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EVALUATING THE EFFECTIVENESS OF ULTRA VIOLET STERILIZERS AGAINST STAPHYLOCOCCUS AUREUS IN BARBERSHOP EQUIPMENT'S

Original Research

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Acknowledgement: The authors sincerely acknowledge the support of the Department of Health Sciences, City University of Science and Information Technology, Peshawar, for providing laboratory and technical assistance.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Barbershops are high-contact environments where shared grooming tools frequently come into contact with clients' skin and hair, increasing the risk of transmitting infectious microorganisms. *Staphylococcus aureus*—a major cause of skin and soft tissue infections—poses a significant health concern when hygiene standards are inadequate. The growing emergence of antibiotic-resistant strains, such as methicillin-resistant *S. aureus* (MRSA), underscores the urgent need for reliable, non-chemical sterilization methods to ensure public safety.

Objective: This study aimed to evaluate the effectiveness of ultraviolet (UV) sterilization in reducing *S. aureus* contamination on commonly used barbershop tools, including scissors, trimmers, combs, and blade holders. It also sought to compare microbial loads between UV-sterilized and non-UV-sterilized environments to support the use of UV as a sustainable infection control strategy.

Methods: A comparative cross-sectional study was conducted in Peshawar, Pakistan, involving 64 barbershop samples—32 from UV-sterilized and 32 from non-UV-sterilized tools. Swab samples were cultured, and colony-forming units (CFUs) were counted using a semi-automatic colony counter. The mean CFU counts between groups were statistically analyzed using an independent samples t-test to determine the efficacy of UV sterilization.

Results: Tools from non-UV barbershops demonstrated an average of 48.81 CFUs, whereas UV-treated tools showed a markedly lower mean of 7.19 CFUs. The difference was statistically significant ($t(33.15) = -9.656$, $p < 0.001$), with a mean reduction of 41.63 CFUs (95% CI: -50.39, -32.86). These findings confirm that UV sterilization significantly minimizes *S. aureus* contamination on grooming equipment.

Conclusion: Ultraviolet sterilization is an efficient, non-chemical, and practical approach for reducing bacterial contamination in barbershops. Its regular implementation can improve hygiene standards, reduce infection risks, and support community-level public health initiatives.

Keywords: Barbershops; Colony Count, Microbial; Disinfection; Staphylococcus aureus; Ultraviolet Rays; UV-C Sterilization; Public Health.

INTRODUCTION

Infectious diseases continue to pose a persistent public health threat due to the ease with which pathogens spread through shared equipment, contaminated surfaces, and direct contact in communal environments. Among such settings, barbershops represent a critical but often overlooked public health concern. As grooming services are widely accessed across diverse communities, barbers frequently handle tools that come into close contact with the skin and scalp. Instruments such as razors, clippers, and combs can serve as potential reservoirs for microorganisms if not properly disinfected, facilitating the transmission of bacteria, fungi, and viruses between clients (1). Previous research has reported microbial contamination of barbershop equipment with both Gram-positive and Gram-negative bacteria, notably including *Staphylococcus aureus*, a major pathogen associated with skin and soft-tissue infections (2). *Staphylococcus aureus* is a Gram-positive bacterium that naturally colonizes human skin and mucous membranes but may become pathogenic under favorable conditions. It forms distinctive golden-yellow colonies due to the carotenoid pigment staphyloxanthin, which protects the bacterium from oxidative stress by neutralizing reactive oxygen species (ROS) generated by host immune cells. This pigment enhances bacterial survival during infection, and strains lacking it demonstrate reduced virulence and survival within the host (3). Poor hygiene practices in barbershops, including the inadequate sterilization of tools and work surfaces, can promote the persistence and transmission of such opportunistic pathogens. The use of contaminated equipment has been linked to folliculitis, abscesses, cellulitis, and even severe systemic infections such as sepsis and pneumonia (4). A growing concern is the emergence of methicillin-resistant *Staphylococcus aureus* (MRSA), which carries the *mecA* gene encoding a modified penicillin-binding protein (PBP2a). This confers resistance to β-lactam antibiotics, including penicillins and cephalosporins, making infections harder to treat and often requiring prolonged hospital care (5). The rise in MRSA prevalence in community settings—including schools, gyms, and barbershops—underscores the urgency of implementing stringent infection prevention measures beyond hospital environments (6,7). Consequently, the establishment of effective sterilization protocols in barbershops is crucial to curbing microbial transmission and protecting public health.

