

1 **Bacterial contamination of the hospital environment-**
2 **the experience of an infection control team in a**
3 **tertiary hospital in Niger Delta Region of Nigeria**

4 **Abstract**

5 Hospital-acquired infections (HAI) are a major public health problem, contributing to
6 morbidity and mortality of susceptible patients. In order to ascertain potential sources
7 of HAI in a tertiary hospital, certain critical surface areas of the hospital, water
8 sources and theatre instruments were sampled. Out of the 44 items sampled, 13
9 (29.5%) yielded 15 bacterial isolates. *Pseudomonas aeruginosa* was the most
10 frequently isolated micro-organism (60% of isolates), while *Klebsiella pneumoniae*
11 and *Staphylococcus aureus* accounted for the remaining 40%. Bacterial load was
12 heaviest in stored bucket water and the tip of the suction tube from the theatre.
13 *Staphylococcus aureus* isolated from a baby cot from the Special care Baby Unit
14 was resistant to all antibiotics tested. Most bacterial isolates were resistant to
15 cefuroxime and cefexime. *S. aureus* was particularly resistant to ceftazidime and
16 ceftriaxone.

17 The results confirm the importance of water and environmental surfaces as potential
18 sources of transmission of HAI. We recommend the overhauling of the Water supply
19 system and institution of robust infection prevention and control practices. Hospitals
20 ought to strictly adhere to infection control guidelines that include cleaning,
21 disinfection and sterilization of hospital surfaces and equipment as appropriate,
22 regular practice of hand hygiene and routine preventive maintenance of water
23 systems.

24 **Keywords:** Water, infection, environment, Hospital-acquired Infection, Bacteria,
25 Cleaning, Antibiotic resistance

26 **Introduction**

27 Hospital-acquired infections (HAI) contribute significantly to morbidity and mortality of
28 patients, and also to the cost of healthcare. The prevention of hospital acquired
29 infections (HAI) is therefore a critical requirement for quality and safety in patient
30 care. The hospital environment is often contaminated by various pathogenic and
31 potentially lethal micro-organisms including multi-resistant *Pseudomonas*
32 *aeruginosa*, methicillin resistant *Staphylococcus aureus* (MRSA), vancomycin
33 resistant *enterococci* (VRE), and *Clostridium difficile*, among others [1]. Certain
34 parts of the hospital are potentially more prone to patients acquiring HAIs and these
35 include the theatre, Intensive care unit (ICU), Special Care Baby Unit (SCBU)
36 because of the severity of illness and the procedures performed [2].

37 Routine cleaning and disinfection of hospital rooms is often inadequate [3-5]. The
38 contamination of environmental surfaces in hospital rooms have been shown to be
39 important in the transmission of Healthcare associated pathogens [5]. Environmental
40 cross-contamination leading to HAI is common in patient's rooms previously
41 occupied by confirmed cases of multi-resistant micro-organisms, especially in the
42 absence of adequate cleaning and disinfection [6-10].

43 The length of time a Healthcare-associated pathogen can persist on a surface
44 increases the risk of transmission to a susceptible patient or healthcare worker [1,
45 11]. Some organisms can survive for a longer period of time even in disinfectant
46 solutions thereby becoming potential pathogens for hospital infections [11, 12]. The
47 prevention and control of HAI is a critical requirement for quality and safety in

healthcare, achieved through implementation of standard infection control guidelines in hospitals [13, 14]. There is paucity of data on the endemic burden of HAI in Africa [15], and particularly in Bayelsa State, Nigeria. The provision of baseline information on the bacterial flora of the hospital environment can guide in the identification of the environment sources of HAI.

This study was therefore designed to provide baseline information on the bacterial flora on the surfaces of critical areas of the Niger Delta University Teaching Hospital (NDUTH) Okolobiri, Bayelsa State, and the susceptibility to antimicrobial therapy of the isolated bacteria, which can inform policies on Infection Prevention and Control.

Materials and Methods

Study Area

The Niger Delta University Teaching Hospital (NDUTH), Okolobiri, Bayelsa State, is a two hundred-bed tertiary health institution located in the South-South geopolitical region of Nigeria. It serves at least 3 neighbouring states in the Niger Delta region of Nigeria. At the time of the study, the hospital had no functional intensive care unit (ICU). Water supply in the hospital is from borehole treated water which is stored in overhead tanks and then piped through underground distribution lines to all hospital buildings, including clinical areas. The water in this area of the Niger Delta has a high iron content, and if not well-treated appears rusty brown. There is also epileptic power supply, so water may not be pumped daily and is therefore stored in buckets and large plastic containers where water can be scooped for use with bowls and cups. .

