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RESEARCH ARTICLE
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COMPARISON OF DECONTAMINATION BY CONVENTIONAL DOMESTIC WASH VERSUS CHEMICAL WASH OF HEALTH PROFESSIONAL UNIFORMS AND ITS RELATIONSHIP WITH FREQUENCY OF MICROORGANISMS ON THEIR UNIFORMS

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Abstract

Background: Healthcare organizations prioritize infection control to ensure a safe, and infection-free environment for patients. The spread of pathogens from hospitals by health care professionals' uniforms and kits, as well as the efficacy of domestic laundering of health professionals' uniforms, are still major concerns.

Objectives: To assess the frequency of microorganisms on the uniforms of health care professionals and to compare the decontamination efficacy of conventional domestic washing with germicidal chemical disinfection.

Methodology: The study utilized a randomized control trial design and a systematic random sampling technique to analyze data from 32 healthcare professionals (doctors and nurses) working in Shaikh Zayed Hospital in Lahore. The collected information was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. The mean and standard deviation were calculated for the bacterial count on health professional uniforms. Frequency and percentage were given for the categorical variable. A Chi-Square test was used to compare disinfection frequency between the interventional and control groups, with a significance level of P-value ≤ 0.05.

Result: The result of the study revealed that microorganisms were found on 32 (50%) uniforms before washing, of which 17 (53%) were from the control group and 15 (47%) were from the interventional group. After washing the uniform with detergent and 3%-H_2O_2 only 06 (19%) uniforms were positive for microorganisms. The following microorganisms were observed: *Staphylococcus Aureus strains, Proteus Mirabilis, E-Coli, Streptococcus,* and *Klebsiella*.

Conclusion: The domestic wash technique was less effective in reducing microorganisms from health professionals' uniforms than chemical wash, as chemical wash can completely remove all types of microorganisms. However, it is also identified that about 78% of *S. aureus* strains were isolated from the positive cases.

Key Words: Microbial Contamination, Health Care Professionals, Conventional Domestic Wash, Chemical Decontamination.

CHAPTER-I
INTRODUCTION
1.1: Background:

Decontamination of health professionals' uniforms is accomplished using a variety of methods, including heat and/or detergents, germicidal chemicals used by hospitals, and in-house laundering (domestically). Microbial decontamination and infection control in the laundering process are necessary to minimize the risk of infection arising from health professionals' uniforms. The laundering of domestic healthcare worker uniforms represents a significant issue because of insufficient supervision and decontamination control. This pathway serves as a source through which pathogens may invade healthcare settings. Compared to domestic laundering, hospital laundering using a germicidal chemical on health professionals' uniforms offers greater assurances for adequate decontamination (Bauchner et al., 2020)

In Pakistan, the health authorities have not established any rules or regulations requiring health professionals to wear hospital uniforms only in the workplace or from home; despite the fact, the international literature suggests that doing so may propagate infections to the general public (Dang et al., 2021). Numerous studies suggest that microorganisms persist on health professionals' uniforms for a longer period and propagate to cutaneous tissues and other areas, implying that it's scientifically possible for contaminated uniforms to be the vector of infectious diseases such as Healthcare-associated infections (HCAIs) (Owen and Laird, 2020). As a result, several case studies have been published that link minor outbreaks to insufficient washing or decontamination control practices in clinical laundry. Research has additionally shown that lethal viruses survive during the washing of health professionals' uniforms, potentially increasing the risk of infection, and vector-borne ailments constitute a substantial risk in society as well as healthcare setups (Moccia et al., 2020)

Infection regulation measures are vital for reducing the outbreak of vector-borne maladies; hand sanitation and uniform disinfecting are regarded as major infection regulation strategies since health workers' uniforms continue to be a potential source of pathogen transmission (Otter et al., 2016). Taking precautionary measures such as proper laundering of uniforms decreases the economical and health burdens experienced by those who become infected due to exposure to vector-infected hospital uniforms. Certain microbial species are deposited on textiles via skin contact with laundering article. Such direct body contact can lead to the migration of the mucosal biota to the clothing and towels. (Reynolds et al., 2022).

In the United Kingdom (UK), there are two methods for laundering medical professional uniforms: in-house laundering for stuff such as chemical washing and domestic washing for outfits worn by medical personnel. Although domestic washing regulations are provided by individual trusts based on the Department of Health (DH) 2010 instruction on uniforms, in-house and contract laundries follow the Department of Health's technical memorandum on disinfection by using germicidal chemicals for hospital laundry services. Two scholarly analyses by Thames Valley University and an empirical study by University College London Hospital serve as the foundation for domestic laundering regulations. It asserts: "Nearly all microbes are eliminated after a 10-minute wash at 60°C. The majority of other pathogens, including meticillin-resistant Staphylococcus aureus, are eliminated by washing with detergent at low temperatures—down to 30°C (Owen et al., 2022). It is recommended

to keep and launder uniforms apart from other clothing. Uniforms worn by medical personnel should be regularly washed and treated with a detergent or germicidal solution after every shift. (Lee et al., 2020).

Laundering as a Germicidal Chemical (Hydrogen Peroxide) H_2O_2:

According to Kimmel et al. (2022), the sanitation efficacy of a laundry method is influenced by four factors: temperature, mechanical force, chemicals, and the time period. However, numerous variables, which aren't addressed in Sinner's concept, could impact the antibacterial efficacy of a washing procedure, including the variety of bacteria present, the number and type of soil, the incorporation of structure, or the degree and type of infection.

Sodium perborate has long been employed to provide hydrogen peroxide in products. A potential benefit of sodium perborate is that it immediately releases hydrogen peroxide in its pure form. Hydrolysis occurs when sodium perborate dissolves in water. It generates hydrogen peroxide as well as sodium borate. As laundry water is often basic, hydrogen peroxide degrades to generate the per-hydroxyl anion. (Stanczak, 2018). Hydrogen peroxide break down into oxygen and water. A particular theory suggests that some of the oxygen created during this process is in a state called singlet oxygen (102) and that it is this singlet oxygen that acts as the active bleaching agent. However, this theory has been extensively refuted when attempts were made to use compounds, like end-product peroxide, for bleaching purposes. (Jiang et al., 2018).

Laundry bleaching is also done by using hydrogen peroxide (H2O2), which is an oxidizing agent. The best choice for laundry is the 3% solution sold in drug stores as a first-aid disinfectant. Use in all washable, dye stable fabric. Similarly, hydrogen peroxide decomposes harmlessly into water and oxygen and constitutes an ecological bleach compared to sodium hypochlorite. (Bockmühl et al., 2019). Hydrogen peroxide (H2O2) has been recognized as potent bacteria, spore, virus, and fungus killer. It appears to be more efficient in neutralizing bacterial particles of Acinetobacter baumannii, Clostridium difficile, and methicillin-resistant Staphylococcus aureus (MRSA). (Torres et al., 2020). High-level disinfection eliminates all bacteria, but not the majority of their spores. Hydrogen peroxide, glutaraldehyde, and sodium hypochlorite are essential chemicals and agents of high-level disinfection. (Indrei et al., 2019).