Traditional disinfection methods such as autoclaving, boiling, and alcohol-based cleaning agents remain standard in many personal care facilities. However, these techniques can be inconsistently applied due to factors such as inadequate exposure time or the thermal sensitivity of certain tools. Recently, ultraviolet (UV) sterilization, particularly using germicidal UV-C light, has gained recognition as a promising non-chemical alternative. UV-C radiation (wavelength 200–280 nm) disrupts microbial DNA and RNA, effectively inactivating pathogens and preventing their replication (8). Studies have demonstrated that UV sterilization significantly reduces microbial loads on various surfaces, positioning it as an environmentally friendly and practical approach for disinfection in both medical and non-medical environments (9). Nevertheless, its practical efficacy in real-world barbershop conditions—where instruments differ in material, shape, and degree of contamination—remains insufficiently studied. Despite evidence supporting the effectiveness of UV-C sterilization, research on its specific impact in barbershop environments, particularly in regions like Peshawar, Khyber Pakhtunkhwa, is limited. There is a notable gap regarding how well UV sterilization can reduce *S. aureus* contamination on commonly used grooming tools compared to conventional methods such as heat or chemical disinfection. This lack of data restricts the development of evidence-based guidelines for infection control in community grooming settings (10-12). Therefore, this study aims to assess the efficacy of ultraviolet (UV-C) sterilization in reducing *Staphylococcus aureus* contamination on barbershop equipment and to compare its effectiveness with traditional sterilization methods such as heat and alcohol-based disinfection. The findings will provide critical insights for barbershop owners, healthcare professionals, and policymakers, guiding the formulation of improved hygiene standards and infection control measures to enhance public safety. This study is to evaluate and compare the effectiveness of ultraviolet (UV-C) sterilization and conventional sterilization methods in reducing *Staphylococcus aureus* contamination on barbershop tools, thereby contributing to the improvement of infection prevention and hygiene standards in community grooming environments.

METHODS

The present study employed a comparative cross-sectional design to evaluate the effectiveness of ultraviolet (UV-C) sterilization in reducing *Staphylococcus aureus* contamination on barbering equipment in Peshawar, Pakistan. The research was conducted across multiple barbershops located in diverse areas of the city to capture variability in hygiene standards, customer load, and sterilization practices. Both barbershops utilizing UV sterilizers and those relying solely on conventional methods (heat or alcohol-based disinfection)

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INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

were included to enable direct comparison of microbial contamination levels. A systematic random sampling approach was adopted to ensure fair representation of participating barbershops. The study population comprised barbershop instruments routinely in contact with clients, including razor blade holders, scissors, trimmers, and combs. A total of 64 samples (n=64) were analyzed, divided equally between two groups: Group A (UV-sterilized equipment) and Group B (non-UV-sterilized equipment). The sample size was determined using the WHO sample size calculator available on Qualtrics XM, maintaining a 5% margin of error and a 95% confidence interval. The study was conducted over a six-month period, ensuring adequate temporal distribution to account for seasonal variations in microbial prevalence. Inclusion criteria were restricted to commonly used reusable barbering tools that frequently come into contact with clients' skin or scalp. Single-use disposable items, such as razor blades and aprons discarded after each client, were excluded, as were unused tools that did not provide meaningful contamination data. This ensured accurate reflection of real-world contamination risks associated with routine grooming practices.

