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INFECTION POTENTIAL OF WASTES FROM SELECTED HEALTHCARE FACILITIES IN IBADAN, NIGERIA

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Abstract

Healthcare facilities in Nigeria produce a variety of infectious wastes and they are co-disposed along with municipal solid wastes. Available data on the types and potential of infection is scanty. This study was carried out to assess the microbial load and the predominant species of infectious bacteria in the solid wastes from four hospitals (private and Government owned) and selected residential areas closer to a large hospital (<500 m) and those, which are farther away. The dominant organisms in the hospital wastes were Klebsiella pneumonia (34.9%) and Staphylococcus aureus (22.2%). K. pneumonia is dominant in the residential areas closer to the hospital and K. aerogenes is found in those far away. Along with these, species of Salmonella, Pseudomonas, Candida, Escherichia, Entercocci and aerobic spore bearers were also found in the wastes from residential areas.

INTRODUCTION

Wastes from healthcare facilities are hazardous in nature. They are generated as a result of the diagnosis, treatment of patients, prevention of infections, or research on human and animal disease. In urban centres of developing countries large quantities of these wastes are generated and disposed of along with municipal wastes without any special care. This practice is of particular concern because the itinerary scavengers, who are poor and illiterate with no guidance or training, go around the dumpsites for collecting recyclables. In the process, these wastes pose health hazards (WHO, 1996). The wastes are grouped into twelve categories according to international convention and comprise of: domestic wastes, human anatomical, plastics, PVC, syringes, swabs, absorbents, alcohol, disinfectants, animal infected anatomical, glass, beddings, shavings, paper, faecal matter, gauze, pads, garments, cellulose, sharps, needles, fluids, residuals, and infectious wastes. It is estimated that acute care hospitals generate about 5 – 6kg of solid waste/patient/day and that 5 – 7% of this is infectious (Rutala et al, 1989). The United States Environmental Protection Agency (1989), uses the term infectious for any waste that harbors a virulent pathogen sufficiently in larger concentration, presence of a host, portal of entry, and host susceptibility (Rutala et al, 1989, Rutala and Weber, 1991, Rutala and Mayhall, 1992). They pose ecological as well as health risks.

In a study carried out on medical waste management in Nepal, Planco Consulting GMBH (1994) observed that the following factors were implicated with increasing risk of cross infection: rodent and insect infestations, access of flies and insects to infectious wastes, waste containers not being washed and becoming contaminated, non-chalant behaviour on the part of the staff in not carrying out instructions and procedures, and lack of a proper waste control programme that everyone can understand and participate in.

Early investigations on the solid wastes by Burchinal and Wallace (1971) and Wallace et al (1972), revealed that pathogenic organisms can be present in hospital solid wastes in significantly high concentration and especially if an organic substrate is present. *Staphylococcus aureus* was by far the most predominant pathogen detected in the waste. Spore forming organisms were not present in sufficient numbers to constitute a potential hazard, if accepted methods of sterilization are followed. It was also reported that nursing stations, and the operating rooms where pathological waste is segregated from other waste, have much lower microbial concentrations than were observed in general refuse as compared to other units. Intensive care unit and paediatrics units produced wastes highly contaminated with coliforms (Block, 1977). It is very well recognized that reliable information on solid waste in health facilities in developing countries is very scarce and besides others, there is "a need to collect data on the pathological contamination of fresh and old hospital waste compared with domestic waste" (Halbwachs, 1994).

Despite the tremendous increase in the number of Health care facilities in urban areas like Ibadan, medical wastes are neglected in scientific investigations. Thus there is a dearth of information about the nature and infective potential of these wastes. This paper describes a study carried out in Ibadan, southwestern Nigeria, on the type and number of dominant infectious bacteria found in solid wastes generated from selected private and government hospitals, and the residential areas in the neighborhood.

MATERIALS AND METHODS

Study area and sampling

The study was carried out in Ibadan, the capital of Oyo State in southwestern part of Nigeria. It has a population of over two million and has over 391 registered healthcare facilities. The Healthcare facilities were stratified into five categories, using the multistage, stratified simple random technique. The five categories are:

a) Federal Government owned hospitals (University College Hospital)
b) State Government owned hospitals
c) Privately owned hospitals
d) Missionary owned hospitals
e) Local Government Area owned and based primary health care facilities.

One hospital was selected from each of the State, private and mission owned hospitals by balloting. From the Local Government owned health care facilities, one health care facility was

picked by the simple random sampling technique. The University College Hospital was purposely selected for the study, since it is the only Federal Government owned facility in Ibadan and the largest in the country where the treatment is given to a variety of patients.