Conventional Domestic Method of Washing Health Professionals' Uniform:

Domestic wash procedures (cleaning uniforms at home with detergents) are most used by health professionals. However, health professionals' clothing's are domestically washed in the United Kingdom and in some hospitals in the United States. The policies of the United Kingdom's Department of Health in 2010 and the National Health Service (NHS) in 2020 indicate that medical professional clothing fails to represent any threat to infection. Most germs are said to be removed by washing at 60 ◦C for 10 minutes while laundering with washing detergent at 30 ◦C eradicates MRSA the majority of Gram-positive pathogen (England and Improvement, 2020). Whereas recent investigations show that microorganisms survive when washed at low temperatures. For example, at a 40◦C traditional laundry cycle with detergent, 3.08–3.81 log10 CFU E. coli and 3.42–3.38 log10 CFU S. aureus endured on polyester cotton and uniforms, and 3.05–3.46 log10 CFU E. coli and S. aureus transmitted to the rest of the clothing in the laundry (Abdelfattah et al., 2020). However, Mutombo (2019) conducted a study in South Africa and determined that scrubs washed in the hospitals contain considerably less pathogens than home-washed scrubs. Samples from uniforms taken before staff started a shift showed that 22 of 57 (39%) from surgical wards, medical and renal, assessed positive for the presence of MRSA, VRE, or Clostridioides difficile, but by the termination of the work shift, 31 of 57 (54%) clothing were infected with a strain of these microbes.

Concerns have been voiced that local laundering machines do not offer an adequately monitored ecology for decontaminating staff uniforms. Cross-contamination with hospital infections could take place if cleaned with other clothing detergents. Although one of these investigations shows that

household laundry fails to minimize microbiological contamination (Schmithausen et al., 2019). According to guidelines, a disinfection cycle should be utilized, providing enough time to ensure heat penetration, and keeping the load at 65°C for a minimum of 10 minutes or, most likely, 71°C for at least 3 minutes. For clothing that cannot sustain these temperatures, it is suggested to employ cooler washes and add germicidal chemical to the penultimate wash (Maal-Bared, 2019).

1.2: Problem Statement:

In Pakistan, the rising rate of hospital infections poses high concern. This increase is frequently linked to the lack of adequate measures to prevent infections in hospitals. Previous studies centered on inefficient laundering techniques employed by hospitals and healthcare professionals. The findings of the research indicate that healthcare professionals' uniform laundry is quite restricted, and strategies and research methods differ extensively, making favorable associations and exact indications challenging for validation. The efficacy of domestic and industrial scrub laundry is contradicted in these studies. The form and frequency of laundry techniques may have an impact on the transmission of infections (Panta et al., 2019). Hospital and domestic laundering are the two laundry methods utilized for infected uniforms. The absence of particular laundry standards or regulations in the research shows that the infection reaches the hospital due to the inadequate maintenance of the uniforms during domestic laundering. The health care professionals' uniforms are considered a reservoir of surviving microorganisms and also a medium for contamination. In addition, there is a rise in interest in the healthcare setting, whereby health professional uniforms are thought to be potential agents of environmental and patient contamination. (Laird and Owen, 2020).

Healthcare-associated infections (HAIs) are a major source of mortality, morbidity, and expenses in hospitals. (Laird et al., 2018). Therefore, it was important to investigate the presence and frequency of microbes on healthcare professionals' uniforms and to assess the efficacy of traditional laundering versus chemical washing procedures in eliminating bacterial contamination from healthcare professionals' uniforms.

1.3: Objective:

- To assess the frequency of microorganisms on health professionals' uniforms before and after decontamination.
- To compare the effectiveness of decontamination through germicidal chemical disinfection and conventional domestic washing of health professionals' uniforms.

1.4: Research Question:

This study seeks to answer the below research questions:

- At what frequency microorganisms are present on health professionals' uniforms before and after decontamination?
- Does the frequency of microorganisms decrease with conventional methods of washing or chemical disinfectant washing?

1.5: Research Hypothesis:

- **Ho:** There are no significant differences in the microbial decontamination of health professionals' uniforms through germicidal chemical disinfection and conventional domestic washing.
- **H_1:** There are significant differences in the microbial decontamination of health professionals' uniforms through germicidal chemical disinfection and conventional domestic washing.

1.6: Significance:

Domestic laundering of health professionals' uniforms causes a significant threat to certain vulnerable groups, such as individuals with weakened immune systems, older adults, pregnant women, and kids. This is because improper laundering of health professionals' clothing or infections between family members could cause various health problems. It has been found that washing uniforms with

germicidal chemicals ensures optimal hygiene. So, the findings from this study could be significant to all healthcare organizations in setting guidelines for preventing transmission of hospital pathogens from hospitals to communities via health care professionals' uniforms as the presence of bacteria is explored on their uniforms. The study will serve as an evidence-based source for policymakers to implement hospital-based washing of contaminated uniforms. Moreover, the comparison of the efficacy of decontaminating health workers' uniforms with germicidal chemicals or conventional domestic wash provides evidence for effective washing methods to control the spread of infectious organisms in communities. The primary goal is to prevent disease transmission, thereby reducing healthcare costs and patient suffering. This research study will be the first endeavor in Pakistan to add information regarding the decontamination of health professional uniforms by H_2O_2.

1.7: Definition of Key Terms:

Microbial Contamination:

The deliberate or unintentional diffusion of pathogenic agents such as protozoa, prions, yeast, bacteria, fungi, mold, viruses, or their harmful byproducts is known as microbiological contamination (Pesce et al., 2020).

Health Care Professionals:

A healthcare professional is anyone who works in a healthcare setting, including doctors and nurses who are involved in direct patient care (Lena et al., 2021b).

Decontamination

Decontamination is a technique that eliminates or undermines infection so that pathogens or additional contaminants are prevented from reaching a vulnerable area at enough levels to cause infections or adverse reactions (Books, 2013).

Conventional Domestic Method:

Two studies of the scientific literature by Thames Valley University and empirical studies by University College London Hospital serve as the foundation for the Department of Health's household laundering strategy. It adds: "A wash for 10 minutes at 60°C removes almost all microorganisms" (Laird et al., 2018).

Chemical Wash:

To wash the uniform chemically, add 1 g/kg of detergent and 5 g/kg of disinfectant (chemical) and wash it for 15 minutes, then soak the uniform for at least one hour or overnight. This can help remove microorganisms and disinfect the uniform (Chiereghin et al., 2020a).

CHAPTER-II
LITERATURE REVIEW

2.1: Background:

Healthcare professionals are a major source of spreading infection to the community when they move from healthcare facilities to the public without changing their uniforms, as the findings of different studies indicate that health professionals' uniforms become contaminated with microorganisms after working in hospitals. However, it has been found that uniforms are often infected below the waistline and significantly infected following practices that are anticipated to involve exposure to infections, such as dressing the wounds (Kanwar et al., 2018). To control the spread of infection, an assessment of the presence and frequency of microorganisms on health care workers' uniforms and a comparison of the effectiveness of decontamination through germicidal chemical disinfection and conventional domestic washing of the uniforms are needed.

