced compared to before skin preparation ($W_1 = 0.00$, $P_1 < 0.001$). The microbial load after the secondary skin preparation was also significantly reduced compared to after the primary skin preparation ($W_2 = 13.50$, $p_2 = 0.001$). And the microbial load after secondary skin preparation was significantly reduced compared to before skin preparation ($W_3 = 1.00$, $P_3 < 0.001$).

In the intervention group, the median of the microbial load before skin preparation was 120, with Q1 of 32, Q3 of 700 and a range of 2000 (min = 0, max = 2000). The median of the microbial load after primary skin preparation was zero, with Q1 of zero, Q3 of zero and a range of 100 (min = 0, max = 100). The median of the microbial load after secondary skin preparation was zero, with Q1 of zero, Q3 of zero and a range of 30 (min = 0, max = 30).

The microbial load in the intervention group after primary

**Table 2: Comparison of microbial load at three skin preparation stages and using solution at two different temperatures (N=126)**

| | Microbial load (CFU/cm$^2$) median (first quartile to third quartile range) | | | | |
|---|---|---|---|---|---|
| Stage / Solution temperature | Before skin preparation | After primary preparation | After secondary preparation | Wilcoxon signed rank test (W) | p value (0.016) |
| room temperature (control, n = 63) | 200 (50–1000) | 0 (0–1) | 0 (0–0) | $W_1 = 0.00$<br>$W_2 = 13.50$<br>$W_3 = 1.00$ | **$p_1 < 0.001$**<br>**$p_2 = 0.001$***<br>**$p_3 < 0.001$*** |
| 35°C (intervention, n = 63) | 120 (32–700) | 0 (0–0) | 0 (0–0) | $W_1 = 0.00$<br>$W_2 = 20.50$<br>$W_3 = 0.00$ | **$p_1 < 0.001$**<br>**$p_2 = 0.003$***<br>**$p_3 < 0.001$*** |
| Mann-Whitney U-test (U) | U = 1877.00 | U = 1894.00 | U = 1895.00 | | |
| p value (0.016) | p = 0.599 | p = 0.572 | p = 0.437 | | |

$W_1/p_1$ = before skin preparation compared with after primary skin preparation, $W_2/p_2$ = after primary skin preparation compared with after secondary skin preparation, $W_3/p_3$ = before skin preparation compared with after secondary skin preparation

* It should be noted that due to the existence of non-zero data in the microbial load after primary and secondary skin preparation stages in both groups, despite the median and the first and third quartiles being zero, the ranking of the data for each stage in the Wilcoxon test was different. As a result, when these stages were compared, the difference was statistically significant.

skin preparation was significantly reduced ($W_1$ = 0.00, $p_1$< 0.001). The microbial load after the secondary skin preparation was also significantly reduced compared to after the primary skin preparation ($W_2$ = 20.50, $p_2$ = 0.003). And the microbial load after secondary skin preparation was significantly reduced compared to before skin preparation ($W_3$ = 0.00, $p_3$ < 0.001).

### Effect of solution temperatures on microbial load

The median microbial load before skin preparation in the control group was 200 (Q1 = 50, Q3 = 1000) compared to a median of 120 (Q1 = 32, Q3 = 700) in the intervention group; however, this difference was not statistically significant (p=0.599). After primary skin preparation, the median microbial load in the control group was zero (Q1 = 0, Q3 = 1) while the intervention group had a median of zero (Q1 = 0, Q3 = 0). Again, this difference was not statistically significant (p=0.572). Similarly, after secondary skin preparation, the median microbial load in the control group was zero (Q1 = 0, Q3 = 0) while the intervention group had a median of zero (Q1 = 0, Q3 = 0), and this difference was also not statistically significant (p=0.437). As a result, the difference in the microbial load before and after skin preparation was not statistically significant between the control and intervention groups.

### Effect of solution temperatures on surgical site infection

There was no difference between the control group and the intervention group in terms of SSI within 24 hours after surgery as there were no infections within that time in either group. In the 30 days after surgery, SSIs were detected in nine (7.1%) of the 126 participants – seven (11.1%) in the control group and two (3.2%) in the intervention group (see Table 3). However, this difference was not statistically significant (p = 0.164).

## Discussion

Surgical site infection is a critical and persistent challenge for health care professionals and the global health system, demanding evidence-based and comprehensive solutions. Appropriate surgical site skin preparation is crucial for preventing SSI. Understanding factors like antiseptic solution temperature can optimise the effectiveness of skin preparation, improving patient outcomes and lowering health care costs.

This study compared the microbial load present before skin preparation, after primary skin preparation (with 7.5% povidone-iodine solution) and after secondary skin preparation (with 10% povidone-iodine solution). The study also compared the microbial load and incidence of SSI after using skin preparation solution at room temperature (control group) and 35°C (intervention group).

