**EVALUATION OF HEALTHCARE WASTE MANAGEMENT AND LAB BENCH SURFACES IN ESUT TEACHING HOSPITAL**

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**ABSTRACT**

Inadequate HCW management and lab bench hygiene is one of the leading causes of nosocomial infection in the hospital. This study aims to evaluate the current HCW management, evaluate the laboratory bench surface at ESUTH. This is a crossectional study involving quantitative and qualitative data collection, carried out at ESUTH between 1stJuly – 27thNovember 2024. Ethical clearance and informed consent were obtained. Data was collected using a pretested questionnaire and 150 samples were swabbed from 5 labs across the hospital, before and after the benches were cleaned. The samples were cultured using Mannitol salt agar, Blood agar & MacConkey agar. The results were analysed using standard method, the isolates were subjected to Biochemical identification and Antibacterial susceptibility of the results obtained. In order of prevalence, bacteria found before the lab benches were cleaned was Staphylococcus aureus at 76%, Escherichia coli at 15%, Proteus mirabilis at 5% and Pseudomonas aeruginosa at 4%. The bacteria found after the benches were cleaned was Staphylococcus aureus at 78% and at 22% with a frequency of 14 and 4. Before cleaning, microbiology lab had the most prevalent bacteria growth with staphylococcus aureus at a frequency of 21, Escherichia coli at 6, Proteus mirabilis at 4 and pseudomonas aeruginosa at 2. Followed by Chemical pathology, then Haematology, Histopathology and phlebotomy. 20 (100%) of respondents agreed that the lab benches were cleaned daily, while only 16 (80%) attested to the benches being cleaned after each use. 7 (14%) of the respondents always segregated waste into the appropriate category, 11 (22%) did so sometimes, and 32 (64%) never segregated waste. Findings of this study revealed that 51% of the respondents indicated they received training on HCWM only once after employment, 24% indicated they never received any training. These findings concur with that of the referenced articles in this study. These findings emphasize the current need for improved waste segregation practices, regular training for HCWs and stringent monitoring of hygiene protocols.

**Keywords:** Healthcare wase, Healthcare waste management, lab bench surface, Nosocomial infections.

**Introduction**

Hospital is the place, which is frequently accessed by the people irrespective of age, sex, race, religion, region and even nationality (susan et. al., 2018). Healthcare waste, also known as medical waste or biomedical waste, is defined as all forms of waste arising from activities within health care facilities, research canters, and laboratories related to medical procedures (Ezeudu et. al., 2022). Healthcare waste (HCW) is the second most hazardous waste after radiation waste, Globally HCW requires proper management by healthcare workers (HWs) because of its infectious nature and potential threats to cause diseases (Aworh et. al., 2022). Proper management of healthcare waste in any given society is an essential part of ensuring that health and social care activities do not pose a risk of infection to man and the environment. Therefore, healthcare wastes if not properly managed can constitute a greater threat than the original diseases themselves (Agbanusi u. j. 2022). According to research, about 85% of HCW is general, non-hazardous waste which is similar to domestic waste; while 15% is considered hazardous material that may be infectious, toxic or radioactive. Furthermore, the hazardous components include infectious waste, pathological waste, cytotoxic waste, chemical waste, pharmaceutical waste, sharps, radioactive waste. HCW management is a principal component of healthcare service delivery however, In the absence of standard prescriptive guidelines for timely disposal, HCW may pose significant health hazards by polluting the environment and leading to some diseases, injuries and outbreaks of epidemics in the community. The World Health Organization (WHO) estimates 8 to 16 million new Hepatitis B virus (HBV) cases, 2.3 to 4.7 million Hepatitis C virus (HCV) cases and 80,000 to 160,000 new cases of Human Immunodeficiency Virus (HIV) cases yearly due to unsafe injection disposal and poor waste management systems (Ekanem et. al., 2021). The segregation of waste is achieved using a uniform colour-coding system to categorize the collected waste and also provides a visual indication of the potential risk posed by the waste in the container. It also makes it easier for hospital workers to put waste items into the correct container as well as maintain segregation of the wastes during transport, storage, treatment and disposal. The containers for collection and storage are meant to be leak-proof. In the minimum recommended standard of segregation by the WHO, the “three-bin system”, general non-hazardous waste is collected in one bin, sharps waste are collected in another bin and potentially infectious waste collected in another bin, each having a different colour code and labelled for easier identification by those who generate the waste (Ekanem et. al., 2021), In addition, it has long been documented that many inanimate surfaces can serve as grounds for the growth and proliferation of various bacterial species. These fomites may include objects that are subject to repetitive touching by hands, things like sinks, doorknobs, cutting boards, and computer keyboards (Ayman et. al., 2021). In the course of laboratory activities, workbench surfaces could be contaminated (Sule et. al., 2018). The fast transmission of hospital germs from patient to patient, healthcare workers to patients, and inanimate surfaces to all bodies is aided by contamination of the inert surfaces of the hospital environment, healthcare workers (HCWs), and medical equipment (Nwankwo et. al., 2022). However, studies has shown that laboratory work benches were contaminated via transfer of microorganisms from the lab technicians’ hands to the working surface area during handling of the microorganisms that they were currently working with (Siti et. al., 2019). Microorganisms are present on inanimate surfaces creating ubiquitous sources of possible contamination in the laboratory. Laboratory acquired infections (LAIs) refer to all infections acquired through laboratory work or laboratory-related activities with or without the onset of infections, and result from occupational exposure to infectious agents. It can also be referred to as occupational illness. Reports have indicated that bacteria account for more than 40% of infections. The laboratory-acquired infections mostly reported were primarily due to bacteria, viruses, and fungi (Sule et. al., 2018).

