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Contamination Of Pulse Oximeter and Decontamination Using Commercially Wipes

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التلوث بمقياس التأكسج النبضي وإزالة التلوث باستخدام المناديل التجارية

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Abstract:
This study investigated the contamination and decontamination of pulse oximeters using wipes saturated with 75% alcohol. The internal surfaces of pulse oximeter probes in intensive care units (ICUs) can serve as overlooked reservoirs for pathogenic microorganisms, potentially contributing to the high rates of hospital-acquired infections. A total of 108 swabs were collected before and after applying the alcohol-saturated wipes on 54 pulse oximetry probes, and the samples were sent to a microbiology laboratory for analysis. Before the application of the wipes, 50 out of the 108 swabs showed bacterial presence, resulting in a contamination rate of 92.6%. The identified bacteria included non-pathogenic Diphtheria (57.4%), Staphylococcus Hemolyticus (24.1%), non-hemolytic Streptococcus (7.4%), Klebsiella pneumoniae (5.6%), Escherichia coli (1.9%), non-lactose fermenting Gram-negative bacilli (3.7%), and Staphylococcus aureus (3.7%). Following the use of the alcohol wipes, the number of contaminated samples decreased to 36, reflecting a reduction rate of 66.7%. The remaining bacteria included non-pathogenic Diphtheria (44.4%), Staphylococcus Hemolyticus (13.0%), non-hemolytic Streptococcus (7.4%), Klebsiella pneumoniae (3.7%), with Escherichia coli, non-lactose fermenting Gram-negative bacilli, and Staphylococcus aureus eliminated entirely. The results indicate that the commercial wipes effectively reduced certain types of pathogenic bacteria, particularly Staphylococcus aureus, which was completely eradicated after alcohol application. Further studies are needed to evaluate the effectiveness of alcohol against specific bacterial species in isolation.

Keywords: Nosocomial infections; Pulse Oximeter; Wipes; ICU.

الملخص
تهدف هذه الدراسة إلى التحقيق في تلوث أجهزة قياس التأكسج (البلس أوكسي ميتر) وإزالة التلوث باستخدام مناديل مشبعة بالكحول بنسبة 75%. قد تُعتبر الأسطح الداخلية لمجسّات أجهزة قياس التأكسج في وحدات العناية المركزة (*ICUs*) من الأماكن المهملة كمخازن للميكروبات المرضية، مما قد يسهم في ارتفاع معدلات العدوى المكتسبة من المستشفيات. تم جمع 108 مسحات قبل وبعد استخدام المناديل المشبعة بالكحول على 54 مجسّاً، وتم إرسال العينات إلى مختبر الميكروبيولوجيا للتحليل. قبل تطبيق المناديل، أظهرت 50 من أصل 108 مسحات وجود بكتيريا، مما أسفر عن معدل تلوث قدره 92.6%. تشمل البكتيريا المحددة: الديفتيريا غير الممرضة (57.4%)، والمكورات العنقودية الانحلالية (24.1%)، والمكورات العنقودية (غير انحلالية) (7.4%)، وكليبسيلا الرئوية (5.6%)، والإشريكية القولونية (1.9%)، والعصيات سالبة جرام غير المخمرة (3.7%)، والمكورات العنقودية الذهبية (3.7%). بعد استخدام المناديل المشبعة بالكحول، انخفض عدد

العينات الملوثة إلى 36، مما يعكس معدل انخفاض قدره 66.7%. كانت البكتيريا المتبقية تشمل: الديفتيريا غير الممرضة (44.4%)، والمكورات العنقودية الانحلالية (13.0%)، والمكورات العنقودية (غير انحلالية) (7.4%)، وكليبسيلا الرئوية (3.7%)، بينما تم القضاء تمامًا على الإشريكية القولونية، والعصيات سالبة جرام غير المخمرة للاكتوز، والمكورات العنقودية الذهبية. تشير النتائج إلى أن المناديل التجارية كانت فعالة في تقليل بعض أنواع البكتيريا الممرضة، وخاصة المكورات العنقودية الذهبية، التي تم القضاء عليها بالكامل بعد تطبيق الكحول. هناك حاجة إلى مزيد من الدراسات لتقييم فعالية الكحول ضد أنواع البكتيريا المحددة بشكل منفصل.