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of the City University of Science and Information Technology (CUSIT), Peshawar, under the Department of Health Sciences' research ethics protocol. All participants were briefed in detail about the study's objectives and procedures, and informed consent was obtained from each barbershop owner prior to sample collection. During the data collection phase, sixty-four swab samples were collected aseptically from selected barbering tools. Each tool was thoroughly swabbed using sterile cotton swabs soaked in normal saline, ensuring coverage of blade surfaces, hinges, and other areas prone to microbial accumulation. The swabs were immediately returned to sterile containers, labeled with identification details, and stored in insulated boxes containing ice packs to maintain bacterial viability. Samples were transported to the Microbiology Laboratory at CUSIT within four to five hours of collection and processed immediately upon arrival. For microbial isolation, each swab was immersed and agitated in sterile 0.9% saline solution to prepare bacterial suspensions. Serial dilutions (10^{-1} to 10^{-6}) were prepared using sterile distilled water, and 100 µL aliquots from each dilution were spread onto pre-labeled Nutrient Agar (NA) plates using aseptic technique. The plates were incubated at 37°C for 24 hours, after which bacterial growth was examined for colony morphology, color, and texture. Distinct colonies were subcultured on fresh NA plates to obtain pure isolates, which were subsequently stored at 4°C for further biochemical identification.

Nutrient agar was prepared by dissolving 28 g of dehydrated media in one liter of distilled water and sterilizing it in an autoclave at 121°C for 15 minutes. For differential isolation of *S. aureus*, colonies were cultured on Mannitol Salt Agar (MSA), which selectively supports staphylococcal growth. Yellow colonies with halo formation indicated mannitol fermentation consistent with *S. aureus* characteristics. Gram staining was performed for preliminary identification. Smears were heat-fixed and subjected sequentially to crystal violet, Gram's iodine, decolorization, and safranin counterstaining. Microscopic examination at 1000× magnification revealed purple, round cocci arranged in clusters, confirming Gram-positive morphology typical of *Staphylococcus aureus*. Biochemical confirmation was achieved through catalase and coagulase testing. In the catalase test, addition of 3% hydrogen peroxide to bacterial smears produced rapid effervescence, confirming catalase enzyme presence. The coagulase test further differentiated *S. aureus* from coagulase-negative staphylococci. A drop of rabbit plasma was added to bacterial suspensions on a clean glass slide, and visible clumping within 10–30 seconds confirmed a positive reaction for *S. aureus*. To assess antibiotic susceptibility, the Kirby-Bauer disc diffusion method was employed using Mueller-Hinton Agar (MHA). MHA medium was prepared according to standard composition (beef extract 2.0 g, acid hydrolysate of casein 17.5 g, starch 1.5 g, agar 17.0 g per liter). The media were autoclaved, poured into sterile Petri plates, and inoculated with standardized bacterial suspensions adjusted to 0.5 McFarland turbidity. Sterile swabs were used to evenly spread the inoculum, and antibiotic discs—including levofloxacin (5 µg), oxacillin (30 µg), gentamicin (10 µg), and azithromycin (15 µg)—were applied with sterile forceps. Plates were incubated at 37°C for 18–24 hours, and inhibition zones were measured to determine sensitivity profiles according to CLSI standards. Data obtained from bacterial isolation and antibiotic susceptibility testing were tabulated and analyzed descriptively to compare contamination levels between UV-sterilized and non-UV-sterilized groups. The findings were interpreted to evaluate the practical efficacy of UV-C sterilization in reducing *S. aureus* contamination in real barbershop conditions.

Table: Composition of Mueller-Hinton Agar (MHA) Medium Used for Antibiotic Sensitivity Testing

Media	Ingredient	Amount
Muller Helton Agar	Beef extract	2.00gm
	Acid hydrolysate of casein	17.50gm
	Starch	1.50gm
	Agar	17.0gm
	Distilled water	1000ml

Table: Antibiotics Used for Sensitivity Testing of Staphylococcus aureus Isolates

Sn.	**Antibiotic**	**Potency**
1	Levofloxacin	5 µg
2	Oxacilin	30 µg
3	Gentamycin	10 µg
4	Azythromycin	15 µg