The health status of Nigerian citizens, especially in less developed areas, is still at risk. One of the key underlying reasons why the public health problem is the challenge faced by Nigerian hospitals is because of the lack of knowledge of health hazards related to healthcare waste, inadequate training in proper waste management, lack of waste management and recycling programs, insufficient financial and human capital, and the low priority provided to the issue (Olukanni et. al., 2022). Also, mixing of general waste with any infectious or hazardous waste contaminates the waste thereby making segregation difficult and such waste must be treated as though it is infectious or hazardous. However, many microorganisms may be transferred to hands or other exposed areas of the body, causing infections. Medical laboratories are a clinical setting where samples like sputum, blood, urine and stool often come from possibly infected patients and thus may lead to the contamination surfaces in the laboratory (Ayman et. al., 2021). Microbial contamination of surfaces such as door handles, telephones and computer keyboards has also been reported in the clinical settings laboratories, These sources of contamination would increase the risk of adverse health effects to the laboratory users especially as the infectious microorganisms has the ability to remain in these surfaces for a certain period of time depending on the type of microorganisms. These contaminants could be spread further by the users and could be transferred to other surfaces or person through contact especially when good laboratory practices were compromised (Siti et. al., 2019). The problem at hand, is the potential impact of poor healthcare waste management system of the largest state teaching hospital on the citizens of Enugu state. However, poor HCW management in ESUTH, can expose healthcare workers, patients and surrounding communities to infections. Also, poor healthcare management can increase the risk of nosocomial infections, which can also be as a result of contaminated lab benches. Contaminated lab benches and lab surfaces can pose a threat to the healthcare workers, patients and surrounding communities.

Globally HCW requires proper management by healthcare workers (HWs) because of its infectious nature and potential threats to cause diseases. Gaps exist regarding HCW management (HCWM) practices in sub-Saharan Africa hence requiring the understanding of hospital personnel especially because of the dangers associated with this special type of waste. However, for proper HCWM, the HWs need to be properly trained and made aware of the associated risks. The nature of HCW as well as practices regarding sustainable HCWM methods like waste segregation and waste recycling, are often poorly examined and documented in several countries despite the health risks posed by the improper handling of these wastes. For example, in Nigeria, the level of awareness of HWs regarding HCWM has not been adequately documented (Aworh et. al., 2022). The role of surface contamination in the transmission of nosocomial pathogens is being recognized increasingly. Contaminated surfaces act as reservoirs on which microorganisms can survive for several months, increasing the risk of cross-contamination through direct or indirect contact with patients (Otter et. al., 2014). These infections are often caused by breaches of infection control practices and procedures, unclean and non-sterile environmental surfaces, and/or ill employees. Healthcare surfaces and wastes act as the store house of harmful infectious pathogens. Potential health risk includes spreading of diseases by these pathogens and wide dissemination of antimicrobial resistance genes (Susan et. al., 2018). Laboratory-acquired infections (LAIs) result from occupational exposure to infectious agents. Reports have indicated that bacteria account for more than 40% of infections. The laboratory-acquired infections mostly reported were primarily due to bacteria, viruses, and fungi. This research is of importance since in the course of laboratory activities, workbench surfaces could be contaminated. Therefore, it is necessary to know the level of safety of laboratory workbench surfaces (Sule et. al., 2018). This research is therefore aimed at evaluating the current HCWM practices, evaluating the lab bench surfaces and identifying bacteria on the lab bench surfaces in ESUTH.

**Materials & Methods**

This study was carried out in Enugu State University Teaching Hospital (ESUTH) Enugu North, Enugu, Nigeria. The cross-sectional study, was conducted using quantitative and qualitative data collection methods and research methods, involving healthcare workers, healthcare facility and labs at ESUT, Parklane, Enugu State. Demographic information and awareness were gathered using questionnaires. The hospital-based study was carried out through healthcare workers (doctors, nurses, laboratory staff, cleaners, etc), and from laboratory benches across ESUT Teaching Hospital.

**Sample Size**

The sample size was determined using the sample size formula by Taro Yamane (1979) which is:

n = N/(1+N(e)2.

Where; n: the required sample size from the population study,

 N: the total population under study,

e: the precision or sampling error at 95% confidence level which is 0.05.

