



# **Microbiological Survey of Animate and Inanimate Surfaces in a Correctional Center, South-South, Nigeria**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Correctional centers (formerly referred to as prisons, in Nigeria) are facilities where offenders of the law are kept after been convicted of a crime. Many factors have in recent time contributed to an increasing rate of morbidity and mortality in these facilities, including overcrowding, poor sanitary conditions, inadequate ventilation, extreme temperatures, inadequate means for maintaining personal hygiene, lack of access to clean drinking water, and nutritionally deficient food. This study therefore centered on the microbiological survey of animate and inanimate surfaces in a correctional center, South-South Nigeria. For this research, a total of 150 samples (100 from skin (upper arm) and 50 from wall surfaces) were collected from the inmate skins and inanimate surfaces, using sterile swab sticks and were immediately transported to the Department of Microbiology Laboratory, Rivers State University for analyses using standard microbiological procedures. Data obtained from the study showed the inmates within the age bracket 21-30 were the highest (44%) while the age bracket 71-80 represented the lowest (1%) number of inmates. The study showed that male inmates represented 75% of the prisoners studied while the female

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represented 25%. The result showed that 37% of the studied inmates had spent 2-4 years in the correctional center while the least period of exposure or stay in the facility was recorded for 13 years in the correctional center, which represented 1% of the inmates. The age bracket 21-30 recorded the highest number of microorganisms (39) and 71-80 showed the least (1). Different microbial species were recovered from the skin of the inmates and included *Staphylococcus* spp, *Escherichia coli*, *Streptococcus* spp, *Klebsiella* spp, *Bacillus* spp, and *Aspergillus* spp., with *Staphylococcus* spp showing the highest occurrence of 48%, while *Klebsiella* spp had the least occurrence (1%). The study indicated that the correctional center could pose serious environmental health concerns, requiring public health interventions. Adequate personal hygiene should be encouraged among the inmates. Regular sanitation as well as adequate healthcare and routine checkup should therefore be made available to the inmates.

**Keywords:** *Animate; correctional center; inanimate; surfaces; microbiological survey; south-south Nigeria.*

## 1. INTRODUCTION

A correctional center, formerly referred to as prison, in Nigeria, is a place where individuals who have been convicted and are being punished for a crime are kept [1]. An agency maintained by the Nigerian government that manages prison facilities is the Nigerian Correctional Service, formerly known as the Nigerian Prison Service. The Interior Ministry and the Civil Defense, Immigration and Correctional Service oversee the agency, which has its headquarters in Abuja. When President Muhammadu Buhari signed the Nigerian Correctional Service Act of 2019 into law in August 2019, the agency's name was changed from the Nigerian Prisons Service to the Nigerian Correctional Service [2].

The substandard prison conditions that prisoners are subjected have become a growing area of concern, as the prison inmates are constantly exposed to conditions that may potentially increase the chances of the transmission of diseases or the decline of health [3]. Overpopulation, which is common in most correctional centers in developing countries such as Nigeria, combined with poor sanitary conditions and inadequate ventilation, can all contribute to the significant risks posed by the prison environment. In addition to the poor conditions typically present in Nigeria's correctional service (NCS) facilities, a climate of animosity, degradation, and bias further hinders people from receiving the help they need from the often inadequate, weak, or nonexistent health care services. A report released by Amnesty International in 2009 reported that the NCS prison population was 39.9 % higher than intended capacity, amounting to 70,056 inmates, when the capacity was only 50,083. According to

Allen's definition of overcrowding, this means that the NCS centers are overcrowded by 39.9 % [4]. Additionally, 50,822 inmates were awaiting trial, which is 71.9% of the prison population. Around 73% of all Nigerian prison inmates are on remand, meaning they haven't been convicted yet; only 19,234 inmates have been convicted, which is 27% of the total. On average, for every single space in Rivers State prisons, there are three individuals present, as reported by Awopetu in 2014 [5].