الكلمات المفتاحية: العدوى المكتسبة من المستشفى، جهاز قياس التأكسج، مناديل تجارية مبللة، وحدة العناية المركزة.

1. Introduction

Pulse oximetry represents a non-invasive diagnostic modality employed to assess the oxygen saturation levels in the bloodstream, utilizing a compact, clip-like device [1,2]. Its application is prevalent in critical care environments such as emergency departments and hospitals, although it can also be utilized in home settings [3,4]. Notably, the internal surfaces of pulse oximeter probes are often overlooked as potential reservoirs for pathogenic microorganisms within intensive care units (ICUs), which may contribute significantly to the elevated rates of hospital-acquired infections [5]. Bacterial contamination in the ICU is a critical risk factor associated with the rising incidence of nosocomial infections. The efficacy of 70% alcohol in the disinfection of non-critical reusable medical equipment is well-documented; without adequate cleaning, certain bacterial strains may persist for durations ranging from 6 to 18 hours [6]. Each disinfectant exhibits distinct advantages and disadvantages that can influence its suitability for use in wipes. Alcohol, being inexpensive and readily available, facilitates efficient wetting of surfaces while exhibiting a rapid bactericidal effect. However, it lacks bacteriostatic properties and may pose relevant toxicity concerns [7].

A study conducted by Korb et al. [8] involved the collection of eighteen swab samples from both the internal and external surfaces of finger pulse oximeters by nursing professionals, resulting in the isolation of 51 bacterial colonies for antimicrobial susceptibility testing. The findings revealed that the nursing staff lacked training in the proper disinfection protocols for this equipment. Of the participants, eight carried the oximeters in their lab coats, while one transported them on a tray. There was a marked reluctance to disinfect the internal components of the devices due to concerns that 70% ethyl alcohol could potentially damage the sensors. In 17 of the samples, various bacterial genera were identified, with 17.7% exhibiting multidrug resistance to antimicrobial agents. This indicates that nursing professionals do not consistently adhere to proper disinfection practices for finger pulse oximeters [8]. Recently, the utilization of pulse oximetry has surged, particularly in light of the COVID-19 pandemic, thus heightening its susceptibility to contamination. Furthermore, conventional sterilization methods are often inadequate for these devices, facilitating the transfer of microbes between patients and contributing to the propagation of infections. Consequently, the primary objective of this study is to evaluate the efficacy of commercially available wipes saturated with 75% alcohol in eradicating pathogenic bacteria, as well as to isolate and identify pathogenic microorganisms from the internal surfaces of pulse oximeters.

2. Materials and Methods

Between June and August 2023, samples were collected from several hospitals in the western region of Libya, specifically Zawia Medical Center, Abu Surra Village Hospital, Sabratha Teaching Hospital, and the National Cancer Institute in Sabratha. To ensure the integrity of the samples and prevent contamination, the following standardized procedures were employed:

- Sample Collection: Sterile gloves were donned prior to handling the pulse oximeter. A cotton swab was used to meticulously wipe the inner surface of the device in a single direction, avoiding any back-and-forth motion. The swab was then placed into a labeled sterile tube, which was securely closed, and the corresponding sample number was recorded.
- Device and Hand Disinfection: A piece of commercial alcohol wipe was utilized to disinfect the external surface of the pulse oximeter. Another alcohol wipe was employed to sanitize the hands. After allowing the surfaces to dry, a second sample was collected using a fresh swab, which was labeled with the same sample number but marked with a plus sign.
- Sample Transport: The collected samples were transported to the microbiology laboratory at Zawia Medical Center and Alpha Laboratory for isolation and identification of microorganisms.

- Repetition of Procedures: The aforementioned procedures were replicated using a different pulse oximeter, assigning a new sample number.