Multiple search engines, such as PubMed, Google Scholar, and Science Direct, are visited to collect data on the topic under study. This chapter is comprised of two sections, i.e., related literature and a theoretical framework.

2.2: Related Literature:

A study conducted in India by Monteiro et al. (2022) found that 95% of the uniforms of health care professionals were contaminated with Gram-negative bacteria and aerobic spore; therefore, their uniforms remain potential vectors for spreading infection to the community. A similar study conducted in Karachi by Iqbal et al. (2020) presented parallel findings as it found that the white coats of health professionals' carry about 53% microorganisms. It is crucial to know and tackle the potential harm of infections spreading beyond the workplace from healthcare professionals' uniforms.

According to Munoz-Price et al. (2012), out of 119 scrubs and white coats, 26 strains of Staphylococcus aureus were discovered; 11 out of 97 (11%) scrubs had Acinetobacter SPP, and 4 out of 21 (19%) MRSA bacteria were primarily found on scrubs, which made them susceptible to Meropenem. Dhimal et al. (2021) reported comparable results, detecting pathogens with resistance in 3 of 32 (9%) scrub cultures compared to 3 of 52 (6%) white coat cultures.

Riley et al. (2017) conducted a survey in England. They received responses from 265 healthcare professionals working as ward clerks, health care assistants, nurses, physical therapists, and janitors; 44% of staff washed their uniforms below the desired temperature of 60°C, which paves a route for cross-contamination and risks.

Thom et al. (2018) found that certain care tasks led to more scrub contamination, such as nurses treating patients with wounds having more infectious uniforms than those treating patients without wounds. Besides, Luo (2021) declared that bacteria last from 10 to 98 days on textiles, with polyester having the least time to survive compared to cotton and blend clothing. For example, Staphylococcus aureus lasts 10 to 26 days, Pseudomonas aeruginosa lasts 18 to 98 days, Escherichia coli lasts 7 to 48 days, and Enterococcus faecalis lasts 8 to 10 days.

According to a Gupta et al. (2019b) study carried out in India, the total colony count on polyester was around 2071 CFUs (colony-forming units), while on polyester cotton, it was approximately 3190 CFUs. Bacterial colonies on polyester declined by approximately 76% (60–87%) and on blends by 81% (63–89%) following the home washing procedure. The combination had mean colony counts of 60.5 CFU (42–77 CFU) after washing, which was 23.4% more than polyester. Similarly, a study performed in Arizona, USA, by Laird et al. (2018) demonstrated that when evaluating bacterial infections on both home-washed scrubs and hospital scrubs, the results showed a substantially higher total bacteria count in home-laundered scrubs than in hospital-laundered scrubs (P =.016). In particular, 44% (18 out of 41) of the locally-washed scrubs screened favorably for coliform germs.

There's a minimal variance in commercial and domestic washing when it involves getting rid of microorganisms from clothing worn by healthcare professionals. A number of Gram-positive bacteria, including Methicillin-resistant Staphylococcus aureus (MRSA, are easily eradicated by using detergents at 30ºC. Furthermore, nearly all microorganisms can be removed with a quick ten-minute wash using detergent and germicidal chemicals. Notably, investigations have revealed that following the chemical wash procedure, a meager 0.1% of Clostridium difficile spores persist.(Andersen and Andersen, 2019).

Therefore, the guidelines provide a pragmatic strategy for the cautious selection and efficient employing of disinfection and sterilization techniques. This method is centered on diligently executed studies that examine efficacy via laboratory tests and effectiveness through clinical evaluations. Earle H. Spaulding developed a technique for sterilizing patient-care supplies and materials more than 30 years ago. (Rutala and Weber, 2016). Despite the wide use of domestic washing machines, their effectiveness in disinfecting staff clothing has come into question due to notable differences in water temperature, water-to-fabric ratio, and detergent components compared to industrial machines. In fact,

a study by Laird and Owen (2020) conducted on pathogen-contaminated swatches from various types of scrubs (including hospital-laundered, home-laundered, fresh, and disposable) found that the average bacteria rate on home-washed scrubs was a concerning 80%. Moreover, Luo (2021) revealed that, regardless of their respective thermostability, enterococci were effectively eradicated by time/temperature combinations in hospital laundries. Nonetheless, a recent investigation undertaken in the UK indicated that Clostridioides difficile particles might persist after a washer extraction cycle that involved commercial laundry conditions (Ajala et al., 2022)

In 1981, the CDC's principles for the prevention of environmental infections provided instructions on how to determine and utilize disinfectants properly. The guideline went through several modifications subsequently. For instance, formaldehyde-alcohol was no longer advised as a significant disinfecting agent or chemical sterilant due to its limited use and hazards. New chemical sterilants were introduced in replacement, including hydrogen peroxide, peracetic acid, and a blend of peracetic acid and hydrogen peroxide (CDC, 2020). Furthermore, iodophors and 3% phenolics have been withdrawn from use as significant disinfectants due to their uncertain potency against M. tuberculosis, bacterial spores, and certain fungi (Rutala and Weber, 2019).

According to the Food and Drug Administration (FDA)-approved label, the recommended timeframe essential to get maximum disinfection is modified from 10–30 minutes to 12 minutes or longer. According to an investigation by Laird and Owen (2020), 44% of nursing personnel laundered their clothing less than the suggested 60˚C. They asserted that “a 10-minute wash at 60˚C is sufficient to remove almost all microorganisms," but “washing with chemicals at 30˚C will remove most gram-positive microorganisms, including all Methicillin-resistant Staphylococcus aureus.