The Centers for Disease Control and Prevention (CDC) reported in 2001 that Methicillin-Resistant *Staphylococcus aureus* (MRSA) is highly common in most prisons, due to factors such as long-term imprisonment, wounds, using antibiotics, inadequate skin hygiene, treating their own wounds, hand washing clothes, and sharing razors, clothing, linen or soap. Joseph's research [6] has found numerous bacterial, viral and fungal infections among inmates, including HIV, Hepatitis A, B and C, *Mycobacterium tuberculosis*, and Varicella-zoster, and *Staphylococcal* infection.

Bacterial diseases and the colonization of living and non-living surfaces can happen because of inadequate personal/environmental cleanliness, substandard medical care, and the inmates' lifestyle and health condition before they were imprisoned. Contaminated surfaces have a significant role in the indirect spreading of infections [7]. Areas in proximity to the prisoners' sphere may be touched frequently, thereby leading to the transfer of potential pathogenic organisms from living sources to others through infected non-living surfaces, like walls, door handles, chairs, bedding and other fomites.

## 2. MATERIALS AND METHODS

### 2.1 Study Location and Sample Collection

The study was carried out at a maximum Security Correctional Center located in the South-South region of Nigeria, using the convenience sampling method. A total of 150 (100 from inmates, 50 from the prison walls) samples were collected. Skin (upper arm) of the inmates and the walls of the prison cells were swabbed using sterile swab sticks and were immediately transported to Microbiology Laboratory, Rivers State University for analyses. Demographical information of the inmates were obtained by administering well-structured questionnaire.

### 2.2 Isolation and Identification of Microorganisms

The specimens were inoculated onto nutrient agar and Sabouraud dextrose agar (SDA) plates for bacterial and fungal species, respectively, using the streak plate method. The bacterial and fungal cultures were incubated for 24 – 48 hours and 5 -7 days, respectively. Distinct colonies from the inoculated and incubated agar plates were sub-cultured onto different selective media for both bacterial and fungal growth. Morphological and Biochemical analysis were carried out for all the test organisms.

The fungal isolates were identified using the Lactophenol cotton blue stain. A drop of 70% alcohol was placed on a microscope slide and immediately followed by making a smear by transferring an inoculum from a fresh Sabouraud dextrose agar culture on the slide. A drop of lactophenol/cotton blue stain was added to the smear before the alcohol dried out. It was carefully covered with a cover slip to avoid air bubbles. The preparation was viewed under microscope using the 10X and 40X lenses.

### 2.3 Storage of Pure Cultures

The pure cultures were stored in 10% (vv) glycerol suspension at -20°C.

### 2.4 Characterization and Identification of the microorganisms

Bacterial growth was examined using their colonial characteristics. Pure cultures of the isolates were subjected to Gram staining and

biochemical tests such as Indole production, Catalase, Coagulase, Oxidase, Starch hydrolysis, Sugar fermentation and Methyl Red Vogue's Proskauer tests.

The fungal species that grew on the Sabouraud dextrose agar (SDA) plates were characterized based on the observed the colonial and microscopic characteristics (color, shape, size, and hyphae) as described by Cheesbrough, [8]. Microscopic examination was done with the aid of Lactophenol cotton blue stain.

## 3. RESULTS

### 3.1 Demographics of the Correctional Center

Data obtained from the study showed the inmates within the age bracket 21-30 represented the highest (44%) number inmates in the facility while the age bracket 71-80 represented the lowest (1%) number of inmates, as shown in Table 1. The study showed that 75% and 25% of the inmates were male and female, respectively (Fig. 1). The result showed that 37% of the studied inmates had spent 2 - 4 years in the correctional center while the least period of exposure was recorded for 13 years in the correctional center, which represented 1% of the inmates Table 2.