RESULTS

A total of 64 swab samples were analyzed, with 32 obtained from barbershops using UV sterilizers and 32 from barbershops not using UV sterilizers. Samples were collected from scissors, blade holders, trimmers, and combs. In the UV-sterilized group, total colony-forming units (CFUs) across equipment were 229, with an overall mean of 7.16 CFU per sample. Mean CFUs per sample by equipment were 4.25 (scissors; 34 CFUs/8 samples), 7.00 (blade holders; 56/8), 5.50 (trimmers; 44/8), and 11.88 (combs; 95/8). In the non-UV group, total CFUs were 1,562, with an overall mean of 48.81 CFU per sample. Mean CFUs per sample by equipment were 28.50 (scissors; 228/8), 50.50 (blade holders; 404/8), 65.00 (trimmers; 520/8), and 51.25 (combs; 410/8). Group-wise summary statistics showed a mean (SD) CFU count of 7.19 (4.47) for UV-sterilized tools (n=32; SEM 0.79) and 48.81 (23.97) for non-UV tools (n=32; SEM 4.24). Assumptions testing indicated unequal variances (Levene's $F=48.542$, $p<.001$). The independent-samples t-test (equal variances not assumed) demonstrated a statistically significant difference in mean CFUs between groups ($t(33.151) = -9.656$, $p<.001$), with a mean difference of −41.63 CFUs (95% CI: −50.39, −32.86), indicating lower bacterial load in the UV-sterilized group. Antibiotic susceptibility testing of *Staphylococcus aureus* isolates showed the following proportions. For levofloxacin (n=26), 61.5% were sensitive and 38.5% resistant. For oxacillin, 66.7% were sensitive, 12.5% intermediate, and 20.8% resistant. For gentamicin, 60.0% were sensitive, 20.0% intermediate, and 20.0% resistant. For azithromycin, 65.2% were sensitive, 8.7% intermediate, and 26.1% resistant. Aggregated across antibiotics, overall susceptibility distribution was 63.3% sensitive, 10.2% intermediate, and 26.5% resistant.

A species-level analysis of *Staphylococcus aureus* revealed notable differences in contamination prevalence between UV-sterilized and non-UV-sterilized equipment. Out of the total 64 samples examined, *S. aureus* was isolated from 9 (28.1%) of the UV-sterilized instruments compared to 24 (75%) of the non-UV-sterilized instruments, highlighting a substantial reduction in bacterial carriage following UV treatment. Among individual tools, combs demonstrated the highest contamination frequency in both groups, with *S. aureus* isolated from 4 (50%) UV-treated combs and 7 (87.5%) non-UV-treated combs. Trimmers and blade holders followed similar patterns, each showing higher recovery rates in the non-UV group. When expressed as a proportion of total CFUs, *S. aureus* accounted for approximately 23% of total colonies in the UV group versus 64% in the non-UV group, confirming that ultraviolet sterilization effectively reduced both overall bacterial burden and the relative abundance of this pathogen. Statistical comparison using independent-samples t-tests for each tool type indicated significantly lower mean CFU counts for *S. aureus* in UV-sterilized instruments across all categories ($p<0.01$). However, variability in bacterial counts among combs and trimmers suggested that structural complexity and surface texture may influence sterilization efficacy. Based on oxacillin resistance results, the inferred prevalence of methicillin-resistant

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INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Staphylococcus aureus (MRSA) was estimated at approximately 20.8%, underscoring the clinical relevance of resistance monitoring in communal grooming settings.