In the University College Hospital, where there are many functional units that produce medical wastes, the units were selected through the simple random sampling technique. In the other health care facilities samples were collected from all the units as there are not many functional units producing medical wastes.

Selected residential areas were also included in the study with a view of finding the degree of transmission of infective organisms from such sources and also to act as controls. The University College Hospital residential area was purposely selected for collection of samples (within a distance of 500 meters from the hospital) and three other residential areas were picked from the inner core (indigenous), transitional and peripheral areas in the city by simple random sampling technique. By systematic sampling technique, samples of wastes were collected from these three areas.

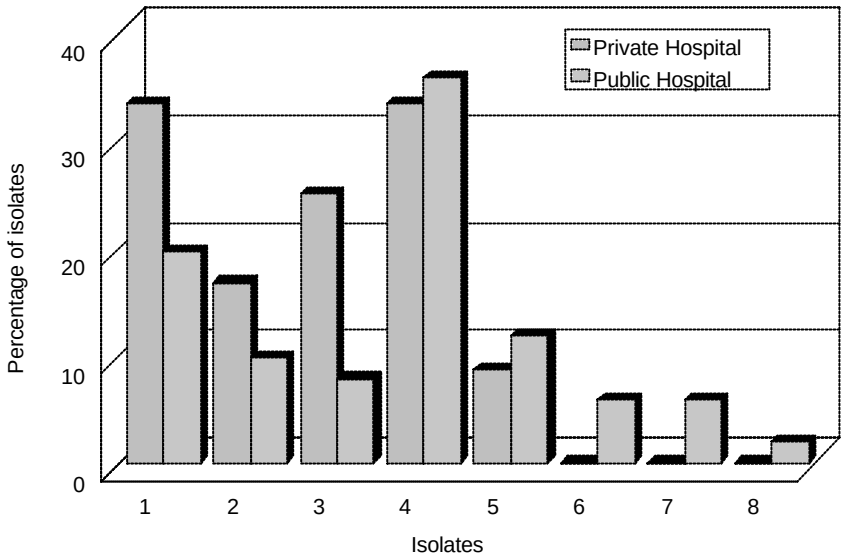
METHODS

The medical wastes generated in each of these units were weighed fresh. The wastes generated from each of the selected units for a whole day were divided into quarters. Samples were then taken from one of the quarters into clean and sterile polythene bags. The weight of the sample taken was noted in order to facilitate the use of correct dilution factor. A total of 62 medical waste samples and 69 domestic waste samples were collected. Each sample was poured into a clean plastic bowl that had been pre-sterilized with 70% alcohol. Sterile normal saline was added to the sample to make a dilution of either 1-in-10 or 1-in-100. The suspension was left for one hour and shaken by mechanical means to release bound microorganisms from the wastes. The eluate was then poured into 10ml universal bottles. The eluate was cultured on blood agar and Cystine Lactose Electrolyte Deficient media (CLED) to identify the type of aerobic bacteria and also to quantify them as described by Collae et al (1989).

RESULTS AND DISCUSSION

Wastes from private and public hospitals

The aerobic bacteria isolated from the 62 waste samples from the selected private and public hospitals are shown in Figure 1 and Tables1 to 2. In private and public hospitals isolates of *Klebsiella pneumoniae* (33.5% and 35.3%, resp.) and *Staphylococcus aureus* (33.3% and 19.6%, resp.), were the most dominant bacteria. The University College Hospital samples showed lower counts of various genera. Some of the samples however, did not show any growth, on the blood agar and the CLED media. The bacteria with the highest mean load was *Staphylococcus albus*, which was $5.9x\ 10^{14}$cfu/ 100g in the private hospital, and $2.36x10^{14}$cfu/100g in the public hospital. It was also observed that some isolates were common in units running similar activities in the hospitals.