Where N is 362 (Chinawa *et al.,* (2020), Our population estimate gotten from a previous study,)

Thus: 362/(1+510(0.05)2

 = 145.

The minimum sample size after calculation is 145 respondents.

Thus, the total sample size to be used is 150.

**Inclusion criteria**

1. Lab bench surfaces of labs across the hospital.
2. Health care workers.

**Exclusion criteria**

1. Labs outside the hospital.
2. Waste generated outside the hospital.
3. Health care workers not directly involved in lab procedures or Healthcare waste.
4. Unused labs and lab benches.

**Materials**

Materials that were used include; Sterile swab sticks, Petri-dish, Weighing balance, Autoclave, Hot air oven, Candle jar, Refrigerator, Antibiotic sensitivity disk, Wire loop, Forceps, Slides, Pasteur pipette, Gloves, Bunsen burner, Cotton wool, Gram staining and Biochemical reagents.

**Sampling technique**

Stratified random sampling technique was used in this study to select a representative sample of lab bench surfaces, healthcare waste management practices and health care workers for the questionnaire.

**Data/Sample collection**

The questionnaire respondents were chosen at random for this research. The sample was collected by me, from laboratory benches across the 5 labs in the the hospital, and the sample was collected from lab bench surfaces before the benches were cleaned and after the benches were cleaned. The sample was taken to the microbiology laboratory ESUTH within two hours of collection.

**Laboratory analysis**

The swabbed benches were analysed in the microbiology laboratory, ESUTH. Specimens were immediately cultured upon arrival in the laboratory.

**Culture and Microscopic Examination**

At the laboratory, the culture media was prepared by reconstituting the commercial powder in distilled water and sterilizing at 121oC for 15 minutes in an autoclave according to the manufacturer’s instructions and poured in petri dishes up to a depth of 4mm then allowed to cool. The inoculums were applied to a small area then spread by streaking out using a sterile wire loop to give single colonies. Blood agar, Mannitol salt agar and MacConkey media were used. All inoculated plates were labelled and incubated at 37°C for 24 hours for the organisms to grow. Specimens were inoculated on blood agar and plates were placed in a CO2 candle jar and incubated for identification. Identification of the bacteria was done using the recommended standard procedures. A sterile wire loop was used to pick a single colony and make a smear on a grease free slide. The smear was air dried, heat fixed and stained by Gram’s stain, in order to group pathogens into Gram positive and Gram negative depending on ability of bacterial cell to retain primary stain. The stained slides were examined microscopically under oil immersion lens for bacterial cells and then quantified as No. of cells/High power field. Isolated colonies were sub-cultured on Mueller Hilton agar for biochemical testing at 37°C for 48hours.

**Identification of Microorganisms Isolated**

Preliminary identification of bacteria was based on the colonial characteristics of the organism considering colonial morphology, haemolysis on chocolate and blood agar, changes in the physical appearance of the differential media and Gram staining. Biochemical tests were performed on colonies.

**Determination of antibacterial activity**

After 24 hours each plate was examined and growth zones were measured to the nearest millimetre, using a measuring rule which was held at the back of the inverted media plate. The Petri dish was held a few inches above a black, non- reflecting background and illuminated with reflected light. The inhibition zone margins were taken as the area showing no obvious, visible growth that could be detected with the unaided eye. Faint growth of tiny colonies, which could be detected only with a magnifying lens at the edge of the zone of inhibited growth, was ignored. However, discrete colonies growing within a clear zone of inhibition were sub cultured, re-identified, and retested. The results were reported as sensitive, intermediate or resistant to the agents that had been tested. Plates were

incubated and maintained at 33-35°C for 18-24 hours. Results were interpreted according to CLSI guidelines (CLSI, 2010).

**Data collection**

Data was collected on the time of sample collection being before and after the lab benches were cleaned.

**Quality Control**

Specimen collection and inoculation onto culture media was done aseptically to minimize contamination. All culture media were prepared according to the manufacturer’s instructions and shown in the appendix. Three plates of each batch were incubated at 37°C for 48 hours to check for sterility. Negative and positive controls were included to validate the biochemical reagents/test kits. Standard quality control procedures were observed in carrying out tests and reading the results.

**Ethical Considerations.**

1. Ethical clearance for the study was obtained from Ethical committee, ESUTH, Enugu State.
2. Politeness: I was very polite and respectful, while interacting with the respondents.