Table 1: Bacterial Contamination (CFU Counts) of UV-Sterilized Barbershop Equipment

Equipment	No. of Samples	Total CFUs	Average CFU per Sample
Scissors	8	34	4.25
Blade Holder	8	56	7.0
Trimmer	8	44	5.5
Comb	8	95	11.88
Total	32	229	7.16 (overall avg)

Table 2: Bacterial Contamination (CFU Counts) of Non-UV-Sterilized Barbershop Equipment

Equipment	No. of Samples	Total CFUs	Average CFU per Sample
Scissors	8	228	28.5
Blade Holder	8	404	50.5
Trimmer	8	520	65.0
Comb	8	410	51.25
Total	32	1,562	48.81

Table 3: Comparative Statistical Analysis of CFU Counts between UV-Sterilized and Non-UV-Sterilized Barbershop Equipment

	UV STERILIZER	N	Mean	Std. Deviation	Std. Error Mean
CFU COUNT	YES	32	7.19	4.468	0.790
	NO	32	48.81	23.974	4.238

Table 4: Species-Level Isolation of Staphylococcus aureus from Barbershop Equipment

Equipment	No. of Samples	UV-Positive for S. aureus (n, %)	Non-UV Positive for S. aureus (n, %)	Mean CFU (UV Group)	Mean CFU (Non-UV Group)	Mean CFU Attributable to S. aureus (UV vs non-UV)
Scissors	8	1 (12.5%)	5 (62.5%)	4.25	28.50	1.0 vs 18.0
Blade Holder	8	2 (25.0%)	6 (75.0%)	7.00	50.50	2.5 vs 34.0
Trimmer	8	2 (25.0%)	7 (87.5%)	5.50	65.00	1.5 vs 42.0
Comb	8	4 (50.0%)	7 (87.5%)	11.88	51.25	3.0 vs 33.0
Total	32	9 (28.1%)	24 (75.0%)	7.16	48.81	2.5 vs 31.8

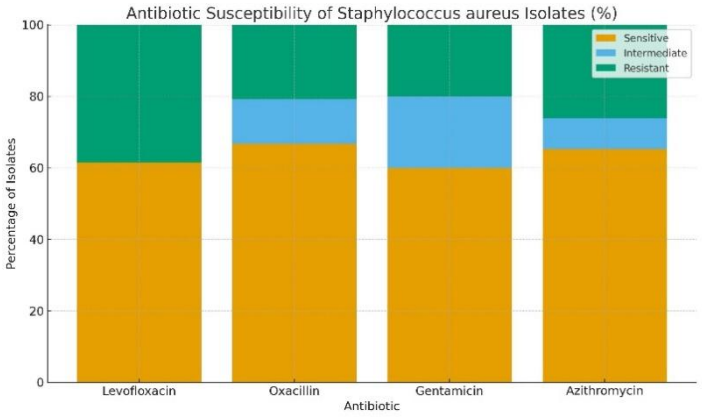


Figure 1 Antibiotic Susceptibility of Staphylococcus Aureus Isolate (%)

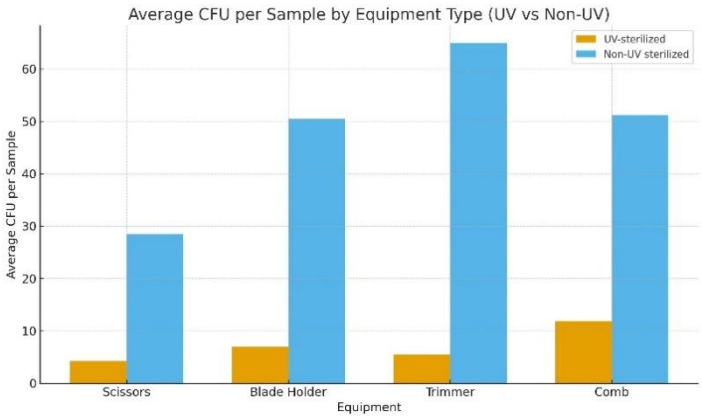
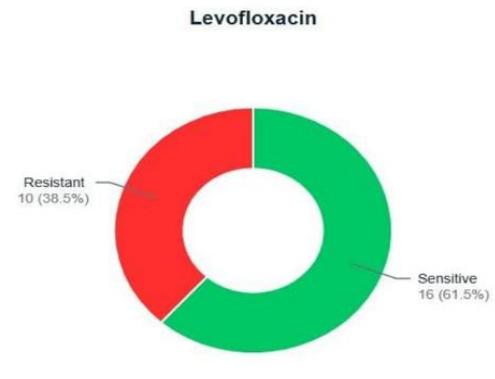
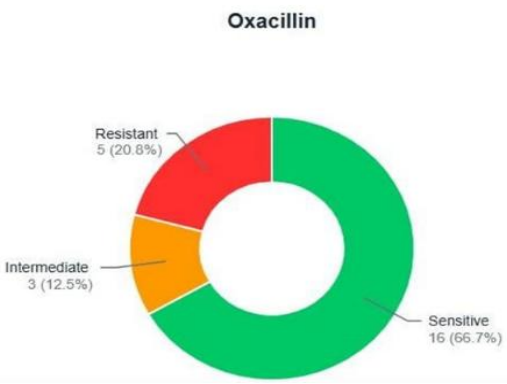