On the first day, the samples were inoculated into Thioglycolate Broth and incubated for 48 hours at 37 °C. Thioglycolate Broth serves as a multipurpose, enrichment, non-selective, differential medium primarily utilized to assess the oxygen requirements of microorganisms. On the second day, all samples in Thioglycolate Broth were cultured on MacConkey agar, Blood agar, Chocolate agar, and Sabouraud agar, followed by incubation for 24 hours at 37 °C. Suspected bacterial colonies were observed and further identified using standard bacteriological procedures. The morphological characteristics of the colonies were recorded, and Gram staining was performed to determine the genera and species of the isolated bacteria via microscopic examination.

Results and Statistical Analysis

A total of 108 swabs were collected from 54 pulse oximeters, both before and after the application of alcohol wipes. The analysis revealed bacterial growth in 48 of the pulse oximeters, while 6 devices exhibited no bacterial contamination. To evaluate the results of this study, descriptive statistics were employed to analyze the data using the Statistical Package for the Social Sciences (SPSS, Version 27). The analysis included the generation of frequency tables, bar charts, and the application of the Chi-square test for goodness of fit. Table 1 illustrates the impact of 75% alcohol on the eradication of bacteria, detailing the various types of bacteria identified before and after the sterilization process.

Table 1: The impact of 75% alcohol on the eradication of bacteria.

Bacteria type	Before		After		P-value
	Positive	%	Positive	%	
NON-Pathogenic Diphtheria	31	57.4	24	44.4	0.345
Staphylococcus Hemolytic	13	24,1	7	13.0	0.180
Streptococcus (NON-Hemolytic)	4	7.4	4	7.4	0.999
Klebsiella Pneumonia	3	5.6	2	3.7	0.655
E. Coli	1	1.9	0	0.0	-
NLF Gram Negative Bacilli	2	7.3	0	0.0	-
S.aureus	2	3.7	0	0.0	-

Upon examining the results presented in Table 1, which delineates the impact of 75% alcohol on bacterial eradication, the following observations can be made:

- Bacterial Presence Pre-Application: Prior to the application of alcohol, various levels of bacterial positivity were recorded for each identified type.
- Post-Application Reduction: Following the application of alcohol, a general decrease in the number of positive bacteria was observed across most bacterial types, albeit with varying degrees of reduction.

To further elaborate, the P-values associated with the statistical analysis indicate the significance of the results. A P-value of less than 0.05 is conventionally regarded as statistically significant, implying that the observed changes are unlikely to occur by random chance. In this analysis, none of the P-values fell below 0.05, suggesting that the observed differences may be attributed to random variation rather than the intervention.

- Reduction in Specific Bacteria: For the bacterial types "NON-Pathogen Diphtheria" and "Staphylococcus Hemolytic," a marked reduction in the percentage of positive bacteria was evident after the application of alcohol. However, the P-values (0.345 and 0.180, respectively) indicate that these reductions may lack statistical significance.
- Minimal Changes in Other Bacteria: Regarding the bacterial types "Streptococcus (NON-Hemolytic)," "Klebsiella pneumoniae," "Escherichia coli," "Non-Lactose Fermenting Gram-Negative Bacilli," and "Staphylococcus aureus," either no changes or negligible changes in the percentage of positive bacteria were observed post-application of alcohol. The relatively high P-values for these types suggest that any differences noted are likely due to random chance.

i. NON-Pathogen Diphtheria

The analysis of bacterial types presents before and after disinfection with 75% alcohol reveals the following for "NON-Pathogen Diphtheria":

- Pre-Disinfection: There were 31 positive cases, accounting for 57.4% of the total sample.
- Post-Disinfection: Following the application of alcohol, the number of positive cases decreased to 24, representing 44.4% of the total sample.
- Statistical Significance: The P-value for this comparison is 0.345.
- Based on these results, it appears that the application of 75% alcohol had a discernible effect on reducing the number of positive cases of "NON-Pathogen Diphtheria."

However, since the P-value exceeds the conventional threshold of 0.05, we cannot confidently assert that this difference is not attributable to random chance. The graph presented in Figure 1 visually illustrates these findings, highlighting the reduction in positive cases of "NON-Pathogen Diphtheria" following disinfection with 75% alcohol.

