Antibiotics Susceptibility Profile of *Staphylococcus aureus* Isolated from Poultry Birds in Kaduna, Nigeria

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Abstract

Periodic antibiotic susceptibility study is imperative for the treatment and management of disease outbreak in clinics, community and poultry farms. This study evaluated the antibiotic resistant profile of *S. aureus* isolated from poultry farms in Kaduna metropolis. *S. aureus* isolation and biochemical identification were carried out using standard microbiological techniques, while susceptibility test was carried out using agar disc diffusion method. The result showed that out of 670 samples collected from broilers and layers nostril, cloaca, trachea and droppings and the farm workers' ears and nostrils; 164 (55.8%) *S. aureus* were identified. Other Staph species identified were *Staph. xylosus* (19.5%), *Staph. hyicus* (6.8%), *Staph. cohnii* (6.8%) and *Staph. intermedius* (3.7%). *S. aureus* was more in layer (51.2%) samples than broilers (48.8%) poultry birds samples in Kaduna metropolis. High resistance was observed against tetracycline (76.8%), ciprofloxacin (60.4%), oxacillin (36.6%) and cotrimoxazole (26.6%). While the isolates showed significant susceptibility to cefoxitin (97.7%), amoxiclav (97.6%) and gentamicin (96.9%). On comparing the percentage resistance of the isolates, this study observed that isolates from farm workers were more resistant to tetracycline, ciprofloxacin, cotrimoxazole and oxacillin than those from broilers while layers were the least resistant. Isolates from layers exhibited high multidrug resistant profile of 81.5% followed by those from farm workers (66.7%), then isolates from broilers (45.9%). High percentage (81.7%) of the *S. aureus* had MAR index ≥ 0.3 and 49.4% (81/164) were multidrug resistant. The most resistance patterns observed among the MDR isolates were: TE, CIP, and OX=12.8% (21); TE, CIP, VA=10.4% (17); TE, CIP, and SXT=7.3% (12); TE, CIP, SXT, and OX=7.3% (12); and TE, CIP, VA, and SXT=6.7% (11). The high resistance to tetracycline and ciprofloxacin showed their frequent use in poultry farm in Kaduna metropolis and immediate action should be taken to correct this anomalies’ as this might contribute significantly to community associated multidrug resistance, increased morbidity and economic loss.

Keywords: *S. aureus*; Antibiotics resistance; Poultry birds

Introduction

*Staphylococcus aureus* is a normal nasal flora microbiota of humans and animals, although they are generally considered commensal bacteria; they have the potential to cause a number of infections which constituted health concerns for women, newborns, elderly, and immunocompromised individuals [1]. In human, *S. aureus* has been implicated in diseases such as dermatisis, pneumonia, septicemiaa, osteomyelitis and meningitis in both humans and swine, as well as bovine mastitis in cattle and bumble-foot disease in poultry [2]. In poultry, the disease conditions associated with staphylococcosis vary with the site and route of inoculation in hatchery and poultry farms, and can infect the bones, joints, tendon sheaths, skin, sternal bursa, navel, and yolk sac through breakage of the skin and mucosal membrane of the birds, especially immunocompromised once are more prone to staphylococcal infections. Once in the host, *S. aureus* invades the metaphyseal area of the nearest joint, which leads to osteomyelitis and localization within that joint. When *S. aureus* invade the bloodstream, it causes systemic infection in multiple organs, thereby influencing economic losses, which accrued as a result of decreased weight gain, decreased egg production, lameness, mortality, and condemnation at slaughter [3]. Reports have shown that the prevalence of enterotoxigenic *S. aureus* in food handlers that serves as vehicle for zoonotic dissemination of pathogenic *S. aureus* among poultry farm workers, communities and hospitals varies in industries and countries [4]. An estimated prevalence of 2% was reported in a study conducted by Talarico et al. [5] among food handlers in Italy, 12% among flight-catering staff in Finland [6], 19% among restaurant workers in Chile [7] and 62% among fish processing factory workers in India [8]. In Japan, a retail survey performed between 2002 and 2003 found 17.6% of raw chicken meat infested with enterotoxigenic *S. aureus*; an indication of future and possible staphylococcosis outbreak, which could influence increased mortality and morbidity [9]. To control and manage these diseases/pathogenic *S. aureus*, inappropriate use of antibiotics is employed in both poultry farms and clinical settings. In poultry management, antibiotics are often used in animal food production for growth promotion and routine disease prevention without prescription or control measures. This has necessitated the development of drug resistance superbug such as methicillin resistant *S. aureus* (MRSA), vancomycin intermediate *S. aureus* (VISA), and vancomycin resistant *S. aureus* (VRSA), which are now known as major emerging public health problem [10]. With increase in population density within a particular geographical location, the incidence of both communities associated and hospital associated multidrug resistant *S. aureus* have been observed to increase with time, regardless of hospital size and control measures due to drug abuse and zoonotic transfer of resistance gene mainly located on mobile elements, such as plasmids or prophages and transferable through horizontal gene transfer [11-13]. Therefore, periodic surveillance of antibiotic susceptibility profile of pathogenic strains especially *S. aureus* in poultry farms and hospital is pertinent in