2.3: Theoretical Framework

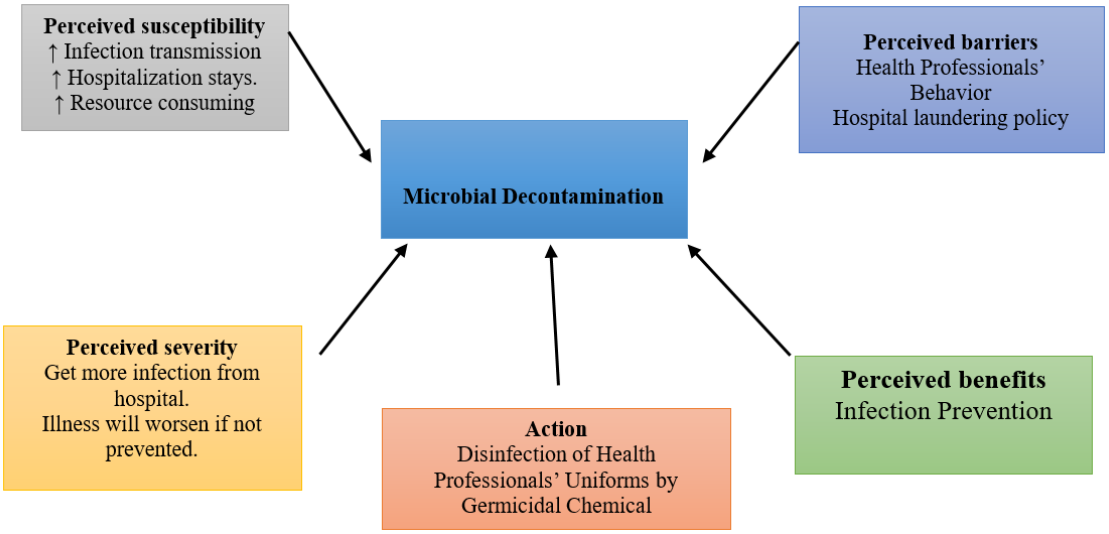
The term framework is used to describe a set of precepts, conceptions, or approaches utilized when looking at specific problems (Khatri, 2020). The healthcare sector frequently encounters workplace hazards that include biological, chemical, physical, psychosocial, and other types of occupational hazards. In this study, the focus is on preventing the transmission of infections among healthcare workers in general hospital wards by implementing a specific framework. Rosen's health belief model, which dates back to the 1950s, has proven to be a valuable tool for our study. With its focus on preventive health behaviors and their role among healthcare professionals, this model offers valuable insights into occupational safety protocols and effective measures for reducing workplace hazards among clinical practitioners (Amadhila et al., 2017).

The model highlights the importance of health practices among healthcare professionals to prevent diseases. It encourages them to adopt healthy lifestyles, reducing susceptibility to diseases. By promoting wellness, the model aims to improve clients' well-being and minimize disease occurrence, ultimately reducing the risks associated with diseases. (Shahsavari et al., 2022). Early in the 1950s, sociologists working for the US Public Health Service developed the Health Belief Model (HBM). The HBM was developed using psychological and behavioral concepts as its basis. According to this theory, there are two main aspects related to health behaviors:

1. The aim to prevent diseases or, if already sick, get well again;
2. The idea that certain health conduct will avoid, or treat disease.

The HBM consists of six mechanisms.

1. Perceived susceptibility
2. Perceived severity
3. Perceived benefits
4. Perceived barriers
5. Cue to action
6. Action



CHAPTER-III
METHODOLOGY

This chapter explains the research methodology that has been used in the study. The systematic collection and assessment of data to address a specific study's problem is known as research methodology. This strategy is composed of several components, including research design, sample size, sampling methods, study setting, collecting data, and analysis of data.

3:1: Study Design:

In this study, randomized control trial was used.

3.2: Setting:

This study was conducted at the University of Health Sciences (UHS), Lahore, in collaboration with Shaikh Zayed Hospital Lahore and the microbiology department of UHS.

3.3: Study Duration:

The present study was concluded in 10 months after the approval from the synopsis review committee.

3.4: Sample Size and Sample Calculation:

The sample size was obtained using the below equation, with an anticipated study power of 80% and a significance level of 5%.

$$n = \frac{\left[Z_{1-\frac{a}{2}} \sqrt{} + Z_{1-\beta} \sqrt{P1(1-P1)} + P2(1-P2) \right] 2}{(\mathrm{P1}-\mathrm{P2})^2}$$

$Z_{1-\beta}$ = Preferred power of study = 80% = 0.84

$Z_{1-\frac{\alpha}{2}}$ = Preferred level of significance = 5% = 1.96

P_1 = Estimated Population proportion 1: After the domestic wash, 20% of the toxins remained on the uniform. (Gupta et al., 2019b) = 80% = 0.80

P_2 = Anticipated Population Proportion 2: After the chemical wash, development of bacteria was not seen at any of the time points assessed. (Chiereghin et al., 2020a) = 100% =1.0

n= calculated sample size = 32

3.5: Sampling Technique and Randomization:

A Systematic Random sampling technique was adopted for study purposes. In systemic randomization, every member in the population has a fair and known possibility of being chosen. In systematic random sampling, the first subject is randomly picked from the population, then every K^{th} subject in the frame is selected from the list. The sampling interval is determined as follows:

K=N/n

Where n represents the sample size, and N represents the population size (Profetto-McGrath et al., 2010).

Method for Systematic Random Sampling:

In the first step, the researcher created a list of doctors and nurses working in general wards (Medicine, Gastroenterology, Nephrology, Urology, Neurosurgery, Private Rooms, Orthopedic & ENT), then selected a beginning number followed by an interval to gather information from a list of health professionals based on the interval number. There were a total of 170 doctors and nurses working in this hospital, and every 5th-health worker was selected for this study. For interval, the researcher divided the total number of doctors and nurses in the suggested hospital (the population size) by the number of doctors and nurses' samples for training (the sample size): 170/32=5.31. This made the interval of 05, meaning every 5^{th} doctor or nurse from the duty roster until the total of 32 sample size was achieved.

32 participants were included using the random sampling technique. After the collection of the uniform from a health professional, the uniform was equally divided into two parts (shirts of the uniforms cut vertically in to two equal part). Thus, 32 subjects (parts of uniform) were assigned to the interventional group and 32 to the control group; group division was performed by a third party using the coin method; and they were single blind to control confounding. The division were done to minimize confounding factors in both groups.

3.6: Sample Selection:

The following inclusion and exclusion criteria were used to gather samples from the study population:

3.6.1: Inclusion Criteria:

The criteria for inclusion were as follows:

- All those doctors and nurses working in the general wards (medicine, gastroenterology, nephrology, urology, neurosurgery, private rooms, orthopedic & ENT) of Shaikh Zayed Hospital, Lahore.
- Both genders, male and female, will be included.

3.6.2: Exclusion Criteria:

The criteria for exclusion were as follows:

- Health professionals (doctors and nurses) working in general wards but not involved in direct patient care, such as head nurses.

3.7: Study Population:

The study population for the current study included health professionals (doctors and nurses) working in Shaikh Zayed Hospital, Lahore.

3.8: Sample Collection Procedure:

This study was conducted on 32 participants (doctors & nurses) from various wards (medicine, gastroenterology, nephrology, urology, neurosurgery, private rooms, orthopedic & ENT) in Shaikh Zayed Hospital, Lahore. The sterilized uniform was distributed among selected participants working at Shaikh Zayed Hospital, Lahore.

- Informed consent was obtained from every participant prior to the start of the study.

- The uniform was sterile before being handled by health care workers.
- Uniforms were given for one complete shift.

3.8.1: Microbiological Procedure

The distributed uniform after one shift was checked for the presence of microorganism growth. The sample was taken from the uniform using a sterile culture swab. To thoroughly cover the area, one swab was used in a horizontal manner and the other in a vertical direction, back and forth (one stroke ahead and one back). The uniform was swabbed hard and evenly. The University of Health Sciences (UHS) Lahore's microbiology section processed each sample in accordance with standard operating procedures for microbiology.