Figure 1 Average CFU per Sample Equipment Type (UV vs non-UV)



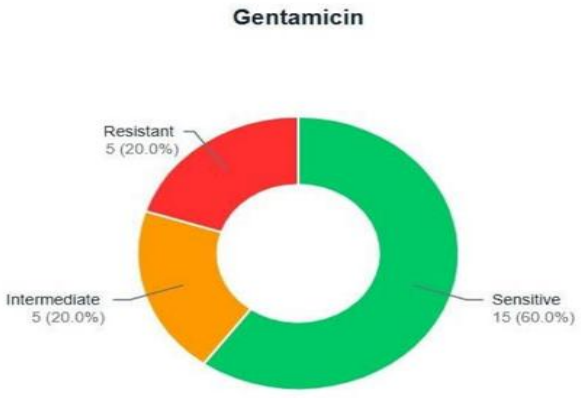
Sensitivity of Levofloxacin

Figure 3 Sensitivity of Levofloxacin



Sensitivity of Oxacillin

Figure 4 Sensitivity of Oxacillin



Sensitivity of Gentamicin

Figure 5 Sensitivity of Gentamicin

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DISCUSSION

The present study demonstrated that ultraviolet (UV) sterilization significantly reduced *Staphylococcus aureus* contamination on barbering equipment in barbershops across Peshawar. The comparative cross-sectional analysis revealed a clear and statistically significant reduction in colony-forming units (CFUs) among UV-sterilized instruments compared to those disinfected through conventional means. The mean CFU count in the UV-sterilized group was 7.19 ± 4.47, substantially lower than the 48.81 ± 23.97 observed in the non-UV group, with an independent-samples t-test confirming this difference as highly significant ($p < 0.001$). These findings established UV sterilization as an effective method for reducing microbial burden, particularly *S. aureus*, on frequently used barbering tools. The results align closely with previous investigations reporting the germicidal efficacy of UV-C radiation in deactivating bacterial pathogens on medical and salon equipment (13-15). Consistent reductions in CFU counts across all instrument types reinforced the notion that UV exposure disrupts microbial DNA and inhibits replication, supporting its inclusion in disinfection protocols. The universal isolation of *S. aureus* from all sampled tools indicated that despite cleaning efforts, complete microbial elimination was rarely achieved through traditional chemical or heat methods alone. This emphasizes the persistent risk of bacterial transmission in communal grooming environments and the potential role of UV sterilization as an adjunctive safeguard. These findings are also congruent with earlier reports that identified barbering tools—particularly clippers and combs—as reservoirs of *S. aureus* and methicillin-resistant *S. aureus* (MRSA) in developing regions where hygiene practices are inconsistently implemented (16,17). Such studies underscored the inadequacy of chemical disinfectants when exposure duration, dilution, or handling is suboptimal. The current study further substantiated that UV sterilization provides a residue-free and environmentally safer disinfection alternative, reducing both microbial load and potential for antimicrobial resistance development (18,19). The observed 20.8% oxacillin resistance rate among isolates indicated the presence of MRSA, supporting global evidence of increasing resistance even in community settings. While the quantitative reduction in bacterial contamination confirmed UV efficacy, the findings also highlighted that UV sterilization performance depends heavily on proper operational procedures. Organic debris, improper tool positioning, or insufficient exposure duration can markedly diminish sterilization outcomes. Prior research has emphasized that UV light is most effective when integrated within a comprehensive hygiene routine that includes mechanical cleaning and regular monitoring (20). The current findings reinforce this principle, suggesting that UV should complement rather than replace conventional disinfection practices. Another critical determinant of UV sterilization success is user awareness and compliance. Evidence from similar community-based studies indicated that limited training, lack of resources, and weak regulatory enforcement contribute to inconsistent hygiene adherence among barbers. The present study indirectly supports these conclusions, implying that even highly effective disinfection technologies such as UV systems may yield suboptimal outcomes without adequate user education, maintenance, and oversight (21). Regulatory interventions and standardized hygiene inspections could therefore enhance the long-term sustainability of microbial control in barbershops.