**Table 1. Demography of the subjects**

Age bracket	No. of inmates	Frequency (%)
≤ 20	4	4
21 -30	44	44
31 -40	38	38
41 - 50	9	9
51 - 60	2	2
61 – 70	2	2
71 – 80	1	1

### 3.2 Prevalence of the Microbial Species in the Prison Facility

Microbial isolates from the skin of the prison inmates were of six (6) different genera. These included *Staphylococcus* spp, *Escherichia coli*, *Streptococcus* spp, *Klebsiella* spp, *Bacillus* spp, and *Aspergillus* spp. (Fig. 2). The result indicated *Staphylococcus* spp had the highest occurrence of 48%, while *Klebsiella* spp had the least occurrence (1%).

The microbial isolates from the inanimate surfaces (wall) were also of 6 different genera as

those from the skin of the inmates. As shown in Fig 2, the result revealed *Staphylococcus* spp had the highest incidence of 32% while *Streptococcus* spp and *Aspergillus* spp had the lowest incidence of 2% each.

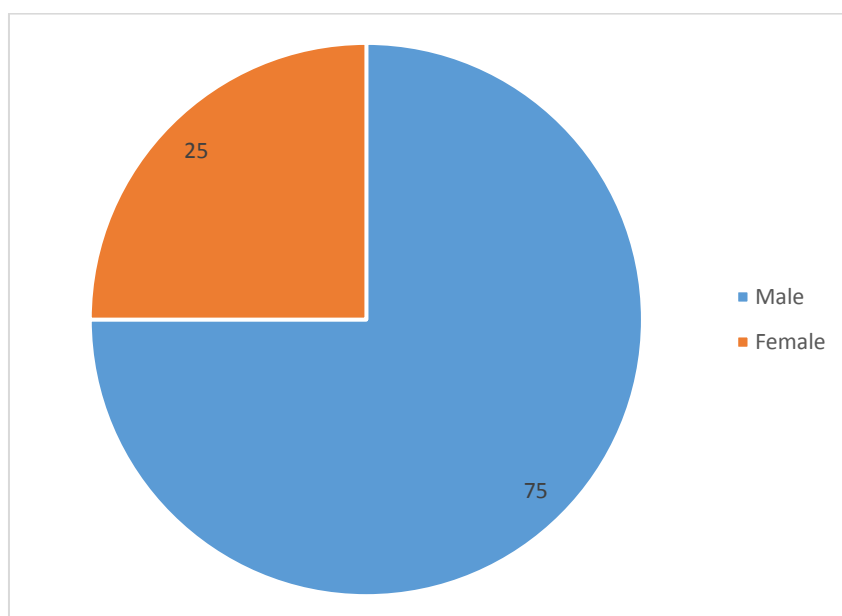
**Table 2. Period of exposure of the inmates in the correctional facility**

Duration (years)	NO of isolates	Frequency (%)
≤ 1	35	35
2 - 4	37	37
5 - 7	18	18
8 - 10	9	9
≥ 13	1	1

The data presented in Table 3 showed *Staphylococcus* spp had 57.9 percent prevalence among 31-40 age groups and 22.2 percent among 41-50 age groups. It had 41.3% prevalence amongst the male inmates and 17% in female inmates. Also, Inmates who had spent 11-13 years in the prison had the highest (100%) staphylococcal incidence while those who had spent 8-10 years had the lowest (33.3%) incidence. *Bacillus* spp had 100 percent (highest) prevalence among inmates within 51-60 years of age and 6.8 percent (lowest) for inmates within the age group of 21-30, and had 16% prevalence in the males. Also, it had 100 (highest) percent prevalence among inmates who had spent 11-13 years in the correctional center and 2.7%

(lowest) for the inmates who had spent 2-4 years. *Escherichia coli* had 100% incidence for age groups ≤ 20 and 61-70 while lowest was 15.9% for age group 21-30 years. It had 30.7% for the male, 55.6% (lowest) for the inmates that had spent 8-10 years in the prison and 11.4% for those who had spent ≤ 20 years. *Klebsiella* spp had 2.6% incidence for inmates within the age of 31-40, 1.3% for the male inmates and 5.6% for the inmates that had spent 5-7 years in the correctional center. *Streptococcus* spp had 100% incidence for inmates in the age group 71-80 and 5.3% for age group 31-40 years. It had 1.3% t incidence for the males, 14.3% for the inmates who had spent ≤1 year in the prison and 5.6% for those that had spent 5-7years. *Aspergillus* spp had 11.1% for prisoners within the age of 41-40, 4.6% for those within the age of 31-40, and 4.3% for the males. It had 11.1% for the prisoner who had spent 8-10 years in prison and 2.7% for those who had spent 2-4 years.