3.8.2: Processing of Specimens:

The sample was dispatched to the UHS microbiology division for microbiological examination. Standard protocols were followed in the processing of the sample. MacConkey agar and nutrients were added to the cultures. Upon examining the plates, the following day, samples appeared to be growing, and gram staining was applied as required.

3.8.3: Culture on Nutrient & MacConkey Agar

The swab was incubated at 37oC for 24 hours after being cultivated on nutritional agar and MacConkey agar to look for bacterial growth prior to disinfection. The development of microorganisms showed up as smooth, white to cream-colored colonies.

3.8.4: Gram Staining:

Microorganisms were intended to be identified via Gram Staining. The slide was screened with a 10X magnification on the dried smear. Following that, an oil drop was added to the slide, and it was examined with a 100X oil immersion lens.
In gram-stained smear, positive cocci appear purple-colored sphere-shaped, while some bacteria appear pink-rod shape. The details are given in table: 4.6.

3.8.5: Identification of Microorganisms:

Identification of microorganisms was done through the catalase test for Gram Positive bacteria, the oxidase test for Gram negative bacteria, and the biochemical standard test for Oxidase negative sample. The test was run according to standard protocol. The details are given in Table: 4.6.

3.8.5.1: Catalase Test:

The catalase test is used to distinguish the presence of gram-positive cocci; either the cocci are staphylococcus or streptococcus. Certain bacteria have the incredible ability to produce catalase, an enzyme which helps in removing toxins. This robust enzyme converts harmful hydrogen peroxide into harmless water and oxygen gas. The formation of bubbles is proof of this procedure. This test is simple to carry out; simply integrate bacteria and H2O2.

3.8.5.2: Oxidase Test:

Microorganisms are oxidase-positive when the shade turns to blue within 15 to 30 seconds. When the color changes to purple within 2 to 3 minutes, microorganisms are delayed oxidase-positive. If the color remains unchanged, the microorganism is oxidase-negative. It was used to detect the presence of gram-negative rods on health professionals' uniforms.

3.8.5.3: Biochemical Standard Test:

Well-isolated gram-negative colonies from nutrient and McConkey agar plates were inoculated in a biochemical tube (TSI, Citrate, Urease, Motility, MR, MR-VP, & Indole). These tubes were transferred into the panel, resealed, and incubated at 37 ^{o}C for 24 hours. After 24 hours, the panel was

read after adding reagents to the mentioned activities. These microorganisms were identified as Proteus mirabilis, E-Coli, and Klebsiella. The details are given in Table: 4.7.

3.8.6: Intervention

The interventional group's uniforms were disinfected with 3% hydrogen peroxide (H_2O_2), while the control group's uniforms were disinfected with a domestic wash procedure. Following intervention, a sterile culture swab was used to collect a sample from both sets of uniforms (interventional and control). The swab was replated on Nutrient agar and MacConkey agar plates to assess the growth of microorganisms.

To evaluate the effectiveness of disinfection, the microorganism growth on the uniform after domestic washing was compared with the microorganism growth following disinfection with 3% H_2O_2. Furthermore, a comparison was made between the frequency of the microorganisms prior to and following intervention.

Washing Method	Time	Temperature	Disinfectant / Detergent
Conventional Domestic Wash	15 Mints	40 °C	30 g/kg of detergent
Chemical Wash	15 Mints	40 °C	30 g/kg detergent + 5 ml/kg of disinfectant (3% H_2O_2)

3.9: Ethical Considerations:

Subjects were assured that their participation in the study would be voluntary and that their identities would be kept anonymous. The participants were clarified about the aim and nature of the study and that they could withdraw from the study at any time. The information collected was kept strictly confidential and used solely for the purpose of this study.

3.10: Statistical Analysis:

The Statistical Package for the Social Sciences (SPSS) version-24 was used for analyzing the collected data. The bacterial count on health professional uniforms was estimated using the mean and standard deviation. The frequency and percentage were given for the categorical variables: domestic uniform disinfection and chemical washing of health professionals' uniforms. The frequency of disinfection of health professional uniforms was compared using a Chi-square test between the interventional group (chemical wash method) and the control group (domestic conventional approach), and a P-value $\leq$ 00.05 was considered significant.

CHAPTER-IV
RESULT OF THE STUDY

4.1 Overview of the Chapter

This chapter is intended to analyze and elaborate the collected data from the participants. The collected data has been tabulated and analyzed by using Statistical Package for Social Sciences (SPSS) version-25. The result is presented into two parts. The first part comprises of descriptive statistics and second part consists of analytical statistics. Descriptive statistics were used to calculate frequencies, percentage for qualitative variables while, mean and Standard Deviation (SD) was calculated for quantitative variables. And analytical statistics were used to assess the effectiveness of chemical wash of health professional uniforms verses domestic conventional wash of their uniform. The findings of this analysis are being presented in the form of charts, tables, columns keeping in view the nature of data collected through Data collection proforma. The tables and charts were further interpreted and elaborated for better understanding.

4.2 Descriptive Statistics

Table 4. 1: *Frequency of Distribution of groups*

Group-A (Conventional Wash group), Group-B (Chemical Wash group)		
	Frequency	Percent
Group A	32	50.0
Group B	32	50.0
Total	64	100.0

Table-4.1 shows that the frequency of distribution of both groups (conventional and interventional) are uniform, there was a total of 32 participants and their uniforms was cut vertically and divide in two equal parts. So, a total of 64 uniforms parts were the part of this study. Group-A (Conventional wash group) was considered as a control group, while group-B (Chemical wash group) was considered as an intervention group.

Table 4. 2: *Frequency of Distribution according to the Designation of the study Participants*

Designation of Participants		
	Frequency	Percent
Doctor	15	46.9
Nurse	17	53.1
Total	32	100.0

A total of 32 health professionals (Doctors & Nurses) were recruited for this study. Out of 32 health professionals 17 (53%) were nurses, and 15 (47%) were doctors, working in general wards of Shaikh Zayed Hospital Lahore.

Table 4. 3: *Distribution of Participants According to the unit placement*

Working Unit / Ward		
	Frequency	Percent
Medicine	09	28.1
Gastroenterology	05	15.6
Nephrology	07	21.9
Neurosurgery	2	6.3
Orthopedic	1	3.1
Urology	3	9.4
ENT	2	6.3
Private Rooms	3	9.4
Total	32	100.0

Table 4.3 shows that there were 09 (28.1%) participants from the general medicine ward, 05 (15.6%) from Gastroenterology ward, 07 (21.9%) from Nephrology Ward, 02 (6.3%) from Neurosurgery ward, 01 (3.1%) from Orthopedic ward, 03 (9.4%) from Urology ward, 2 (6.3%) from ENT ward, and 3 (9.4%) from Private Rooms. About 65% of the total population was from 3 wards General medicine, Gastroenterology and Nephrology.

Table 4. 4: *Frequency of Health Professionals According to their level of Education*

Education Level of Participant		
	Frequency	Percent
Diploma in Nursing	1	3.1%
Bachelor (BSN / MBBS)	21	65.6%
Post-Graduation	10	31.3%
Total	32	100.0%

Table 4.4 shown that most of the participants education level was graduation such as 21 (66%) of the health professionals' education was bachelor (06 were M.B.B.S while 16 were B.S.N), 10 (31%) was Post graduation, while only one participant education level was just diploma in nursing.