1: *Staphylococcus aureus*; 2: *Proteus mirabilis*; 3: Aerobic spore bearers; 4: *Klebsiella pneumoniae*; 5: *Staphylococcus albus*; 6: *Pseudomonas aeruginosa* ; 7: *Candida albicans*; 8: No growth

Figure 1. Frequency distribution of various isolates from the private and public hospital wastes

Table 1. The mean bacterial counts in various categories of hospital wastes

Isolate	Private Hospital (cfu/100g)	Public Hospital (cfu/100g)	UCH (cfu/100g)
Staphylococcus aureus	**$5.74x10^{14}$**	**$6.65\ x10^{13}$**	**$3.01\ x10^{12}$**
Proteus mirabilis	**$2.40\ x10^{14}$**	**0**	**$5.74\ x10^{12}$**
Aerobic spore bearers	**$1.95\ x10^{14}$**	**$1.15\ x10^{14}$**	**$6.9\ x10^{9}$**
Klebsiella pneumoniae	**$5.73\ x10^{14}$**	**$9.16\ x10^{13}$**	**$4.35\ x10^{13}$**
Staphylococcus albus	**$5.9\ x10^{14}$**	**$4.01\ x10^{14}$**	**$1.26\ x10^{14}$**
Pseudomonas aeruginosa	**0**	**$1.56\ x10^{14}$**	**0**
Candida albicans	**0**	**0**	**$6.1\ x10^{13}$**

Table 2. The predominant isolates in the wastes from various units of the hospitals

Hospital Units	Predominant isolates	Mean Microbial Count (cfu/100g)
Children's Wards	***Klebsiella Pneumoniae***	**$5.3x10^{14} \pm 8.08x10^{14}$**
Lying in wards	***Staphylococcus albus***	**$3.04x10^{14} \pm 3.12x10^{14}$**
Casualty	***Klebsiella pneumoniae***	**$2.50x10^{13} \pm 3.53X10^{13}$**
Labour ward	***Klebsiella pneumoniae***	**$1.02x10^{14} \pm 8.81\ x10^{14}$**
Family planning	***Staphylococcus albus***	**$1.23\ x10^{14} \pm 1.72\ x10^{14}$**
Medical wards	***Staphylococcus aureus***	**--**
	Klebsiella pneumoniae	**$4.32\ x10^{13} \pm 4.02\ x10^{13}$**
	Proteus mirabilis	**$1.3\ x10^{14} \pm 7.07\ x10^{12}$**
Surgical wards	***Klebsiella pneumoniae***	**$4.50\ x10^{13} \pm 5.74\ x10^{13}$**
Laboratories	***Staphylococcus aureus***	**$2.32\ x10^{14} \pm 3.15\ x10^{14}$**

Wastes from residential areas

From the residential area of the University College Hospital (UCH) within a distance of <500m, 39 samples of domestic wastes were collected and cultured. Of the frequency of various isolates, *Klebsiella pneumoniae* (71.8%) was dominant followed by S*taphylococcus aureus (28.2%)*. In the other 30 samples from residential areas not close to any hospital or health care facility, the dominant isolates were *Klebsiella aerogenes*, and S*taphylococcus aureus* along with relatively low count of *Klebsiella pneumoniae*. Wastes from peripheral and transitional areas did not show any significant differences. The wastes from inner core area however showed low counts of the various isolates (Table 3).

Table 3. Frequency distribution of various isolates in the wastes from residential areas

Isolates	UCH Residential Area, %	Inner Core Area, %	Peripheral Area, %	Transitional Area, %
Staphylococcus aureus	**28.2**	**3.3**	**16.7**	**6.7**
Proteus mirabilis	**20.5**	**NG**	**6.7**	**3.3**
Aerobic spore bearers	**20.5**	**NG**	**3.3**	**NG**
Klebsiella pneumoniae	**71.8**	**6.7**	**13.3**	**23.3**
Pseudomonas aeruginosa	**2.6**	**NG**	**NG**	**NG**
Candida albicans	**5.1**	**NG**	**3.3**	**3.3**
Candida sp.	**15.4**	**6.7**	**3.3**	**3.3**
Enterococci	**5.11**	**NG**	**NG**	**NG**
Salmonella sp.	**2.6**	**NG**	**NG**	**NG**
Klebsiella aerogenes	**12.8**	**20.0**	**13.3**	**16.7**
Escherichia coli	**NG**	**3.3**	**NG**	**NG**

NG = No growth

The mean load of bacteria in the residential wastes ranged from 1.01×10^{15}cfu / 100 g to 7.02×10^{14}cfu / 100 g. In the areas close to a health care facility, *Enterococci* and *Salmonella sp.* were the lowest with mean counts of 1.01×10^{15}cfu /100g and 1.96×10^{13} cfu / 100g, respectively. In the other residential areas, K*lebsiella aerogenes* counts were the highest (5.15×10^{14}cfu/100g) in inner core area, followed by S*taphylococcus albus* (5.68×10^{14}cfu/ 100g) in the transitional area (Table 4).