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every geographical location, as this will assist in antibiotic prescription, management and treatment of infections.

**Methodology**

**Sample size determination**

A total of 647 samples were randomly collected from 4 Poultry farms representing the 4 geographical zones of Kaduna metropolis using the method describe by Kadam and Bhalerao [14].

Thus, 
\[ n = Z^2_a \times \frac{P \times (1 - P)}{L^2} \]

- Where \( n \) = Number of samples
- \( Z_a \) = Standard normal deviation at 95% confidence limit = 1.96
- \( P \) = Prevalence = 50%
- \( L \) = Allowable error of 5% = 0.05
- \( n = 1.96^2 \times 0.5 \times 0.8416 / 0.05^2 = 647 \)

**Sample collection and areas**

Swab samples from poultry birds (broilers and layers) nostrils, cloacae, droppings, ears and farm workers ear and nostrils were aseptically collected from 4 randomly selected locations within Kaduna metropolis which represent East, South, West and North. The samples were transported to the laboratory for bacteriological analysis in ice packs.

**Isolation, identification, purification and biochemical characterization of S. aureus**

Samples were inoculated into sterile nutrient broth and incubated at 37°C for 24 hours. The overnight cultures were then subcultured on the surface of sterile mannitol salt agar by streaking and incubating at 37°C for 18-24 hours. Cultural characteristics of the resulting colonies were observed and the isolates that produced deep golden yellow coloration were selected and sub-cultured onto increased salt concentrated mannitol salt agar and incubated again overnight. Isolates that grow and still maintained the morphological features of S. aureus, were evaluated for catalase, oxidase and other biochemical characteristics using Microgen Staph. ID kit. Isolates that showed the properties of S. aureus, were then sub-cultured onto nutrient agar (NA) slants and incubated overnight at 37°C for susceptibility test.

**Antibiotic susceptibility test**

The antibiotics susceptibility profile of the identified S. aureus from poultry and farm workers were determined using the Kirby-Bauer modified disc agar diffusion (DAD) technique, [15,16]. Discrete colonies on NA plate were emulsified in 3 ml of normal saline and the turbidity was adjusted to 0.5 McFarland standard. Using sterile swab sticks, the surface of Muller Hinton agar in 90 mm-diameter plates, were inoculated with the bacteria suspension by streaking the surface of the agar in three directions, rotating the plate approximately to 60° to ensure even distribution. The inoculated plates were then allowed to dry for 10 minutes after which the antibiotic discs were placed on the surface of the agar. The plates were then left at room temperature for the pre-diffusion time before inverted and incubated aerobically at 37°C for 16-18 hrs. The diameter of the zones of growth inhibition were measured to the nearest millimeter and isolates classified as; sensitive, intermediate or resistant based on CLSI interpretative chart zone size [17].

**Determination of multiple antibiotic resistance (mar) index**

The MAR index will be determined for each isolate by dividing the number of antibiotics to which the isolate is resistant to by the total number of antibiotics tested [18].

\[ MAR \text{ Index} = \frac{\text{Number of antibiotics to which isolate is resistant}}{\text{Total number of antibiotics tested}} \]

**Results**

**Sample collection and processing**

A total of 670 poultry samples were randomly collected from 4 farms, which represent the 4 geopolitical zones in Kaduna metropolis. From the birds, 20 samples each were collected from the broilers and layers nostril, cloacae, trachea and droppings while from the farm workers samples were collected from their nostrils and ears (Table 1).