**Statistical analysis**

Data obtained was analysed using the statistical package for social science (SPSS Inc., Chicago, IL, USA) for windows software version 21. Continuous variables will be presented as means and standard deviations while categorical variables will be presented as numbers (percentages). Comparison between means will be carried out using the student's t-test while comparison between percentages was carried out using chi square test. One-way Analysis of variance (ANOVA). The level of statistical significance will be set at a P value less than 0.05

**Results**

**Table 1: Demographic Data (n = 50)**

|  |  |  |
| --- | --- | --- |
| Variables | Frequency | Percentage |
| Gender |  |  |
| - Male | 5 | 10 |
| -Female | 45 | 90 |
| Age |  |  |
| -18–29 | 2 | 4 |
| -30–39 | 33 | 66 |
| -40–49 | 15 | 30 |
| -50+ | 0 | 0 |
| Occupation |  |  |
| - Doctor  | 8 | 16 |
| - Nurse  | 10 | 20 |
| - Laboratory Scientist  | 20 | 40 |
| -Cleaner  | 12 | 24 |
| Years of Work Experience |  |  |
| -< 1 year | 0 | 0 |
| - 1–5 years | 7 | 14 |
| - 6–10 years | 27 | 54 |
| -> 10 years | 16 | 32 |

Table 1 presents the demographic characteristics of the respondents. Among the 50 participants, 45 (90%) were female and 5 (10%) were male. In terms of age, the majority were aged 30–39 years 33( 66%), followed by 40–49 years 15(30%), while 2(4%) were in the 18–29 age group, and no participants were aged 50 and above. Regarding occupation, 20 (40%) were laboratory scientists, 12 (24%) were cleaners, 10 (20%) were nurses, and 8 (16%) were doctors. In terms of work experience, the majority had 6–10 years of experience (27 or 54%), followed by >10 years (16 or 32%), while 7 (14%) had 1–5 years of experience, and no participants had less than 1 year of work experience.

**Table 2: Knowledge of healthcare workers regarding healthcare waste management at ESUTH, Parklane (n = 50)**

|  |  |  |
| --- | --- | --- |
| Variables | Frequency | Percentage (%) |
| Are you familiar with the term “healthcare waste management”? |  |  |
| -Yes | **50** | **100** |
| -No | **0** | **0** |
| What are the categories of healthcare waste? |  |  |
| -Infectious waste | **50** | **50** |
| - Non-infectious waste | **50** | **50** |
| - Hazardous waste | **0** | **0** |
| - Radioactive waste | **0** | **0** |
| Do you know the color-coding system for healthcare waste segregation? |  |  |
| -Yes | **37** | **74** |
| -No | **13** | **26** |
| What are the risks associated with improper healthcare waste management? |  |  |
| -Spread of infections | **17** | **34** |
| -Environmental pollution | **7** | **14** |
| -Injuries from sharps | **4** | **8** |
| -All of the above | **22** | **44** |
|  Have you received training on healthcare waste management? |  |  |
| - Yes | **44** | **88** |
| -No | **6** | **12** |

Table 2 presents the knowledge of healthcare workers regarding healthcare waste management at ESUTH, Parklane. All 50 (100%) respondents were familiar with the term "healthcare waste management." When asked about the categories of healthcare waste, 50 (50%) identified infectious waste and non-infectious waste, while 0% mentioned hazardous waste or radioactive waste. Regarding the color-coding system for healthcare waste segregation, 37 (74%) of respondents were aware of it, while 13 (26%) were not. In terms of the risks associated with improper healthcare waste management, 22 (44%) identified all of the above (spread of infections, environmental pollution, and injuries from sharps) as risks, while 17 (34%) mentioned the spread of infections, 7 (14%) identified environmental pollution, and 4 (8%) mentioned injuries from sharps. Furthermore, 44 (88%) of respondents had received training on healthcare waste management, while 6 (12%) had not.

**Table 3: Attitudes of healthcare workers regarding healthcare waste management at ESUTH, Parklane (n = 50)**

|  |  |  |
| --- | --- | --- |
| Variables | Frequency | Percentage |
| Do you think healthcare waste management is important? |  |  |
| -Yes | **50** | **100** |
| -No | **0** | **0** |
| Who do you think is most responsible for proper healthcare waste management? |  |  |
| - Individual healthcare workers | **46** | **92** |
| - Hospital administration | **4** | **8** |
| -Government authorities | **0** | **0** |
| How often are healthcare workers trained on healthcare waste management in your facility? |  |  |
| Only once after employment | **23** | **51** |
| Occasionally | **9** | **20** |
| Regularly | **2** | **4** |
| Never | **11** | **24** |
| Do you believe the current waste management practices in ESUTH, Parklane, are adequate? |  |  |
| -Yes | **7** | **14** |
| -No | **4** | **8** |
| -Not sure | **39** | **78** |
|  |  |  |

Table 3 presents the attitudes of healthcare workers regarding healthcare waste management at ESUTH, Parklane. All 50 (100%) of the respondents affirmed that healthcare waste management is important. When asked about responsibility for proper waste management, 46 (92%) of the respondents felt that individual healthcare workers should take the primary role, while 4 (8%) believed the hospital administration should be most responsible. No respondents (0%) thought that government authorities were primarily responsible.

Regarding the frequency of training on healthcare waste management, 23 (51%) of the respondents reported receiving training only once after employment, 9 (20%) indicated occasional training, 2 (4%) stated they were trained regularly, and 11 (24%) had never received any training on the subject.