Table 4. 5: *Frequency of distribution according to the contact with patients/day*

Number of Patients to Contact	Frequency	Percent
1-5	08	25.0
6-10	06	18.8
11-15	05	15.6
16-20	05	15.6
21-25	04	12.5
26-30	04	12.5
Total	32	100.0

Table 4.5 show that the majority of participants 08 (25%) had contact with 01 to 05 patients in their duty duration, while 06 (18.8%) participants were that whose contact was with 06 to 10 patients in their duty duration, whereas some participants were contact with more than 10 patients during their duty hours. The mean number of participants contact with patients was 3.09 patients with (SD±1.73).

Figure 4. 1: *Frequency of Microorganism Presence Before Wash*

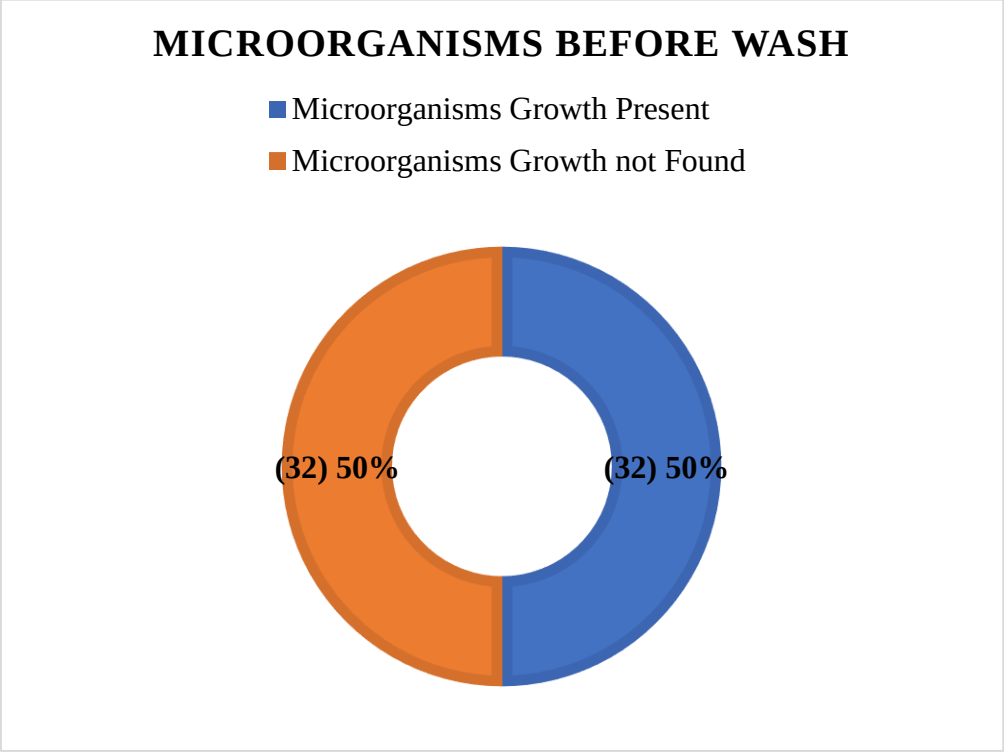


Figure 4.1: revealed that out of 64 uniform parts microorganisms found on 32 (50%) uniform before wash, in which 17 (53%) were from Control Group While 15 (47%) were from Interventional group. In positive sample the Doctors and Nurses ratio was 44:56. While, on the remaining 32 (50%) uniforms the microorganism's growth didn't find.

Figure 4. 2: *Frequency of Microorganism Presence After Wash*

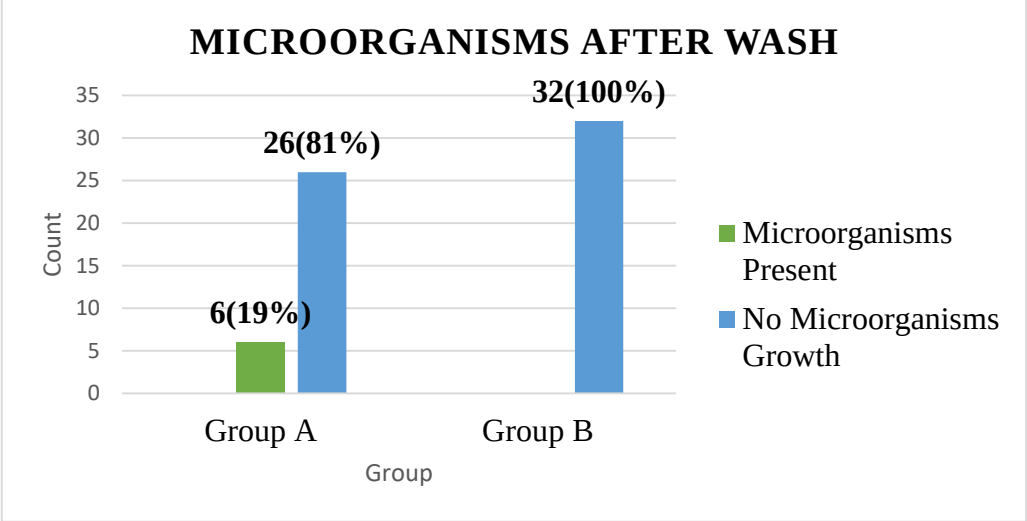


Figure 4.2: revealed that after wash of uniform of control group with detergent and interventional group with detergent + 3%-H_2O_2. The microorganisms were found on only 06 (19%) uniforms in control group, while in Interventional group there were no microorganisms found.

Table 4. 6: Types of Microorganism Before Wash

Types of Microorganisms before Wash		
	Frequency	**Percent**
Staphylococcus	25	78.125
Streptococcus	1	3.12
Escherichia coli	2	6.25
Proteus Mirabilis	3	9.37
Klebsiella	1	3.12
Total	32	100.0

Table 4.7: show that A total of 25 (78%) S. aureus strains were isolated from 32 samples. The highest number of S. aureus isolates (28%) were obtained from Gastroenterology wards followed by Nephrology wards (24%), Medical wards (16%), Urology and Private rooms (12%) and Neurosurgery and Orthopedic wards (4%). while 3 (09%) strains were Proteus Mirabilis, 02 (06%) E-Coli, and 01 (3%) were Streptococcus and Klebsiella.