**Isolation, identification and biochemical characterization**

Out of the 670 samples collected, 530 presumptive organisms with golden yellow colonies grew on mannitol salt agar; of which 454 had the irregular cluster cocci shape, while 362 produced bubbles when tested in H₂O₂ (catalase positive) and 294 formed agglutination when tested with Oxoid latex agglutination kit. Further identification using Microgen Staph. ID showed that 24.5% (164) of the total samples collected were identified as S. aureus (Table 2).

**Occurrence of other Staphylococcus species**

Among the organisms identified, S. aureus, S. xylosus, S. hyicus, S. cohnii and S. intermedius were the predominant Staphylococcus species identified. Farm 1 had the highest occurrence of S. cohnii, S. intermedius and S. hominis, while S. hyicus was more in Farm 2. Farm 3 had the highest occurrence of S. aureus, while S. xylosus was predominant in farm 4 (Table 3).

**Incidence of S. aureus in boiler and layers in Kaduna metropolis**

The result below showed that the incidence of S. aureus in Kaduna

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**Table 1:** Distribution of sample collection in kaduna metropolis.

<table>
<thead>
<tr>
<th>Farms distribution</th>
<th>Sources of sample collection</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BN</td>
<td>BC</td>
</tr>
<tr>
<td>Farm 1 (Kaduna North)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Farm 2 (Kaduna East)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Farm 3 (Kaduna South)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Farm 4 (Kaduna West)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

**Table 2:** Identification of S. aureus.

<table>
<thead>
<tr>
<th>Farms (No of samples)</th>
<th>Isolates on mannitol</th>
<th>Microscopy</th>
<th>Catalase Test</th>
<th>Latex agglutination test</th>
<th>Microgen Staph. ID</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm 1 (166)</td>
<td>128</td>
<td>106</td>
<td>81</td>
<td>60</td>
<td>9</td>
<td>5.4</td>
</tr>
<tr>
<td>Farm 2 (164)</td>
<td>137</td>
<td>117</td>
<td>96</td>
<td>85</td>
<td>61</td>
<td>37.2</td>
</tr>
<tr>
<td>Farm 3 (174)</td>
<td>149</td>
<td>128</td>
<td>98</td>
<td>69</td>
<td>64</td>
<td>36.8</td>
</tr>
<tr>
<td>Farm 4 (166)</td>
<td>116</td>
<td>103</td>
<td>87</td>
<td>80</td>
<td>30</td>
<td>18.1</td>
</tr>
<tr>
<td>Total (670)</td>
<td>530</td>
<td>454</td>
<td>362</td>
<td>294</td>
<td>164</td>
<td>24.5</td>
</tr>
</tbody>
</table>
metropolis was more in Layer (51.2%) poultry birds than broilers (48.8%) poultry birds (Table 4).

Antibiotics susceptibility testing

High resistance was observed against tetracycline (76.8%), ciprofloxacin (60.4%), oxacillin (36.6%), cotrimoxazole (26.6%) and vancomycin (25%). While the isolates showed significant susceptibility to cefoxitin (2.3%), amoxiclav (2.4%) and gentamicin (3.1%) (Table 5).

Comparative evaluation of the antibiotic susceptibility profile of poultry samples

The isolates from the farm workers were more resistant to tetracycline, ciprofloxacin, cotrimoxazole and oxacillin compared to those from broilers then followed by layers. To cefoxitin, isolates from broilers were more resistant than those from layers and farm workers. To amoxiclav and gentamicin, isolates from farm workers were totally susceptible followed by layers then broilers (Figure 1).

Percentage multidrug resistant

This study showed that isolates from layers exhibited high multidrug resistant profile of 81.5% followed by those from farm workers (66.7%), while 45.9% of isolate from broilers were multidrug resistant (Figure 2).

Multiple antibiotic resistance index

Table 6 showed that 81.7% of the S. aureus had MAR index ≥ 0.3 while few had MAR index ≤ 0.2; an indication that the organisms tested in this study have been pre-exposed to the antibiotics tested (Table 6).