Table 4. The mean counts of various isolates from the residential wastes

Isolates	UCH Residential Area (cfu/100g)	Inner Core Area (cfu/100g)	Peripheral Area (cfu/100g)	Transitional Area (cfu/100g)
Staphylococcus aureus	**$2.78x10^{14}$**	**$3.0 x10^{14}$**	**$1.85 x10^{14}$**	**$1.55 x10^{14}$**
Proteus mirabilis	**0**	**0**	**$50 x10^{14}$**	**$4.4 x10^{14}$**
Aerobic spore bearers	**$1.98 x10^{14}$**	**0**	**$2.4 x10^{14}$**	**0**
Klebsiella pneumoniae	**$1.13 x10^{14}$**	**$3.58 x10^{14}$**	**$5.4 x10^{14}$**	**$1.74 x10^{14}$**
Staphylococcus albus	**$3.66 x10^{14}$**	**$2.62 x10^{14}$**	**$7.02 x10^{14}$**	**$5.68 x10^{14}$**
Pseudomonas aeruginosa	**$2.5 x10^{14}$**	**0**	**0**	**0**
Candida albicans	**$1.0 x10^{14}$**	**0**	**0**	**0**
Candida sp.	**$1.76 x10^{14}$**	**$1.35 x10^{14}$**	**$1.20 x10^{14}$**	**0**
Enterococci	**$1.01 x10^{15}$**	**0**	**0**	**0**
Salmonella sp.	**$1.96 x10^{13}$**	**0**	**0**	**0**
Klebsiella aerogenes	**$2.27 x10^{14}$**	**$5.15 x10^{14}$**	**$2.11 x10^{14}$**	**$3.02 x10^{14}$**
Eschericia coli	**0**	**$2.08 x10^{14}$**	**0**	**0**

Klebsiella pneumoniae and *Staphylococcus aureus* are the most prevalent aerobic bacteria present in medical wastes. Others include *Staphylococcus albus, Proteus mirabilis, Pseudomonas aeruginosa* and *Candida albicans.* Most of these bacteria are also present in the environment and are of medical importance.

Even in the samples collected from the residential areas, which acted as controls, *Klebsiella pneumoniae* was isolated. This is suggestive of its abundance in the environment (Duncan and Razzell, 1972). Another species, *Klebsiella aerogenes* was found to be predominant in the residential areas ((50%), not close to any health care facility. It is found in soil, vegetation, natural wasters and other environments outside the body (Duguid et al, 1978). *Escherichia coli* was not isolated from the samples collected from hospitals. Apart from *Staphylococcus aureus, Staphylococcus albus* was also isolated. These bacteria occurred commonly in female related units. *Proteus mirabilis* was isolated in some of the units. This species is implicated in many clinical conditions. It was also isolated in some residential areas not close to any health care facility, which suggests that it is present in the general environment. It was also noted that about 8.3% and 29.4% of waste samples, respectively, from units in the private and public hospitals, showed no growth at all. This could probably be due to the nature of the organism, or the effect of possible pre-treatment given to wastes.

Unfortunately, there is no known work that gives the safe microbial load of these bacteria in wastes even though the available information is limited to latency periods of common pathogens in water, soil and food. The route of transmission of these pathogens from the wastes is also not known. The bacterial load of wastes from the private hospitals is more than in the public hospital. This is a reflection of the practices in these establishments and may be attributed to improper or insufficient treatment of the wastes before disposal. The tertiary hospital however pre-treats their wastes before disposal.

The microbial load of the residential areas close to a health care facility ($5.70x10^{14}$cfu/ 100g) was higher than that of the residential areas farther away ($4.52x10^{14}$cfu/ 100g) which

indicates that proximity to a health care facility increases their population in the surroundings. The Government of Nepal and Catz (Planco Consulting GMBH (1994)) in their study, came to the conclusion that medical wastes are more dangerous to handle than domestic solid wastes. Doan (1991) reported that most medical wastes are not capable of disease transmission due to many factors. He went further to say that most organisms found in the medical wastes are already commonly found in the environment. It is also to be noted that these wastes may not provide the required infective dose of organisms needed to cause infection. Several investigations have documented that household wastes, which are not regulated, contain a hundred times more microorganisms with infectious potential for humans than does hospital wastes (Althaus et al 1983, Donnelly and Scarpino, 1984).

Many of the bacterial isolates found in the waste samples reported here are also known to cause hospital acquired or nosocomial infections (from the records of University College Hospital, 2000). It is however believed that medical wastes are the least possible source of a hospital-acquired infection. This study confirms this point, but cautions that in the communities, these wastes can be a health risk. There is need to manage them properly and also to train waste generators and handlers on safe work practices during collection, storage and transportation.

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