Statistical analysis however showed no statistical differences in the prevalence of the microbial species between the various populations (Age, gender) as well as the cell type (male and female cells). Pearson Correlation analysis showed a significant relationship between microbial prevalence on skin and wall surfaces ( $p < 0.05$ ). There was however, no statistically significant relationship between the duration of exposure and the prevalence of the microbial species ( $p > 0.05$ ).



**Fig. 1. Gender distribution of the subjects**

**Table 3. Prevalence of the various isolates in the study groups (%)**

<b>Age Bracket</b>	<b><i>Staphylococcus</i> spp</b>	<b><i>Bacillus</i> spp</b>	<b><i>Escherichia</i> <i>coli</i></b>	<b><i>Klebsiella</i> spp</b>	<b><i>Streptococcus</i> spp</b>	<b><i>Aspergillus</i> spp</b>	<b>Mean</b>	<b>P-value</b>
≤ 20	2(50)	2(50)	4(100)	0	2(50)	0	41.7	0.9432
21 - 30	21(47.7)	3(6.8)	7(15.9)	0	6(13.6)	2(4.5)	14.8	
31 - 40	22(57.9)	3(7.9)	8(21.1)	1(2.6)	2(5.3)	1(2.6)	16.2	
41 - 50	2(22.2)	1(11.1)	2(22.2)	0	0	1(11.1)	11.1	
51 - 60	1(50)	2(100)	-(0)	0	0	0	25	
61 – 70	0	1(50)	2(100)	0	0	0	25	
71 - 80	0	0	0	0	1(100)	0	16.7	
<b>Gender</b>								
Male	31(41.3)	12(16)	23(30.7)	1(1.3)	8(10.7)	4(5.3)	17.5	0.7483
Female	17(68)	0	0	0	3(12)	0	13.3	
<b>Cells</b>								
Male cells	33(77.7)	15(31.9)	13(27.6)	5(10.6)	2(4.3)	2(4.3)	26.1	0.8137
Female cells	2(66.7)	1(33.3)	0	1(33.3)	0	0	22.2	
<b>Duration in prison</b>								
≤ 1	18(51.4)	6(17.1)	4(11.4)	-(0)	5(14.3)	2(5.7)	16.7	
2-4	15(40.5)	1(2.7)	11(29.7)	-(0)	5(13.5)	1(2.7)	14.9	
5-7	11(61.1)	2(11.1)	3(16.7)	1(5.6)	1(5.6)	-(0)	16.7	
8-10	3(33.3)	2(22.2)	5(55.6)	-(0)	-(0)	1(11.1)	20.4	
≥ 11-13	1(100)	1(100)	-(0)	-(0)	-(0)	-(0)	33.3	
<b>Total Prevalence</b>	<b>48</b>	<b>12</b>	<b>23</b>	<b>1</b>	<b>11</b>	<b>4</b>		