According to our results, the microbial load was significantly reduced after secondary skin preparation compared to before skin preparation in both groups. Also, the microbial load after secondary skin preparation using solution at 35°C was not significantly different to the microbial load after secondary skin preparation using solution at room temperature. Based on our findings, using 10% povidone-iodine solution at 35°C rather than room temperature did not affect its antimicrobial properties, and this antiseptic solution could significantly reduce the microbial load of the surgical site skin at both temperatures.

Our findings add to the growing body of literature regarding antiseptic solution temperature in surgical site skin preparation and were consistent with most other studies. Leung et al.[15], in their two-stage in vitro and in vivo study, did not find a difference in the bactericidal properties of 10% povidone-iodine at 25°C and 32°C (0 CFU/plate after disinfection in both groups). Smock et al.[16], in their comparative prospective in vitro study, did not find a significant difference in the antimicrobial

**Table 3: Comparison of surgical site infection rates using solution at two different temperatures (N=126)**

| Solution temperature | Surgical site infection rate frequency (percentage) | | Fisher's exact test (FE) p value ( 0.05) |
|---|---|---|---|
| | During 24 hours after surgery | During 30 days after surgery | |
| room temperature (control, n = 63) | 0 (0%) | 7 (11.1%) | FE = 2.991 p = 0.164 |
| 35°C (intervention, n = 63) | 0 (0%) | 2 (3.2%) | |

efficacy of the 10% povidone-iodine solution stored at room temperature (25°C) compared to the solution stored at 40–42°C. Wistrand et al.[26] conducted an RCT investigating skin microbial colonisation after skin disinfection using preheated (36°C) and room temperature (20°C) chlorhexidine-alcohol solution in cardiac pacemaker implantation surgery. They reported no difference in the incidence of skin microbial colonisation – the proportion of participants with microbial growth was the same (28.6%) in both groups[26]. In contrast, an RCT by Hu et al.[5] showed that surgical site skin disinfection was more effective with the iodophor at 36°C (96%) compared to 25°C (81.33%).

With regard to the incidence of SSI 24 hours and 30 days after laparotomy surgery, we found the difference between the two groups was not statistically significant. In line with our results, an RCT by Kılıç et al.[19] found no significant difference in SSI rate between caesarean section patients who received skin preparation with 10% povidone-iodine at room temperature and those who received skin preparation using the solution at 36°C. Similarly, Wistrand et al.[26] did not find a significant difference in the incidence of SSI when comparing chlorhexidine-alcohol solution used at room temperature and 36°C. In contrast, Gezer et al.[18] reported that using povidone-iodine antiseptic at 37°C on surgery patients with malignant and premalignant gynaecologic conditions led to fewer SSIs than using it at 25°C. Patients with gynaecological malignancies are at a higher risk of developing SSIs due to factors such as older age, higher BMI and the presence of other health conditions[18].

Hypothermia can delay wound healing and create a suitable microenvironment for infection development by causing vasoconstriction and reducing tissue oxygenation[27–29]. Current evidence on warm disinfection to prevent hypothermia is limited, particularly regarding its effectiveness and patients' experiences during surgical site skin preparation[30]. Wistrand et al.[30] found that warm disinfection, using 38°C chlorhexidine, resulted in the skin losing less heat than using chlorhexidine at 20°C (-1.4°C after warm disinfection versus -2.5°C after room-temperature disinfection). Also, participants reported experiencing less discomfort after being disinfected with chlorhexidine solution at 38°C[30].

Hu et al.[5] reported that the body temperature of participants was higher after skin preparation using iodophor at 36°C than using it at 25°C (36.24°C after 36°C disinfection versus 35.67°C after 25°C disinfection). In addition, , fewer patients reported their skin feeling cold after skin preparation when the iodophor was used at 36°C than when it was used at 25°C (2.67% after 36°C disinfection versus 12.00% after 25°C disinfection) .[5] Although we did not observe a significant difference between the control and intervention groups regarding microbial load and incidence of SSI, our research outcomes add to the growing evidence into warm disinfection.

## Limitations

A limitation of this study was that the temperature of the 7.5% povidone-iodine solution could not be altered during primary skin preparation due to the effect of temperature change on the antiseptic solution's effectiveness. Another limitation of the study was the self-reporting of SSI occurrence by patients or their caregivers. In this study, the link between patient demographic variables and the methods of reporting the SSI was not investigated. Future research could examine these relationships to provide a more comprehensive understanding.

## Conclusion

No significant difference was found on the microbial load and incidence of SSI between using 10% povidone-iodine antiseptic at room temperature and using it at 35°C. Since warming the povidone-iodine solution is a precise, controlled process that requires time and energy, it is recommended to use the solution at room temperature for routine surgical site skin preparation.

## Competing interests

The authors have declared no competing interests.

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