Antibiotic resistance pattern of S. aureus from poultry birds

Out of 164 S. aureus isolated, 30 were susceptible to all the antibiotics tested. Table 7 showed that 49.4% (81) of the isolates were multidrug resistant (resistant to ≥ 3 class of antibiotics), while 50.6% (83) were not multidrug resistant but resistant to one or two antibiotics. The most resistance patterns observed among the MDR isolates were: TE, CIP, SXT=7.3% (12), while 1.2% (2) had TE, CIP, VA=10.4% (17), TE, CIP, and OX=12.8% (21), TE, CIP, and SXT=7.3% (12), while 1.2% (2) had TE, SXT, and OX (Table 7).

Discussion

Poultry meat is considered the most commonly reported foodborne pathogens vehicle, followed by the red meat, in which
S. aureus related food poisoning is the third largest cause of food related illness worldwide [19]. Infections as a result of *Staph aureus* from poultry samples are becoming untreatable due to antibiotics misuse and development of drug resistance strains, such as methicillin resistant *S. aureus* (MRSA) and vancomycin resistant *S. aureus* (VRSA) [20]. According to Andreassen [21], disease conditions associated with Staphylococcosis (a bacterial disease that affect a wide range of avian species, including poultry worldwide) vary with the site and route of inoculation and can involve the bones, joints, tendon sheaths, skin, sternal bursa, navel, and yolk sac, which will in-turn influence huge economic losses resulting from decreased weight gain, decreased egg production, lameness, mortality, and condemnation at slaughter of poultry birds. In lieu of this, A total of 670 samples were randomly analysed during a one-year survey in Italy. Among *S. aureus* isolates from poultry sample had varied antibiotic susceptibility pattern and that vancomycin, in-line with the finding of Paula et al. [22]. identified *S. hyicus* (3.7%), *S. hominis* (3.4). This result is also in-line with the finding of Paula et al. [23] who observed an occurrence of 62% *S. aureus* among *S. hyicus* (55.8%), *S. xylosus* (19.5), *S. hyicus* (6.8%), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4). This result is also in-line with the finding of Paula et al. [23] who observed an occurrence of 62% *S. aureus* among *S. hyicus* (55.8%), *S. xylosus* (19.5), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4).

### Antibiotics resistance pattern and classification resistance profile

<table>
<thead>
<tr>
<th>S/N</th>
<th>Pattern of MDR Resistant F</th>
<th>NAT</th>
<th>Percentage</th>
<th>Class of R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CN, FOX, VA, SXT, CIP, AMC, OX</td>
<td>1</td>
<td>8</td>
<td>0.6</td>
</tr>
<tr>
<td>2</td>
<td>TE, CIP, and OX</td>
<td>21</td>
<td>3</td>
<td>12.8</td>
</tr>
<tr>
<td>3</td>
<td>TE, CIP, and VA</td>
<td>17</td>
<td>3</td>
<td>10.4</td>
</tr>
<tr>
<td>4</td>
<td>TE, CIP, and SXT</td>
<td>12</td>
<td>3</td>
<td>7.3</td>
</tr>
<tr>
<td>5</td>
<td>TE, CIP, VA, and OX</td>
<td>12</td>
<td>4</td>
<td>7.3</td>
</tr>
<tr>
<td>6</td>
<td>TE, CIP, VA, and SXT</td>
<td>11</td>
<td>4</td>
<td>6.7</td>
</tr>
<tr>
<td>7</td>
<td>TE, SXT, and OX</td>
<td>2</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>8</td>
<td>FOX, AMC, OX</td>
<td>1</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>9</td>
<td>TE, CIP</td>
<td>18</td>
<td>2</td>
<td>11.0</td>
</tr>
<tr>
<td>10</td>
<td>TE, OX</td>
<td>3</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>11</td>
<td>TE, VA</td>
<td>3</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>12</td>
<td>TE, CN</td>
<td>2</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>13</td>
<td>TE, OX, SXT</td>
<td>2</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>14</td>
<td>VA, OX, SXT, CIP</td>
<td>1</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>15</td>
<td>VA, OX, SXT, CIP</td>
<td>1</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>16</td>
<td>VA, OX, CIP</td>
<td>1</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>17</td>
<td>Susceptible to all antibiotics</td>
<td>30</td>
<td>0</td>
<td>18.3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>164</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**S. hyicus**: that other than *S. hyicus*, the list resistant. Isolates from layers exhibited high multidrug resistant (MDR) and can involve the bones, joints, tendon sheaths, skin, sternal bursa, navel, and yolk sac, which will in-turn influence huge economic losses resulting from decreased weight gain, decreased egg production, lameness, mortality, and condemnation at slaughter of poultry birds. In lieu of this, A total of 670 samples were randomly collected from poultry breeders and layers nostril, cloaca, trachea and droppings in four poultry farms in Kaduna metropolis, Nigeria, of which, a total of 24.5% (164) harbored coagulase positive *S. aureus* (most pathogenic *S. spp*). The percentage of *S. aureus* isolated from this study is lesser than 33% occurrence reported by Bala et al. [10] in Kano, but similar to the work of Nostro et al. [22] who observed 23.8% occurrence of coagulase positive *S. aureus* from poultry sample analysed during a one-year survey in Italy. Among *S. spp* identified include *S. aureus* (55.8%), *S. xylosus* (19.5), *S. hyicus* (6.8%), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4). This result is also in-line with the finding of Paula et al. [23] who observed an occurrence of 62% *S. aureus* among *S. hyicus* (55.8%), *S. xylosus* (19.5), *S. hyicus* (6.8%), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4). This result is also in-line with the finding of Paula et al. [23] who observed an occurrence of 62% *S. aureus* among *S. hyicus* (55.8%), *S. xylosus* (19.5), *S. hyicus* (6.8%), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4). This result is also in-line with the finding of Paula et al. [23] who observed an occurrence of 62% *S. aureus* among *S. hyicus* (55.8%), *S. xylosus* (19.5), *S. hyicus* (6.8%), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4). This result is also in-line with the finding of Paula et al. [23] who observed an occurrence of 62% *S. aureus* among *S. hyicus* (55.8%), *S. xylosus* (19.5), *S. hyicus* (6.8%), *S. cohnii* (6.8%), *S. intermedius* (3.7%) and *S. hominis* (3.4).