70

71

72 Study design

73 This was a prospective cross-sectional study carried out in the hospital between 15th
74 March and 30th July 2014.

75 Study sites

76 High risk wards and clinical units known for admitting patients susceptible to
77 acquisition of HAI from contaminated hospital environment were selected (Five
78 wards and two units) for specimen collection. These were the Combined Medical
79 Ward (CMW), Paediatric Ward (PDW), Special Care Baby Unit (SCBU), Male
80 Surgical Ward (MSW), Female Surgical Ward (FSW), Theatre (T). To assess
81 possible bacterial contamination of sterile packs, study samples were also obtained
82 from the Central Sterilization and Supply Department (CSSD).

83 Specimen Collection

84 The surfaces and fluids were sampled in the morning after routine cleaning and
85 disinfection had been done.

86 **Surfaces:** Sterile swab sticks dampened with sterile water were used to swab
87 selected surfaces (baby cots, stethoscopes, operating tables, suction tube tips,
88 sphygmomanometer, surgical instruments). To ensure maximal coverage of a
89 surface area, the swab was rolled back and forth over each surface.

90 **Fluids:** Fifteen (15) millilitres of either tap water from faucets or water in a bucket,
91 and also 15ml of disinfectant used in the wards, were collected into sterile universal
92 bottles. A little quantity of a lubricant commonly used in procedures (KY jelly) was
93 obtained from the tube for culture.

94 Controls

95 Samples of sterile swabs and the sterile water used for specimen collection served
96 as controls.

97 **Sample processing**

98 The swabs and collected fluids, as well as control samples were inoculated onto
99 suitable media (Blood agar, MacConkey agar and chocolate agar) and incubated for
100 24 to 48 hours at 37°C. Isolates were Gram-stained and standard biochemical tests
101 were used to identify and classify them.

102 Antibiotic susceptibility testing was done using the Kirby-Bauer disk diffusion method
103 and was interpreted by the standards of the Clinical Laboratory Standards Institute
104 [16].

105 Antibiotic discs used had the following concentrations: Amoxycillin-Clavulanic acid
106 30µg; Cefixime 5µg; Ceftazidime 30µg; Ceftriaxone 30µg; Cefuroxime 30µg;
107 Ciprofloxacin 5µg; Erythromycin 5µg; Gentamicin 10µg; Nitrofurantoin 30µg;
108 Ofloxacin 5 µg.

109 The resistance pattern of each particular isolate was determined by the number of
110 isolates resistant to each antibiotic divided by the total number of that isolate and
111 expressed as percentage of resistance.

112 **Ethical approval**

113 The study was approved by the hospital's institutional ethical review board.

114 **Results**

115 In order to identify possible environmental reservoirs of infection in the Niger Delta
116 University Teaching Hospital (NDUTH), specimens were obtained from surface
117 areas, water sources and instruments.

118 A total of 47 specimens including 44 study specimens and 3 control specimens were
119 collected from 5 wards and 2 clinical units of the hospital (Table 1.). Thirteen (29.5%)
120 out of the 44 study specimens were culture positive. These included all (100%) of the

121 tap water specimens (6 out of 6), 4 (66.7%) of 6 bucket water specimens, and 1
 122 (11.1%) of 9 baby cots. One (20%) of 5 stethoscopes and the tip of the suction tube
 123 in the theatre were also culture positive. The surfaces of theatre anaesthetic
 124 machine and operating bed, as well as the sampled disinfectants, thermometers, and
 125 all sterilised equipment from the CSSD were culture negative. All three control
 126 samples were culture negative.

127 **Table 1: Distribution of hospital surfaces, fluids and medical devices sampled**
 128

s/ n	Items	Ward/Unit								TOTAL
		SCBU	CMW	FSW	MSW	PDW	THEATRE	CSSD	CONTROLS	
1	Baby cot	9								9
2	Thermometer	1		1	1					3
3	Stethoscope	1	1	1	1		1			5
4	Tap water	1	1	1	1	1	1			6
5	Bucket water	1	1	1	1	1	1			6
	Disinfectant solution	1	1	1	1		1			5
6	KY Jelly		1				1			2
7	Anaesthetic machine						1			1
8	Operating table						1			1
9	Tip of suction machine						1			1
10	Gally pot							1		1
11	Artery forceps							1		1
12	Scissors							1		1
13	Needle holder							1		1
14	Kidney dish							1		1
15	Sterile swab								1	1
16	Sterile swab dampened in sterile water								1	1
17	Sterile water								1	1
	TOTAL	14	5	5	5	2	8	5	3	47