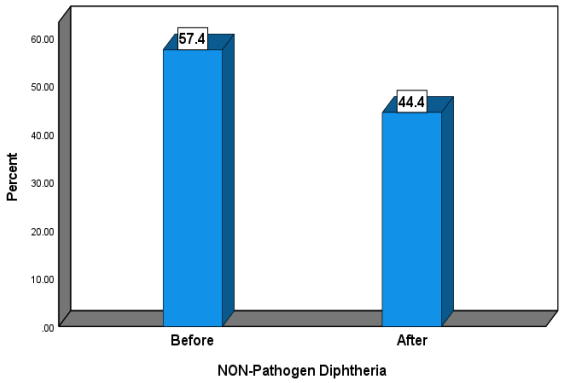

Figure 1: Effect of 75% alcohol on Non-Pathogenic Diphtheria**.**

ii. Staphylococcus Haemolyticus

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "" yielded the following results:

- Pre-Disinfection: There were 13 positive cases, representing 24.1% of the total sample.
- Post-Disinfection: Following the application of 75% alcohol, the number of positive cases decreased to 7, accounting for 13.0% of the total sample.
- Statistical Significance: The P-value for this comparison is 0.180, suggesting that the observed difference in the percentage of positive cases may not reach statistical significance.

These findings indicate that the application of 75% alcohol did have a discernible effect in reducing the number of positive cases of "S. haemolyticus." However, since the P-value exceeds the conventional threshold of 0.05, we cannot confidently conclude that this reduction is not attributable to random chance.

The graph presented in Figure 2 visually illustrates these results, highlighting the reduction in positive cases of "S. haemolyticus" following disinfection with 75% alcohol.

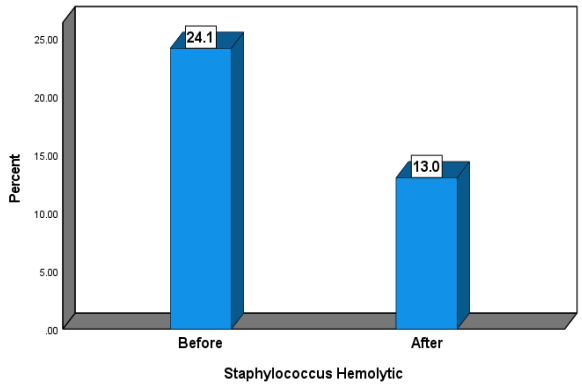

Figure 2: Effect of 75% alcohol on Staphylococcus haemolyticus.

iii. NON-Hemolytic Streptococcus

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "NON-Hemolytic Streptococcus" yielded the following results:

- Pre-Disinfection: There were 4 positive cases, representing 7.4% of the total sample.
- Post-Disinfection: After the application of alcohol, the number of positive cases remained unchanged at 4, accounting for 7.4% of the total sample.
- Statistical Significance: The P-value for this comparison is 0.999, indicating that the observed difference in the percentage of positive cases is not statistically significant.

These findings suggest that the application of 75% alcohol did not have a noticeable effect on the number of positive cases of "NON-Hemolytic Streptococcus." Notably, most invasive isolates of Streptococcus are β-hemolytic (55), which further underscores the limited impact of the alcohol treatment in this context. The graph presented in Figure 3 illustrates these results, demonstrating the lack of change in the number of positive cases of "NON-Hemolytic Streptococcus" following disinfection with 75% alcohol.

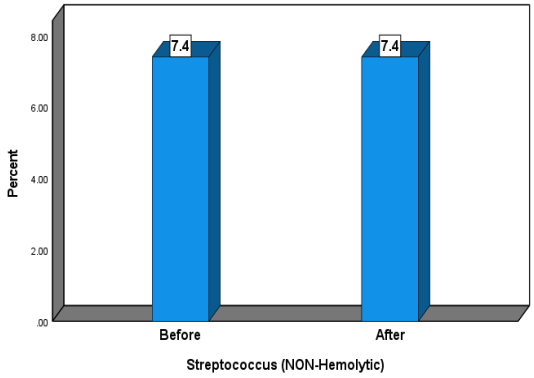

Figure 3: Effect of 75% alcohol on Streptococcus (Non-Hemolytic).

iv. Klebsiella Pneumoniae

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "Klebsiella pneumoniae" yielded the following results:

- Pre-Disinfection: There were 3 positive cases, accounting for 5.6% of the total sample.
- Post-Disinfection: Following the application of alcohol, the number of positive cases decreased to 2, representing 3.7% of the total sample.
- Statistical Significance: The P-value for this comparison is 0.655, indicating that the observed difference in the percentage of positive cases may not achieve statistical significance.