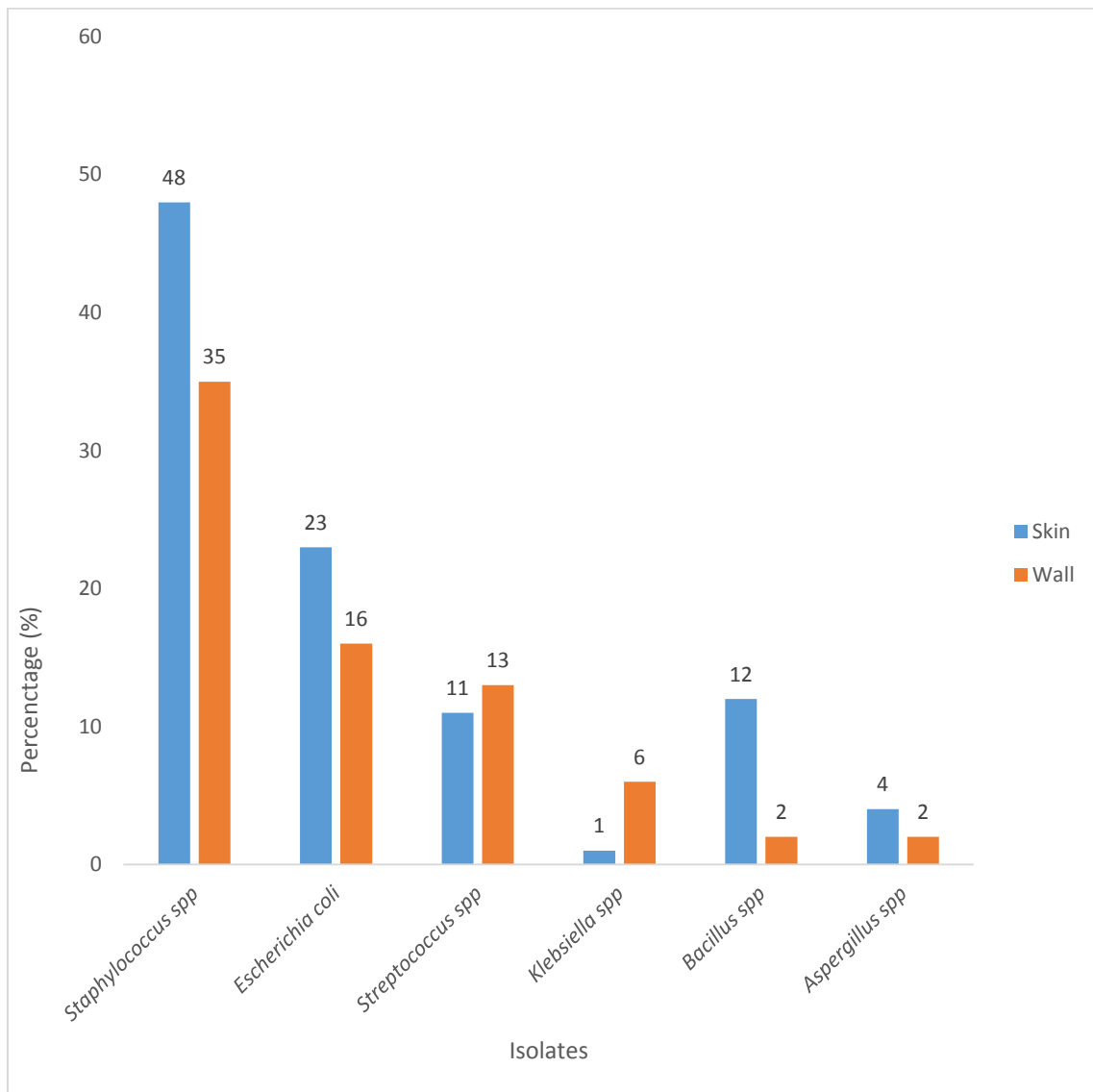


Fig. 2. Occurrence of the microbial species in the study

## 4. DISCUSSION

### 4.1 Demography of the Correctional Center

With the increasing rate of crimes all over the world, correctional centers/prisons tend to be overcrowded with inmates. Majority of the prisons in Nigeria are overcrowded, with the Port Harcourt prison having 327% overpopulation, which translates to at least 3 (three) inmates occupying the space meant for 1 (one) person [5]. In this study, it was observed that the correctional center was dominated by male prisoners, which implies that the crime rate is higher among male than female. This may be attributed to the fact that men have more

responsibilities than women. In order to meet up with household demands, some may be tempted to commit all sorts of crime.