In evaluating the adequacy of current waste management practices at ESUTH, Parklane, the majority of respondents, 39 (78%), were unsure about their adequacy, 7 (14%) felt that the practices were adequate, and 4 (8%) disagreed with this view.

**Table 4: Practice of healthcare workers regarding healthcare waste management in ESUTH, Parklane (n = 50)**

|  |  |  |
| --- | --- | --- |
| Variables | Frequency | Percentage (%) |
| How often do you segregate waste into appropriate categories? |  |  |
| -Always | 7 | 14 |
| -Sometimes | 11 | 22 |
| -Rarely | 0 | 0 |
| -Never | 32 | 64 |
| What is the most common method used for treating and disposing of healthcare waste? |  |  |
| -Incineration | 26 | 52 |
| -Landfill disposal | 24 | 48 |
| -Autoclaving | 0 | 0 |
| -Chemical disinfection | 0 | 0 |
| How often do you use personal protective equipment (PPE) when handling healthcare waste? |  |  |
| -Always | 45 | 90 |
| -Sometimes | 5 | 10 |
| -Rarely | 0 | 0 |
| -Never | 0 | 0 |

Table 4 presents the practice of healthcare workers regarding healthcare waste management in ESUTH, Parklane. 7 (14%) of the respondents always segregated waste into appropriate categories, 11 (22%) did so sometimes, and 32 (64%) never segregated waste. 26 (52%) of respondents indicated that incineration is the most common method used for treating and disposing of healthcare waste, while 24 (48%) reported using landfill disposal. No respondents selected autoclaving or chemical disinfection as common methods. Regarding the use of personal protective equipment (PPE) when handling healthcare waste, 45 (90%) always used PPE, while 5 (10%) used it sometimes. No respondents reported rarely or never using PPE.

**Table 5: Lab Bench Surface Hygiene (n=20)**

|  |  |  |
| --- | --- | --- |
| Variables | Frequency | Percentage (%) |
| How often are lab bench surfaces cleaned and disinfected? |  |  |
|  - Daily | 20 | 100 |
|  - Weekly | 0 | 0 |
| - Monthly | 0 | 0 |
| What cleaning agents are used for lab bench surfaces?  |  |  |
|  - Bleach | 15 | 75 |
|  - Disinfectant spray | 3 | 15 |
|  - Soap and water | 2 | 10 |
| Are lab bench surfaces properly disinfected after each use? |  |  |
| -Yes | 16 | 80 |
| -No | 4 | 20 |
| Are there any visible signs of contamination or spills on lab bench surfaces |  |  |
| -Yes | 17 | 85 |
| -No | 3 | 15 |
| Are laboratory staff trained on proper cleaning and disinfection procedures? |  |  |
| -Yes | 20 | 100 |
| -No | 0 | 0 |

Table 5 presents the hygiene practices for lab bench surfaces in ESUTH, Parklane. All 20 (100%) of the respondents indicated that lab bench surfaces are cleaned and disinfected daily, with no respondents indicating they are cleaned weekly or monthly. Regarding cleaning agents, 15 (75%) of respondents indicated they use bleach, 3 (15%) indicated they use disinfectant spray, and 2 (10%) indicated they use soap and water for cleaning the surfaces. When asked if lab bench surfaces are properly disinfected after each use, 16 (80%) indicated yes, while 4 (20%) indicated no. In terms of contamination or spills, 17 (85%) of respondents indicated seeing visible signs of contamination on the surfaces, while 3 (15%) indicated they did not. Finally, all 20 (100%) of the laboratory staff indicated they were trained on proper cleaning and disinfection procedures.

**Table 6: Bacterial pathogens on different lab bench surfaces before cleaning in the laboratories at ESUTH Parklane**

|  |  |  |
| --- | --- | --- |
| Organism | Frequency | Percentage (%) |
| *Staphylococcus aureus* | 59 | 76 |
| *Escherichia coli* | 12 | 15 |
| *Proteus mirabilis* | 4 | 5 |
| *Pseudomonas aeruginosa* | 3 | 4 |

Table 6 shows the distribution of bacterial pathogens on different lab bench surfaces before cleaning in the laboratories at ESUTH Parklane. *Staphylococcus aureus* was the most prevalent pathogen, accounting for 59 cases (76%), followed by *Escherichia coli* with 12 cases (15%), *Proteus mirabilis* with 4 cases (5%), and *Pseudomonas aeruginosa* with 3 cases (4%). This indicates that Staphylococcus aureus is the dominant pathogen present on lab bench surfaces prior to cleaning.