These findings suggest that the application of 75% alcohol had a minimal effect on reducing the number of positive cases of "K. pneumoniae." The graph presented in Figure 4 visually illustrates these results, highlighting the slight reduction in positive cases following disinfection with 75% alcohol.

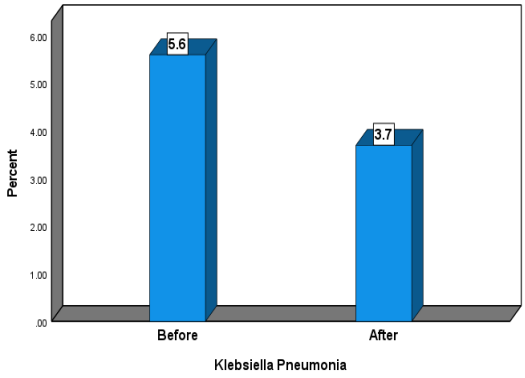

Figure 4: Effect of 75% alcohol on K. pneumonia.

v. Escherichia Coli

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "Escherichia coli" revealed the following results:

- Pre-Disinfection: There was 1 positive case, representing 1.9% of the total sample.
- Post-Disinfection: Following the application of alcohol, there were no positive cases of "E. coli" detected.

These findings indicate that the application of 75% alcohol effectively eliminated the presence of "E. coli" bacteria. The graph presented in Figure 5 visually illustrates these results, demonstrating the complete eradication of "E. coli" following disinfection with 75% alcohol.

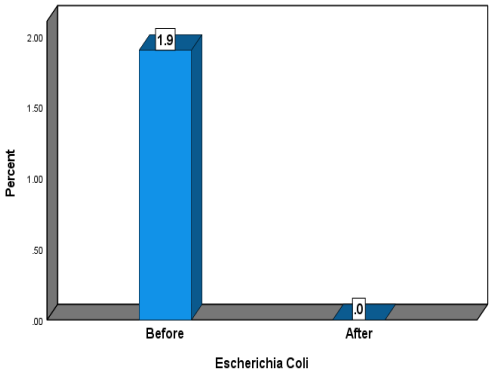

Figure 5: Effect of 75% alcohol on E. coli.

vi. NLF Gram Negative Bacilli

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "Non-Lactose Fermenting (NLF) Gram-Negative Bacilli" yielded the following results:

- Pre-Disinfection: There were 2 positive cases, accounting for 3.7% of the total samples.
- Post-Disinfection: Following the application of 75% alcohol, no positive cases of NLF Gram-Negative Bacilli were detected.

These findings indicate that 75% alcohol effectively eliminated the presence of NLF Gram-Negative Bacilli in the samples. The graph presented in Figure 6 visually illustrates these results, demonstrating the successful eradication of NLF Gram-Negative Bacilli following disinfection with 75% alcohol.

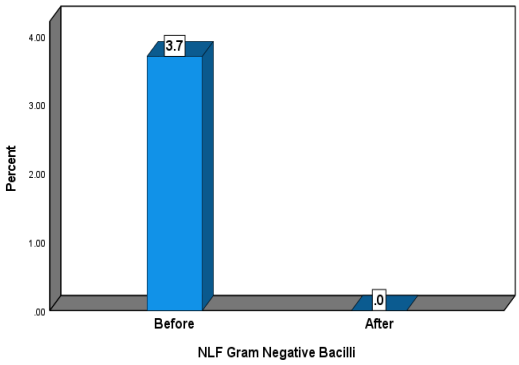

Figure 6: Effect of 75% alcohol on NLF Gram Negative Bacilli

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "Staphylococcus aureus" yielded the following results:

- Pre-Disinfection: There were 2 positive cases, accounting for 3.7% of the total sample.
- Post-Disinfection: Following the application of 75% alcohol, no positive cases of "S. aureus" were detected.