129 Key: SCBU-special care baby unit; FSW-female surgical ward; CMW-combined medical ward; PDW-paediatrics ward; MSW-
 130 male surgical ward; CSSD-central supply and sterilization department

131 Bacterial isolates

132 Fifteen bacterial species were isolated from 13 specimens, with tap water in the
 133 CMW and PDW and bucket water in the PDW yielding two different bacteria species
 134 each. Most of the isolated organisms were Gram-negative bacilli (86.7%), with
 135 *Pseudomonas aeruginosa* being the most frequently isolated organism (60%) (Table
 136 2). Out of the 15 isolates, 9 (60%) were *Pseudomonas aeruginosa*, 4 (26.7%) were
 137 *Klebsiella pneumoniae* and 2 (13.3%) were *Staphylococcus aureus*. Bacterial load
 138 ranged from 1000 colony forming units (cfu)/ml to greater than 10^6 cfu/ml. Bucket
 139 water from the Paediatric ward and the tip of the suction tube from the Theatre
 140 yielded the most load with counts of greater than 10^6 cfu/ml (Table 3).

141 **Table 2. Frequency of isolated micro-organisms**

Bacterial Isolate	No. Isolated	No. of Items with bacterial growth
<i>Pseudomonas aeruginosa</i>	9 (60%)	Bucket water - 4
		Tap water - 5
<i>Klebsiella pneumoniae</i>	4 (26.7%)	Tap water - 3
		Tip of suction tube - 1
<i>Staphylococcus aureus</i>	2 (13.3%)	Baby cot -1
		Stethoscope - 1
Total	15 (100%)	

142

143 **Table 3. Bacterial load of micro-organisms isolated from surfaces and water**

Ward/ Units	Specimen	Isolates	CFU/ml
SCBU	Bucket water	<i>Pseudomonas aeruginosa</i>	17,500
	Tap water	<i>Pseudomonas aeruginosa</i>	6,500
	Baby Cot 5	<i>Staphylococcus aureus</i>	6,500
FSW	Tap water	<i>Pseudomonas aeruginosa</i>	13,000
Theatre	Tip of suction tube	<i>Klebsiella pneumoniae</i>	$>10^6$
	Tap water	<i>Pseudomonas aeruginosa</i>	14,500
	Bucket water	<i>Pseudomonas aeruginosa</i>	37,500
CMW	Tap water	<i>Klebsiella pneumoniae</i>	9,000
		<i>Pseudomonas aeruginosa</i>	15,000

PDW	Bucket water	<i>Pseudomonas aeruginosa</i>	>10 ⁶
	Stethoscope	<i>Staphylococcus aureus</i>	8,000
	Tap water	<i>Pseudomonas aeruginosa</i>	6,500
		<i>Klebsiella pneumoniae</i>	1000
	Bucket water	<i>Pseudomonas aeruginosa</i>	9,500
		<i>Klebsiella pneumoniae</i>	8000

Susceptibility/Resistance patterns

Resistance of the *Pseudomonas aeruginosa* isolates to the cephalosporins - (apart from ceftazidime) was high, ranging from 77.7% to 88.8%, but were most sensitive to gentamicin (Table 4 and Fig. 1). *Klebsiella pneumoniae* isolates were also resistant to cefixime and cefuroxime (average of 75% resistance), but were sensitive to ciprofloxacin and gentamicin (Table 4).

Staphylococcus aureus isolates were 100 % resistant to ceftazidime, ceftriaxone and erythromycin. *Staphylococcus aureus* isolated from one of the baby cots in the Special care Baby Unit was resistant to all the antibiotics tested, while *Klebsiella pneumoniae* isolated from tap water in the Paediatric ward was sensitive to all the antibiotics tested. Most bacterial isolates were resistant to cefuroxime and cefexime.

Table 4. Susceptibility of the isolated bacteria to tested antibiotics, measured in percentage resistance.