**Table 7: Distribution of Bacterial Pathogens on Laboratory Bench Surfaces before cleaning in Different Laboratories at ESUTH Parklane**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Organism | Microbiology | Chemical pathology  | Haematology | Histopathology | Phlebotomy | Total |
| *Staphylococcus aureus* | **21** | 16 | **11** | **4** | **7** | 59 |
| *Escherichia coli* | **6** | **1** | **3** | 2 | **0** | 12 |
| *Proteus mirabilis* | **4** | **0** | **0** | **0** | 0 | 4 |
| *Pseudomonas aeruginosa* | **2** | **1** | **0** | 0 | **1** | 3 |

Table 7 shows the distribution of bacterial pathogens on laboratory bench surfaces before cleaning in different laboratories at ESUTH Parklane. *Staphylococcus aureus* was most commonly isolated, with the highest counts recorded in the Microbiology laboratory (21), followed by the Chemical Pathology laboratory (16). *Escherichia coli* was more prominent in the Microbiology laboratory (6), with smaller counts in Haematology (3) and Histopathology (2). *Proteus mirabilis* was exclusively found in the Microbiology laboratory (4). *Pseudomonas aeruginosa* was detected mainly in the Microbiology laboratory (2) and once in Phlebotomy (1). These findings suggest a higher burden of bacterial pathogens in the Microbiology laboratory compared to others.

**Table 8: Bacterial pathogens on different lab bench surfaces after cleaning in the laboratories at ESUTH Parklane**

|  |  |  |
| --- | --- | --- |
| Organism | Frequency | Percentage (%) |
| *Staphylococcus aureus* | 14 |  78 |
| *Escherichia coli* | 4 | 22 |

Table 8 shows the distribution of bacterial pathogens on different lab bench surfaces after cleaning in the laboratories at ESUTH Parklane. *Staphylococcus aureus* was the most prevalent pathogen, accounting for 14 cases (78%), followed by *Escherichia coli* with 4 cases (22%). This indicates that although cleaning was performed, Staphylococcus aureus remains the dominant pathogen on lab bench surfaces.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Organism | Microbiology | Chemical pathology  | Haematology | Histopathology | Phlebotomy | Total |
| *Staphylococcus aureus* | 13 | 0 | 0 | 1 | 0 | 14 |
| *Escherichia coli* | 4 | 0 | 0 | 0 | 0 | 4 |

**Table 9: Distribution of Bacterial Pathogens on Laboratory Bench Surfaces after cleaning in Different Laboratories at ESUTH Parklane.**

Table 9 shows the distribution of bacterial pathogens on laboratory bench surfaces after cleaning in different laboratories at ESUTH Parklane. *Staphylococcus aureus* was most commonly isolated, with the highest count recorded in the Microbiology laboratory (13), and a single occurrence in the Histopathology laboratory (1). *Escherichia coli* was exclusively isolated from the Microbiology laboratory (4). These findings highlight the predominance of bacterial pathogens, particularly *Staphylococcus aureus*, on bench surfaces in the Microbiology laboratory, suggesting a greater need for hygiene interventions in this area compared to others.

**Fig:1 Laboratory Bench Surfaces Before and After Cleaning**

**Table 10: Antimicrobial susceptibility pattern of *Escherichia coli* isolated from Lab Bench Surfaces.**

|  |  |  |
| --- | --- | --- |
| Antibiotics | Sensitive | Resistant |
| Nitrofurantoin | 6(37.5) | 10(62.5) |
| Gentamicin | 9(56.3) | 7(43.8) |
| Ciprofloxacin | 6(37.5) | 10(62.5) |
| Chloramphenicol | 1(93.8) | 15(93.8) |
| Ofloxacin | 11(68.8) | 5(31.3) |
| Clarithromycin | 11(68.8) | 5(31.3) |
| Pefloxacin | 8(50.0) | 8(50.0) |
| Ceftriaxone | 0(0) | 16(100) |
| Amoxicillin | 6(37.5) | 10(62.5) |
| Streptomycin | 6(37.5) | 10(62.5) |

**Table 11: Antimicrobial susceptibility pattern of *Proteus mirabilis* isolated from Lab Bench Surfaces.**

|  |  |  |
| --- | --- | --- |
| Antibiotics | Sensitive | Resistant |
| Nitrofurantoin | 0(0) | (100) |
| Gentamicin | 0(0) | 4(100) |
| Ciprofloxacin | 0(0) | 4(100) |
| Chloramphenicol | 0(0) | 4(100) |
| Ofloxacin | 0(0) | 4(100) |
| Clarithromycin | 0(0) | 4(100) |
| Pefloxacin | 0(0) | 4(100) |
| Ceftriaxone | 0(0) | 4(100) |
| Amoxicillin | 0(0) | 4(100) |
| Streptomycin | 0(0) | 4(100) |

**Table 12: Antimicrobial susceptibility pattern of *Pseudomonas aeruginosa* isolated from Lab Bench Surfaces.**

|  |  |  |
| --- | --- | --- |
| Antibiotics | Sensitive | Resistant |
| Nitrofurantoin | 0(0) | 3(100) |
| Gentamicin | 0(0) | 3(100) |
| Ciprofloxacin | 0(0) | 3(100) |
| Chloramphenicol | 0(0) | 3(100) |
| Ofloxacin | 0(0) | 3(100) |
| Clarithromycin | 0(0) | 3(100) |
| Pefloxacin | 0(0) | 3(100) |
| Ceftriaxone | 0(0) | 3(100) |
| Amoxicillin | 0(0) | 3(100) |
| Streptomycin | 0(0) | 3(100) |