S. aureus isolated from the clinic (15.3%) when compared to those from the poultry farm (6.1%) in Ebonyi, Nigeria. This might be as a result of routine use of these antibiotics in clinical therapy which has degenerated to high level of resistance [37]. The classification and evaluation of resistance pattern of the isolates showed that 81.7% of the S. aureus had MAR index ≥ 0.3 while 18.3% had MAR index ≤ 0.2. Also, 45.7% (75) of the isolates were multidrug resistant (resistant to 3 or 4 class of antibiotics), 3.7% (6) were expanded drug resistant (resistant to ≥ 5 antibiotics classes) while 50.6% were not multidrug resistant but resistant to one or two antibiotics. The most resistance patterns observed among the MDR isolates were: TE, CIP, VA, and SXT=6.7% (11), TE, CIP, SXT, and OX=7.3% (12), TE, CIP, VA=10.4% (17), TE, CIP, and OX=12.8% (21), TE, CIP, and SXT=7.3% (12), while 1.2% (2) had TE, SXT, and OX. Suggesting that this resistant isolate originated from a high-risk source of contamination where antibiotics are often used or that a large proportion of the bacterial isolates have been pre-exposed to several antibiotics [38]. Also, the use of antibiotics as prophylaxes, growth promoters or inaccurate dosages given to sick flocks by unqualified personnel may likely have resulted in plasma concentrations that are inconsistent with the desired objectives in the poultry birds, which might have possibly influenced resistance profile of the birds [39].

**Conclusion**

This study isolated S. aureus with high percentage of antibiotic resistant index from poultry samples in Kaduna metropolis, it also showed that in cases of staphylococcus epidemic outbreak in poultry farms around Kaduna, antibiotics such as tetracycline and ciprofloxacin should not be prescribed treatment but rather cefoxitin and amoxicillin-clavulanic acid should be recommended.

**Recommendations**

Indiscriminate use of tetracycline and ciprofloxacin in poultry farms should be highly restricted, as this could encourage the development of efflux pump, which encourages resistant to structurally unrelated antibiotic with time. Community dissemination of antibiotic resistant genes could be propagated as poultry samples serves as vehicles for dispersal of resistant and pathogenic S. aureus. Also, periodic monitoring of resistance profile of S. aureus is important as this could help clinicians in diagnosis, treatment of infection and policy formulation.

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