These findings indicate that 75% alcohol effectively eliminated the presence of "S. aureus" bacteria in the samples. The graph presented in Figure 7 visually illustrates these results, demonstrating the successful eradication of "S. aureus" following disinfection with 75% alcohol.

vii. Staphylococcus Aureus

The analysis of bacterial types presents before and after disinfection with 75% alcohol for "Staphylococcus aureus" yielded the following results:

- Pre-Disinfection: There were 2 positive cases, accounting for 3.7% of the total sample.
- Post-Disinfection: Following the application of 75% alcohol, no positive cases of "S. aureus" were detected.

These findings indicate that 75% alcohol effectively eliminated the presence of "S. aureus" bacteria in the samples. The graph presented in Figure 7 visually illustrates these results, demonstrating the successful eradication of "S. aureus" following disinfection with 75% alcohol.

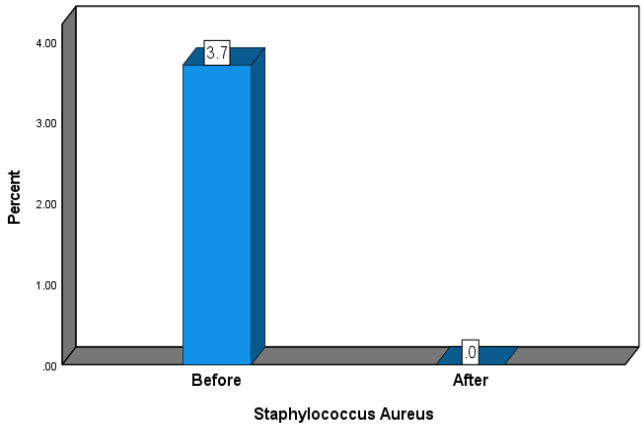

Figure 7: Effect of 75% alcohol on S. aureus

Table 2: Effect of 75% of alcohol on eliminate bacteria.

Item	Before		After		P-value
	Positive	%	Positive	%	
Bacteria existing	50	92.6%	36	66.7%	0.131

The P-value of 0.131 indicates that there is no statistically significant difference in bacterial elimination between the "before" and "after" conditions. This suggests that the observed reduction in bacterial counts may have occurred by chance rather than as a direct consequence of the application of 75% alcohol.

Discussion

The results of this study provide valuable insights into the effectiveness of disinfectant wipes in eliminating various types of bacteria. Initially, there were 50 instances of bacterial presence, accounting for 92.6% of the total samples. Following exposure to 75% alcohol, the number of bacterial instances decreased to 36, representing 66.7% of the samples, with a P-value of 0.131 indicating no statistically significant difference in bacterial elimination. The study has demonstrated the use of various agents to sterilize devices and surfaces that cannot be effectively disinfected through conventional methods. These agents include gauze soaked in water, cosmetic wipes, sodium hypochlorite, and the application of 70% alcohol. However, these approaches often failed to completely eliminate contaminated bacteria from devices or surfaces. In our study, we focused on the application of 75% alcohol, which proved effective against certain bacterial types, including non-pathogenic diphtheria, Staphylococcus, Escherichia coli, and non-lactose fermenting Gram-negative bacilli. Notably, the number of positive cases for Staphylococcus haemolyticus reduced from 13 to 7 following the use of 75% alcohol wipes. We employed a circular wiping motion rather than a linear one, which may have influenced our results.

Conclusion

The findings of this study indicate that the internal surfaces of pulse oximeter probes can act as reservoirs for a variety of pathogenic bacteria, which have the potential to contribute to nosocomial

infections through contact between healthcare workers (HCWs) and patients. The use of commercial wipes containing 75% alcohol proved effective in eliminating and reducing bacterial presence, as evidenced by a decrease in the percentage of positive samples from 92.6% to 66.7% following their application. These results underscore the importance of proper disinfection practices in mitigating the risk of infection in healthcare settings.

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