**Table 13: Antimicrobial susceptibility pattern of *Staphylococcus specie* isolated from Lab Bench Surfaces.**

|  |  |  |
| --- | --- | --- |
| Antibiotics | Sensitive | Resistant |
| Erythromycin | 51(70) | 22(30) |
| Ceftriaxone | 53(72.6) | 20(27.4) |
| Ampicillin | 18(24.7) | 55(75.3) |
| Cloxacillin | 24(32.9) | 49(67.1) |
| Levofloxacin | 46(63.0) | 27(37.0) |
| Cephalexin | 30(41.1) | 43(58.9) |
| Ciprofloxacin | 44(60.3) | 29(39.7) |
| Gentamicin | 42(57.5) | 31(42.5) |
| Ofloxacin | 39(53.4) | 34(46.6) |
| Clindamycin | 37(50.7) | 36(49.3) |

**DISCUSSION**

This study sought to evaluate the current healthcare waste management system and lab bench surface hygiene at Enugu State University Teaching Hospital (ESUTH), Parklane, Enugu. Regarding the knowledge of healthcare workers about healthcare waste management, the findings revealed that all respondents (100%) were familiar with the term “healthcare waste management.”

Additionally, the study further revealed that infectious waste (25.5%), sharps (25.5%), and general waste (24.5%) were the most commonly highlighted categories of healthcare waste by the respondents, followed by chemical waste (14.3%) and radioactive waste (10.2%). These findings align with those of Ezeudu et al. (2022), whose study similarly categorized healthcare waste as sharps, infectious waste, chemical waste, and radioactive waste. This alignment may be due to the shared focus on the most prevalent waste categories across both studies. The consistency in these findings suggests that healthcare workers, regardless of the study setting, recognize the same critical waste categories, which is essential for improving waste management practices.

Waste segregation is a crucial first step in achieving waste reduction, cost reduction, and sustainable waste management. It provides the health facility with the means to evaluate its waste composition more accurately and positions the facility to implement practical strategies for healthcare waste management (Olukanni *et al*., 2022). A study conducted by Ezeudu *et al*. (2022) shows that waste segregation is more commonly practiced in Lagos than in any other state in the country, due to the existence of effective government health monitoring units and regulations in the state. The findings of this study corroborate these results, as the majority (64%) of the respondents were not aware of the color-coding system for healthcare waste segregation. This lack of awareness indicates a gap in the training and education of healthcare workers, which could hinder effective waste management practices. It highlights the need for improved education and awareness programs to ensure that healthcare workers are well-informed about proper waste segregation methods, especially in regions with less stringent regulations.

Findings of the study revealed that 51% of the respondents indicated they had received training on healthcare waste management only once after employment, while a considerable proportion (24%) indicated they had never received any training. These findings align with those of Ezeudu *et al*. (2022), who stated that in the majority of studies, the training of healthcare workers occurs only once after employment, with little or no subsequent training to update their knowledge. Furthermore, essential training on occupational health and safety is lacking, as evidenced by the fact that the majority of respondents (78%) in this study were uncertain about the current waste management practices in ESUTH, Parklane. This suggests that the training provided to healthcare workers in these facilities may be inadequate or not standardized according to WHO guidelines, potentially contributing to poor knowledge and practices in healthcare waste management in Nigeria (Ezeudu *et al*., 2022).

Incineration was found to be the most common method used for treating and disposing of healthcare waste, according to 52% of the respondents. These findings align with the study conducted by Ezeudu *et al*. (2022), which indicated that incineration appears to be the most favoured method because it quickly reduces about 90% of the waste. This alignment could be attributed to the fact that that incineration is an efficient method for significantly reducing the volume and potential hazards of healthcare waste, making it a preferred choice in facilities where proper waste management infrastructure is available.

 Before cleaning, *Staphylococcus aureus* was the most commonly isolated pathogen, with the highest occurrence in the Microbiology laboratory, followed by the Chemical Pathology laboratory. *Escherichia coli* was also predominantly isolated from the Microbiology laboratory, with fewer occurrences in Haematology and Histopathology. *Proteus mirabilis* and *Pseudomonas aeruginosa* were exclusively found in the Microbiology laboratory, with the latter also detected once in Phlebotomy. These results indicate that the Microbiology laboratory had the highest burden of bacterial contamination compared to other laboratories.

After cleaning, there was a notable reduction in bacterial counts. *Staphylococcus aureus* remained the most frequently isolated pathogen, predominantly in the Microbiology laboratory, with a single occurrence in Histopathology. *Escherichia coli* was exclusively detected in the Microbiology laboratory, with no presence in other laboratories. The observed reduction in bacterial counts, particularly for *Staphylococcus aureus*, highlights the importance of effective cleaning practices in minimizing contamination.