Organism isolated	Antibiotic									
	NIT	OFL	CRX	GEN	AMX-CLA	CAZ	CXM	CPR	ERY	CTR
<i>Pseudomonas aeruginosa</i>	44.4	44.4	88.9	33.3	44.4	33.3	77.8	44.4	-	-
<i>Klebsiella pneumoniae</i>	75.0	50.0	75.0	25.0	50.0	25.0	75.0	25.0	-	-
<i>Staphylococcus aureus</i>	-	50.0	50.0	50.0	50.0	100	-	-	100	100

NIT - Nitrofurantoin; OFL - Ofloxacin; CRX -Cefuroxime; GEN - Gentamicin;
 AMX-CLA - Amoxycillin-Clavulanic acid; CAZ - Ceftazidime; CXM - Cefixime;
 CPR - Ciprofloxacin; ERY - Erythromycin; CTR - Ceftriaxone

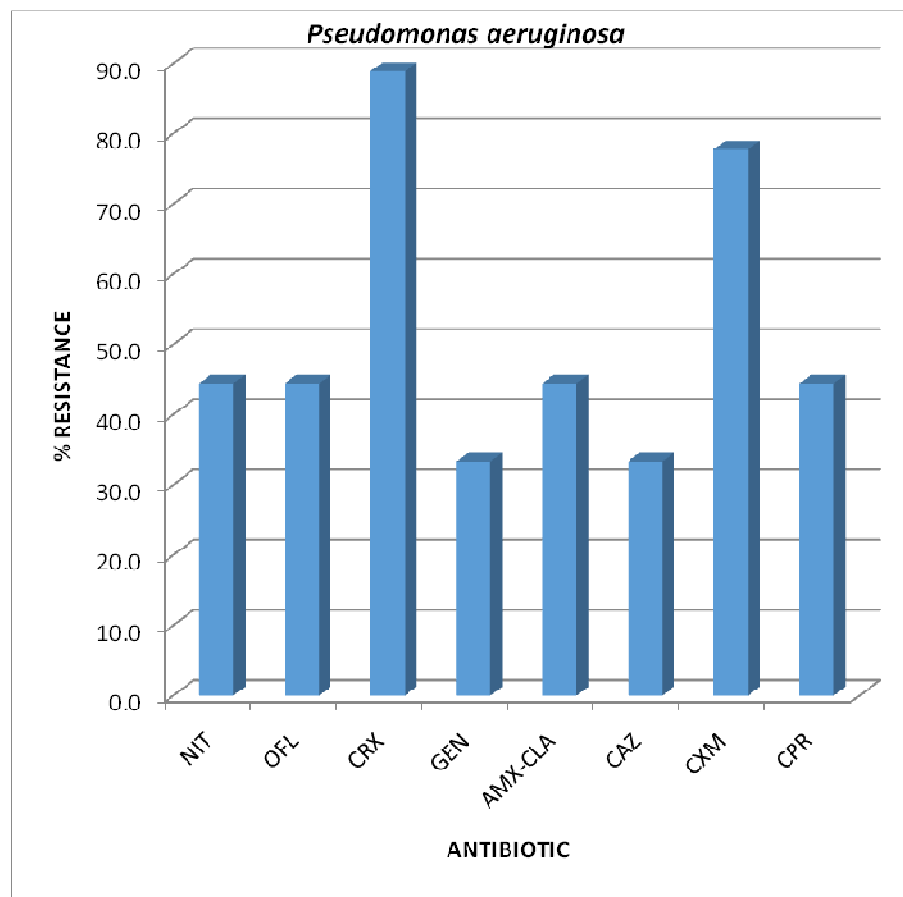


Fig. 1. Resistance pattern of *Pseudomonas aeruginosa* to antibiotics

Actions taken by infection control team after the survey

Infection control activities of the hospital are co-ordinated by an Infection Prevention and Control (IPAC) team consisting of infectious disease specialists, microbiologists, infection control nurse, public health physician, and medical laboratory scientists, among other members.

Results of this survey were presented to the Hospital's management and the hospital community. The following actions were taken: immediate cleaning and disinfection of all baby cot's, all ward-based stethoscopes, and all the suction tubes using appropriate disinfectants according to established guidelines [17, 18]; emptying, cleaning and disinfection of hospital's water storage tanks, repair of broken portions of underground pipes and flushing of water distribution systems to clear debris; water treatment in storage tanks including chlorination; cleaning and disinfection of sinks and faucets; emptying, cleaning and disinfection of water storage containers in wards. Weeks after this survey, and after a comprehensive infection control assessment of the hospital was concluded [19], the IPAC team developed an institutional infection control and prevention manual based on established infection control guidelines.

Discussion

The importance of the hospital environment remaining sterile or infection-free cannot be over-emphasised. Contamination of the hospital environment could be from varying sources as airborne micro-organisms have been isolated from the air circulating indoors within hospital wards [20].