The age brackets 21-30 years had the highest number of inmates while the age bracket 71-80 had the lowest. This means that the crime rate is higher among the youths. High poverty rate and pressure from peer groups might be the contributing factor to the high rate of crimes amongst the youths. This is in agreement with the work of Otutu and Shu [9], who reported that the Onitsha, Enugu, and Abakaliki prisons were dominated by male inmates, who were within the age of 21-30 and 31-40 years. Their reason was that these age brackets represent the most productive periods of human life,

characterized by hyper-activity and high sense of belonging.

Data from the study had reported that 37 percent of the studied inmates had spent 2-4 years in the correctional center compared to the one (1) percent of the inmates that had spent more than 13 years in the correctional center. This showed that the convicted inmates spend at least 2- 4 years or more in the prison before they are being released.

#### 4.2 Prevalence of the Microbial Species in the Prison

This study revealed that *Staphylococcus aureus*, a bacterium that colonizes the skin and the nose, had the highest frequency of 48% and 35% on both the skin of the inmates and the prison walls, respectively. *Staphylococcus aureus* is the main cause of skin and soft tissue infections such as boils, impetigo, furuncles, and cellulitis. It can also cause serious infections like pneumonia, toxic shock syndrome, bacteremia, and food poisoning. Since *S. aureus* is transmitted through unwashed hands, the presence of high rate of *S. aureus* within the prison implies that the inmates do not practice proper hand hygiene [10,11]. This could be as a result of overcrowding, which means the inmates sits/sleeps in close proximity to each other hence, the transfer of *S. aureus* within the inmates. The presence of high rate of *S. aureus* on the walls of the prison cells implies that the cells are contaminated and can further be a contributing factor to the spread of *Staphylococcus aureus* within the prison. This is in line with the work of Mukherjee et al. [12] who reported the prevalence rate of *Staphylococcus aureus* among male and female prison inmates to be greater than what has been found in the community.

#### 4.3 Distribution of the Microbial Species among the Study Groups

Of the six (6) genera of microbial species (*Staphylococcus* spp, *Bacillus* spp, *E. coli*, *Klebsiella pneumonia*, *Streptococcus* spp, and *Aspergillus* spp) that were isolated from the inmates, six (6) of them were present among the male inmates compared to the female inmates in which only 2 of the microbial species were recovered [13]. The incidence rate of the microbial species was also highest among the male inmates with the mean value of 17.5%. This may be due to the fact that females are better at keeping to personal hygiene than male. WHO,

[14] stated in a similar report that this is attributed to exposure rather than to biological differences. The study emphasized that women are more likely than men to spend the day at home, which increases their risk of contracting illnesses in the home. In contrast, men are more likely to be exposed to illnesses spread outside the house at work. This may be the case in the prison, where the male inmates socialize among themselves and also engage in sports activities. This will in turn increase the rate of body contact and shaking of hands, which is known to be a contributing factor for transmission of microbial pathogens.

In this research, it was also observed that inmates within the age bracket  $\leq 20$  had the highest incidence of microbial growth. This might be as a result of unawareness/ignorance to personal hygiene, carelessness and unavailability of washing materials and clean water.

It was observed that the inmates who had served longer prison terms of  $\geq 11$  years to 13 years had the highest microbial incidence. This is in agreement with the study by Mamman and Reuben [15], who discovered that inmates serving jail terms were the most parasitized. This might be due to over exposure poor sanitary condition associated with the toilet facilities [16], lack of good cleaning agents as well as dearth of good medical attention at the correctional facility.

## 5. CONCLUSION

From the study, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Aspergillus niger*, *Bacillus flexus*, and *Streptococcus faecalis* were recovered from the prison animate and inanimate surfaces. The result showed that *Staphylococcus aureus* was the highest prevalent organism.

The study highlighted the demography as well pattern of exposure of inmates to different milieu in the correctional center. It can be inferred based on the data obtained from the study that the correctional center could pose serious environmental health concerns, requiring public health interventions to curb outbreaks in the correctional centers.

Adequate personal hygiene should be encouraged among the inmates. Regular sanitation as well as adequate healthcare and

routine checkup should therefore be made available to the inmates.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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