The findings emphasize the predominance of *Staphylococcus aureus*, a commensal bacterium that asymptomatically colonizes humans but can cause infections through direct contact or contaminated surfaces. *Escherichia coli* also remained a significant pathogen, particularly in the Microbiology laboratory. These results differ from those of Sule et al. (2018), who reported a broader range of bacterial species, including *Micrococcus sp*. and *Aerococcus sp*., alongside *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The discrepancies may be attributed to differences in cleaning methods, environmental conditions, or sampling techniques.

**Conclusion**

The findings revealed that while healthcare workers demonstrated a basic understanding of healthcare waste management, significant challenges remain, particularly in waste segregation, training frequency, and awareness of standard practices. Regarding lab bench hygiene, *Staphylococcus aureus* was consistently the most prevalent bacterium both before and after cleaning, likely due to its ability to survive on dry surfaces and its association with human skin. The persistence of *Escherichia coli* also indicates potential hygiene lapses. These findings emphasize the urgent need for targeted interventions, including improved waste segregation practices, regular training for healthcare workers, and stringent monitoring of hygiene protocols.

**Recommendation**

Regular and comprehensive training on healthcare waste management and lab hygiene should be implemented for all healthcare workers, Healthcare facilities should adopt standardized and consistent protocols for waste segregation, treatment, and disposal to reduce environmental and health risks. Awareness programs should also address the risks of bacterial persistence on lab surfaces, with a focus on improving cleaning and disinfection practices. Additional studies should be conducted to explore the factors influencing bacterial persistence on surfaces in healthcare settings.

**References**

1. Agbanusi, U. J (2022). “Assessment of Healthcare Waste Management Strategies in Selected Hospitals in Abuja, Nigeria”. Texila International Journal of Public Health ISSN: 2520-3134
2. Aworh, M. K., Kwaga, J. K. P., and Okolocha, E. C. (2022). “Assessment of healthcare waste management practices among healthcare workers at two hospitals in Abuja, Nigeria”. Sokoto Journal of Veterinary Sciences, 20(Special): 153 – 163.
3. Ayman, D. A. A., Alia, S. K., Al-shoubaki, L. A. (2021). “Incident of the contamination of medical laboratories in four selected universities by pathogenic bacteria in Jordan”. Rawal Medical Journal: Vol. 46. No. 2, April-June 2021.
4. Ekanem, A. M., Ijezie, A. E., Undie, M. U., Etuk, J. J., David, A. E., Peter, O. I., Paul, U. M., Agwu, C. E. (2021). “ Assessment of knowledge and practices of healthcare waste management among health workers in a general hospital in southern Nigeria”. Ibom Medical Journal Vol.14 No.1 January, 2021. Pages 34 – 45.
5. Ezeudu, O. B., Ezeudu, T. S., Ugochukwu, C. U., Imokhai, T. T., Agbaji, P. A., Uchenna, V. N., and Charles, C. A. (2022). “Healthcare Waste Management in Nigeria”: A Review. Recycling 2022, 7, 87.
6. Nwankwo, I. U., Edward, K. C., and Udensi C.G. (2022). “A Case Study on Antimicrobial Resistance of Bacterial Isolates From High-Touched Surfaces in Hospitals in Madonna Catholic Hospital, Abia State”. Stamford Journal of Microbiology Vol. 12, Issue 1, p. 1-7.
7. Olukanni, D. O., Justin, D. L., and Emannuel, F. (2022) “Healthcare Waste Management Practices in Nigeria”: A Review. Health Care Waste Management and COVID 19 Pandemic.
8. Otter, J. A., Saber, Y., Barbut, F. (2014). “Surface Contamination in Operating Rooms: A Risk for Transmission of Pathogens?”. Surgical Infections Volume 15, Number 6.
9. Raji, M. O., and Adeogun, A. G. (2024). “Healthcare Waste Management”: An Overview. ABUAD Journal of Engineering Research and Development (AJERD) Volume 7, Issue 1, 14-27.
10. Siti, S. Z., Mohamad, F.A. H., and Abu bakar, N. F. (2019). “Microbiological Assessment of Selected Laboratories at a Local University in Malaysia”. Jurnal Sains Kesihatan Malaysia Isu Khas 2019: 119-126.
11. Sule, I. O., Odebisi-Omokanye, M. B., Agbabiaka, T. O., Saliu, B. K., Ahmed R. N., Adewumi O. S. and Afolabi A. A. “Microbiological Assessment of Laboratory Workbench Surfaces”. Ilorin Journal of Science Volume 5, Number 1, 2018, pp. 48 – 62.
12. Susan, M. M., Andrew, K. N., and Caroline, W. N. (2018). “Isolation of bacterial diversity present in medical waste and health care settings in hospitals in Kenya”. African Journal of Microbiology Research Vol. 12(26), pp. 606-615.