Eighty percent (80%) of the bacterial isolates in this study, were from water, confirming earlier studies which implicated water sources in the transmission of HAI

190 [21, 22]. The present study observed *Pseudomonas aeruginosa* as the most
 191 frequently isolated micro-organism from water sources. This agrees with earlier
 192 studies which linked environmental reservoirs like water with the spread of
 193 *Pseudomonas aeruginosa* infections in hospital settings [23-26]. *Pseudomonas*
 194 *aeruginosa* has the potential to form biofilms in water distribution systems and water
 195 containers and may thrive better in water stored for long periods [27]. Patient
 196 exposure to water-borne micro-organisms has been linked to bathing, drinking and
 197 contaminated medical equipment rinsed with tap water in hospital sinks [28].
 198 Avoidance of hospital water and the use of low cost sterile water has been
 199 recommended for hospitalised patients at high risk for infection [29]. Bucket water
 200 yielded higher colony counts compared with tap water, and this could be due to the
 201 fact that standing water is more suitable for bacterial replication. Availability of water
 202 and its quality remain a problem in the hospital. This will invariably affect Hand
 203 hygiene and other infection control measures in the hospital. The prevention of
 204 microbial contamination of hospital water should follow established guidelines [17,
 205 18, 30], including: hand hygiene; water chlorination; regular flushing of pipes to clear
 206 debris; draining, disinfection and refilling of storage tanks; and routine preventive
 207 maintenance of water systems to forestall corrosion and repair leakages that may
 208 promote soil and dust contamination of water. Hospital water should not be stored in
 209 containers for prolonged periods before use. Policies for cleaning, use and changing
 210 of hospital water stored in reservoirs should be strictly adhered to [17]. Tap-fitted
 211 water containers may be useful cost-effective alternatives to bucket water in
 212 resource limited settings. Hospitals may also consider point of use water filters,
 213 which has been shown to be decrease bacterial colonization of faucets [31, 32].

214 Environmental surfaces are important in the transmission of HAI in the hospital. The
 215 isolation of multidrug-resistant *Staphylococcus aureus* from a baby cot in the SCBU
 216 is worrisome. It concurs with findings from studies of the potential risk of
 217 environmental surfaces in the transmission of Hospital acquired infections. About
 218 80% of stethoscopes used by Medical students have been observed to have
 219 bacterial contamination, mostly by *Staphylococcus aureus* [33]. Also 91.3% of white
 220 coats used by physicians were infected [34]. Other potential sources of HAI include
 221 mobile phones, which have been found to be contaminated with bacteria in health
 222 workers [35], as well as *Pseudomonas aeruginosa* isolated from bronchoscopes and
 223 endoscopes [22]. There is thus a need for re-education of staff about cleaning and
 224 sterilising of stethoscopes and medical equipment. Although other standard methods
 225 are used in determination of efficacy of sterilization [17], the absence of bacterial
 226 contamination of items sterilised in the CSSD may suggest that the sterility of sterile
 227 packs was not breached before use.

228 Antimicrobial resistance is a global problem with new resistance mechanisms being
 229 discovered [36, 37]. Extended-Spectrum Beta-Lactamases (ESBL) enzymes have
 230 been demonstrated in clinical isolates in patients in Nigeria [38, 39]. It is noteworthy
 231 that all the three species of bacteria isolated in our study, *Pseudomonas aeruginosa*,
 232 *Klebsiella pneumoniae* and *Staphylococcus aureus*, showed evidence of multi-
 233 resistance to two or more classes of antibiotics, and certain strains have been known
 234 to acquire carbapenemases [26].

235 . Acquisition of multi-resistant organisms from the environment may lead to serious
 236 life threatening infections in susceptible individual [17, 40], mainly due to absence of
 237 alternate effective antibiotics or cost constraints to purchase such antibiotics [40].

The limitations of this study include the inability to culture bacterial contaminants that require special growth media such as *Clostridium difficile*, *Legionella pneumophila* and *Actinobacteria baumani*, and also the inability to confirm if the isolates were extended spectrum beta lactamase producing variants.

Recommendations

There is a need for the overhauling of the water supply system in the hospital. Hospital water systems are advised to be designed in a way to minimise stagnation and the colonisation and multiplication of bacteria [41]. There should be continuous and efficient water treatment strategies. Cleaning of the hospital environmental surfaces should be routine and effective. There is also a need to revamp the Infection Prevention and Control processes. Regular/routine sampling of the hospital for micro-organisms should be built into the work plan for the Hospital.

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