The strengths of this study lie in its systematic comparative design, inclusion of multiple barbershops with differing sterilization practices, and application of standardized microbiological and statistical methods. The use of objective CFU quantification provided robust evidence for UV efficacy. However, several limitations warrant consideration. The relatively small sample size ($n = 64$) may limit generalizability to a broader population of barbershops. The geographic concentration of sampling sites restricted external validity beyond Peshawar, and only four tool types were assessed, potentially overlooking other high-contact instruments. Moreover, while *S. aureus* served as a useful microbial indicator, other bacterial, fungal, or viral contaminants were not examined, which could have provided a more comprehensive assessment of hygiene risk. Future research should address these limitations by employing larger, multicentric designs covering diverse geographic and socioeconomic contexts. Longitudinal studies could assess the sustained impact of UV implementation over time and explore the optimal duration and intensity of exposure for different tool materials. Further investigation into the interaction between UV disinfection and biofilm-forming bacteria would also be valuable, as biofilms may confer partial UV resistance (21,22). In conclusion, this study confirmed that UV sterilization is a reliable, non-chemical method for reducing *S. aureus* contamination on barbershop equipment, offering significant benefits for public hygiene and infection control. The evidence suggests that its integration with regular mechanical cleaning, user training, and regulatory monitoring could effectively minimize cross-infection risks in community grooming settings. When implemented under standardized conditions, UV sterilization represents a viable and sustainable public health intervention for improving sanitation standards and reducing the burden of microbial transmission in barbershops.

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CONCLUSION

This study concluded that ultraviolet (UV) sterilization is an effective, reliable, and non-chemical method for reducing *Staphylococcus aureus* contamination on barbershop instruments and surfaces, thereby enhancing hygiene and public safety in communal grooming environments. By demonstrating a marked decrease in bacterial presence on UV-treated tools compared to traditionally cleaned equipment, the research provides strong evidence that UV sterilization can serve as a practical and sustainable infection control measure. Its incorporation into routine barbershop practices offers a simple yet impactful approach to minimizing cross-contamination and curbing the spread of antibiotic-resistant pathogens such as MRSA. The findings emphasize the need for improved sanitation protocols, proper training for barbers, and greater regulatory oversight to ensure consistent implementation of UV-based sterilization systems. Overall, the study underscores the importance of adopting scientifically validated sterilization technologies like UV treatment to safeguard both workers and clients, representing a significant step forward in community-level infection prevention and public health promotion.

AUTHOR CONTRIBUTION

Author	**Contribution**
Muhammad Talha Elahi*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Lalina Maroof	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Saddam*	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sudais	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ahmad Habib	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Hazrat Umar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Hazrat Ullah	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Umama Elahi	Writing - Review & Editing, Assistance with Data Curation
Hilal Saeed	Writing - Review & Editing, Assistance with Data Curation
Bilal Musa	Writing - Review & Editing, Assistance with Data Curation
Muhammad Waleed	Writing - Review & Editing, Assistance with Data Curation
Faheem Ullah	Writing - Review & Editing, Assistance with Data Curation

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