Figure 4. 3: *Types of Microorganism After Wash*

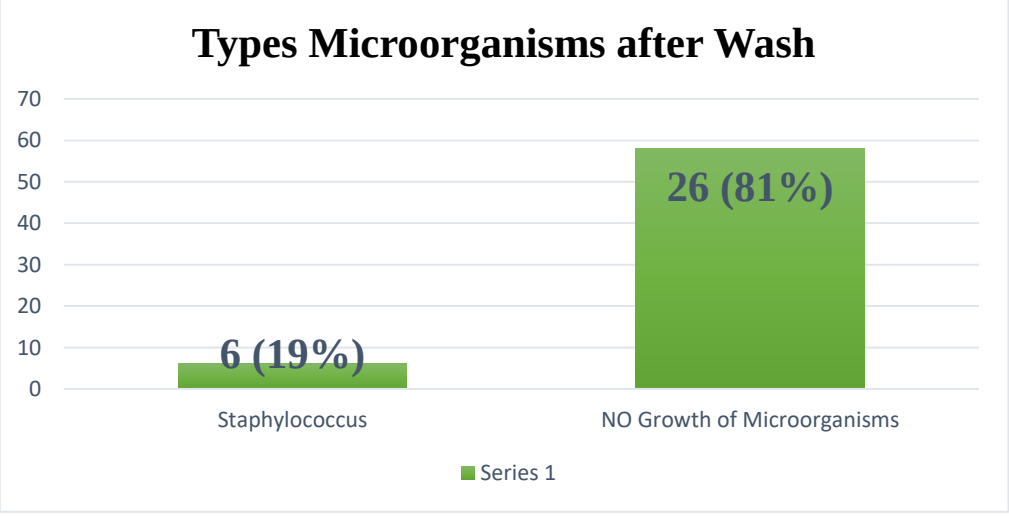


Figure 4.3: revealed that after washing uniforms with detergent only 06 (19%) uniforms remain positive in control group in which only Staphylococcus Aureus strains were isolated from that samples. While in 26 (81%) uniforms there was no growth found of microorganisms.

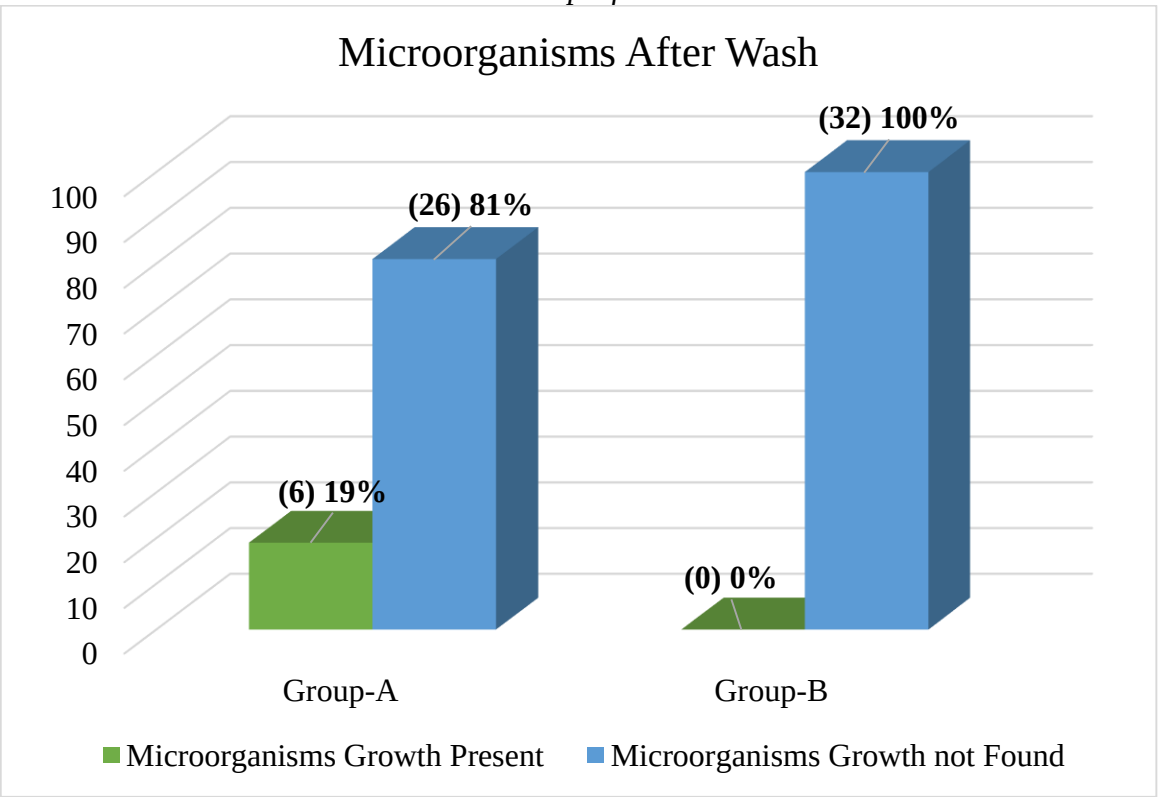
4.3: Comparison between Control and Interventional Group

***Table 4. 7**: Comparison between Control (Conventional Wash) Versus Interventional Chemical Wash group before Wash*

Microorganisms before Wash			
	Microorganisms Present	**No growth of Microorganisms**	**P-Value**
Control (Conventional Wash) Group	17 (53.1%)	15 (46.9%)	0.83
Intervention (Chemical Wash) Group	15 (46.9%)	17 (53.1%)	
Total	32 (50%)	32 (50%)	

Out of 32 in control group 17 (53%) were positive for microorganism's growth while 15 (47%) were negative. In intervention group 15 (47%) were positive while 17 (53%) were negative for microorganism's growth. although the association were not statistically significant (P-value = 0.83). which revealed that control and intervention groups were equally infected.

***Figure 4. 4:** Comparison between Control (Conventional Wash) Versus Interventional Chemical Wash Group After Wash*



Out of 32 in control group 06 (19%) were positive for microorganism's growth while 26 (81%) were negative. In the intervention group no microorganism's growth found. However, the association was statistically highly significant (P-value = 0.024). Thus, the null hypothesis that "there is no significant differences in the microbial decontamination of health professionals' uniform through germicidal chemical disinfection and conventional domestic wash" is rejected.

Table 4. 8: *Comparison between type of microorganisms in Control (Conventional Wash) Versus Interventional Chemical Wash Group before Wash*

		Types of Microorganisms before Wash					P-Value
		Staphylococcus	Streptococcus	Escherichia coli	Proteus Mirabilis	Klebsiella	
Control (Conventional Wash) Group	Count	12	1	2	1	1	0.48
	%	37.5%	3.1%	6.3%	3.1%	3.1%	
Intervention (Chemical Wash) Group	Count	13	0	0	2	0	
	%	40.6%	0.0%	0.0%	6.3%	0.0%	
Total	Count	25	1	2	3	1	
	%	39.1%	1.6%	3.1%	4.7%	1.6%	

Before wash the health professional uniform of intervention and control group was almost equally infected by different microorganism, from control group the following microorganism's species was isolated Staphylococcus 38%, Streptococcus 3%, Escherichia Coli 6.3%, Proteus Mirabilis 3%, Klebsiella 3%. While from intervention group Staphylococcus 41%, and Proteus Mirabilis 6% was isolated. However, the association is not statistically significant (P-value = 0.48).

Table 4. 9: *Comparison between type of microorganisms in Control (Conventional Wash) Versus Interventional Chemical Wash Group before Wash*

Types of Microorganisms before Wash			
	Staphylococcus	**NO Growth of Microorganisms**	**P-Value**
Control Group	6 (19%)	26 (81%)	0.012
Interventional Group	0 (0%)	32 (100%)	
Total	6	58	

Table 4.10 shows that after washing the health professional uniform, intervention group with detergent + 3% H_2O_2 and control group with only detergent only 6 (19%) Staphylococcus species were isolated. While in intervention group there were no growth of microorganisms found. However, the association is highly statistically significant (P-value = 0.012) which proves that uses of 3% H_2O_2 with detergent for the laundering of health professional uniform are effective.

CHAPTER-V
DISCUSSION

In this chapter, key findings of the study will be discussed in the context of literature relevant to the current study topic, "Comparison of Decontamination by Conventional Domestic Wash versus Chemical Wash of Health Professional Uniform and its relationship with Frequency of Microorganisms on their Uniform". It also provides recommendations for future studies.

The study on the persistence of pathogens on hospital clothing following the local wash is highly varied and contradictory. Several factors like water temperature, bleach usage, and drying method significantly influence microbial contamination reduction in laundering health personnel uniforms at home, thus leading to conflicting findings on the effectiveness of this practice. (McQueen and Ehnes, 2022).

Literature is also evident of the high frequency of microorganisms on the unlaundered Health-care Professionals' (HCPs') white coats and uniforms. The most prevalent bacteria are *Acinetobacter Lwoffii, Micrococcus Luteus,* and *Staphylococci.* Although the bioburden of Gram-negative and -positive pathogenic bacteria can be reduced after domestic laundry, but not completely (Bockmühl et al., 2019).

The results are discussed in two sections: Frequency & Type of Microorganism Presence Before and After Wash.

5.1: Frequency & Types of Microorganism Presence Before Wash

In the present study, microorganisms were found to be present on 50% of uniforms after one complete shift of duty hours, of which 17 (53%) were from the control group and 15 (47%) were from the interventional group. Before washing those infected uniforms, 25 (78%) staphylococcus aureus strains were isolated from 32 samples. The gastroenterology wards had the most S. aureus isolates (28%) followed by nephrology wards (24%), medical wards (16%), urology and private rooms (12%), and neurosurgery and orthopedic wards (4%). while 3 (09%) strains were Proteus mirabilis, 02 (06%) were E-Coli, and 01 (3%) were Streptococcus and Klebsiella. The results of this study align with several investigations conducted in Pakistan, which revealed that *S. aureus* contamination of hospital ambient areas is 28.7% (Shaheen and Baqai, 2016), 32% (Khan et al., 2018), 29% (Khattak et al., 2015), and 40% (Zaib et al., 2019). Moreover, several studies have demonstrated that *S. aureus* is a pathogen that is often identified in healthcare settings and that nurses' uniforms, when washed at home, serve as a significant channel for propagation of healthcare-acquired infections (HCAIs) (Lena et al., 2021a).

Svetanoff and colleagues reported that 39% of home-laundered uniforms were infected with bacteria at the beginning of the work shift, as vancomycin-resistant enterococci, methicillin-resistant *Staphylococcus aureus*, and *Clostridioides difficile*, indicate that the laundering processes for uniforms may not have been sufficient (Svetanoff et al., 2021). The pre-wash contamination levels for the 45 selected uniform prints in the domestic washing group were found to be higher than those in the chemical wash group (Owen and Laird, 2021).

5.2: Frequency & Types of Microorganism Presence After Wash

After washing the uniforms of the control group with detergent and the interventional group with detergent + 3%-H_2O_2 microorganisms were found to be present on six (19%) uniforms in the control group, and only Staphylococcus aureus strains were isolated from those samples. While in the interventional group, there was no growth of microorganisms. Our findings align with a study that found an array of bacteria, such as *Staphylococcus aureus and Escherichia coli*, on nurses' uniforms that were washed at home following domestic laundering procedures. According to the data, both bacteria demonstrated the ability to endure on polyester for a maximum of seven days and on cotton for a duration of 21 days (Panta et al., 2019).

In a related investigation, textile samples were infected with substantial bacterial counts (108) to simulate and then washed with detergent to see if cross-contamination might happen during washing. The majority of the pathogens were eliminated upon washing, but over 1,000 cells remained, whereas an equivalent amount were relocated to the sterile objects (Laird et al., 2018). This demonstrates the possibility of cross-contamination in domestic laundered uniforms, which could recontaminate the home and/or healthcare setting.

The current study identified that the frequency of microorganisms after domestic washing with detergent was 19% which shows that there is a chance of cross-contamination and that microorganisms can transmit to other media. The study is supported by prior investigations, which revealed that cross-contamination is possible during washing due to the presence of microorganism-soiled items (Huang et al., 2020). Various physical and chemical factors help eliminate pathogens while washing. As the soaps and detergents release soil, their antibacterial properties help in the elimination of microorganisms. The heat from washing, drying, and ironing also helps in eradicating some of the microbes and preventing further contamination. Studies have shown that chemical laundry in hospitals reduces microbiological contamination to a satisfactory level (Landeck et al., 2020).

Another study found that cross-contamination happened when sterile and infected fabric samples were laundered at home and some Escherichia coli and Staphylococcus aureus germs survived (Chiereghin et al., 2020b). A survey indicated that 91% of respondents (242/265) didn't utilize germicidal

chemicals for laundry, probably due to the social impression that detergent is vital for washing clothes and that doing laundry without detergent may be unhygienic (Ayalew et al., 2019).
Moreover, domestic laundry increases cross-contamination risk due to infections in washing machines and contaminated uniforms stored at home, potentially contaminates other clothing and home surfaces. (Laird et al., 2018).
This study confirms that washing health professionals' uniforms with detergents + 3% H_2O_2 at the hospital level ensures complete decontamination of clothing, and while utilizing a hospital laundry facility, the chances of cross-contamination are very low. According to further studies, this study revealed that contrary to chemical methods, home laundering was found to be less potential in fully removing bacteria from health professional uniforms (Gupta et al., 2019a).
In conclusion, using domestic laundering to reduce microorganisms on health professionals' uniforms proved less effective than using chemical alternatives. Chemical washing was effective in total eradication of all bacteria. However, it is also identified that about 78% of *S. aureus* strains were isolated from the positive cases.

Recommendations:
On the basis of the study's findings, the following recommendations are made:

- At the time of induction, the health professional shall be provided guidelines for uniform usage and its laundering.
- The government should enact policies for safe laundering of uniforms, such as that the uniforms should be laundered with 3% H_2O_2 along with detergents.
- Separate uniforms from other clothing when washing and storing them.
- Before the commencement of the next shift, uniforms must be washed within twenty-four hours.
- The study did not evaluate the potential transfer of residual bacteria on uniforms to patients after being washed at home, and its impact on the safety of healthcare workers and patients, thus for those areas, further research should be preferred.

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