World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Antibiotic resistance phenotypes of different species belonging to *Staphylococcus* genus isolated at the China-Guinea Friendship Hospital of Kipé in Conakry

Abdoulaye Makanéra [1, 2, *], Taliby Dos Camara [3], Mariam Condé [1] and Alex Landry Comoé [2]

[1] *Biomedical Laboratory of the China-Guinea Friendship Hospital of Kipé, Cité des Médecins, Commune Ratoma 30 BP: 710 Conakry, Guinea.*
[2] *Faculty of Health Sciences and Technology, Department of Medical Sciences, Chair of Basic Sciences, Gamal Abdel N.asser University of Conakry, BP: 1147 Republic of Guinea.*
[3] *Faculty of Sciences, Department of Biology, Gamal Abdel Nasser University of Conakry, BP: 1147 Republic of Guinea.*

World Journal of Advanced Research and Reviews, 2025, 25(01), 884-896

Publication history: Received on 28 November 2024; revised on 05 January 2025; accepted on 07 January 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.1.0001

Abstract

Introduction: Staphylococcal infections constitute a worldwide public health problem, particularly in hospitals. This is a retrospective study from July 1, 2012 to December 31, 2016 carried out at the Biomedical Laboratory of the China-Guinea Friendship Hospital (HASIGUI) in Kipé/Conakry. The aim of this study was to determine the antibiotic resistance phenotypes of species of the genus *Staphylococcus* isolated from various biological secretions.

Material and methods: A total of 226 strains belonging to genus of *Staphylococcus* isolated from 226 patients were studied. Cultures were made on agar media. Bacterial identifications and antibiograms were done by Vitek2 automated system and by the API method (bioMérieux France). Minimum inhibitory concentrations (MIC) were determined by Vitek 2 Compact. Results: Male were predominant and sex ratio (Male/Female) was 1.45. The mean age of the patients was 47.5% ± 21years [1-91years] and the most prominent age group (34.51%) was 60 years and over. The majority of staphylococci were isolated from urine (68.58%), pus (13.72%). Vaginal secretions (5.75%) and semen (5.31%). Fifteen *Staphylococcus* species were identified with a predominance of *Staphylococcus aureus* (26.11%), followed by *Staphylococcus epidermidis* (15.49%), *Staphylococcus xylosus* (15.04%), *Staphylococcus haemolyticus* (13.72%). The majority of strains were sensitive to nitrofurantoin (97.10%), tobramycin (92.86%), moxifloxacin (92.75%), tigecycline (91.30%) and gentamicin (85.51%), ciprofloxacin (73.85%), quinupristin/dalfopristin (75.36%) levofloxacin (53.62%). On the other hand, the majority of these strains were resistant to benzylpenicillin (98.55%), to the combination trimethoprim/sulfamethoxazole (81.16%), oxacillin (79.71%) and tetracycline (78.26%), erythromycin (62.32%), clindamycin (62.32%), rifampicin (62.32%) and vancomycin (62.32%).

Conclusion: All of these results show that many species of the genus *Staphylococcus* are involved in human infections, sometimes with multidrug resistance to many families of antibiotics.

Keywords: *Staphylococcus*; Antibiotics; Resistance phenotype; Conakry

1. Introduction

Bacteria belonging to genus *Staphylococcus* remain among the most important and serious pathogens in human infections [1]. It is Gram-positive cocci, catalase positive and belongs to the family *Micrococcaceae*. They include 45 species including 21 subspecies and are responsible for a large number of pathologies [2]. The recommended minimal standards for describing a new *Staphylococcus* species are based on the results of phenotypic and genomic studies of at

* Corresponding author: Abdoulaye Makanéra

Copyright © 2025 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution Liscense 4.0.

least five independently isolated strains [3]. They include colony morphology and the results of the following conventional tests : pigment production, growth requirements, fermentative and oxidative activity on carbohydrates, novobiocin susceptibility, enzymic activities (nitrate reductase, alkaline phosphatase, arginine dihydrolase, ornithine decarboxylase, urease, cytochrome oxidase, staphylocoagulase in rabbit plasma, heat-stable nuclease, amidases, oxidases, clumping factor, and haemolytic activity on sheep or bovine blood agar) [3].

Staphylococci are responsible for numerous cutaneous and mucous membrane damage which can be benign or serious [4]. They are often associated with urinary tract, pleuropulmonary, osteo-articular and neuro-meningeal infections, sepsis [4,5]. Bacteremia/septicemia and neuro-meningeal attacks caused by staphylococci are serious forms [6-8]. This diversity from the clinical point of view therefore requires effective management. This has been complicated by the emergence of cases of resistance. In fact, in the years following the introduction of penicillin in therapy in 1929, the first cases of resistant staphylococci were reported in 1941.

Similarly, 2 years after the appearance of the first anti-staphylococcal agent, methicillin, in 1959, the first staphylococci resistant to this antibiotic were observed [9].

The epidemiological situation has evolved considerably in recent decades. The frequency of isolation continues to increase in many regions of the world. High prevalence have been noted in numerous countries. In Shanghai, 64% of *Staphylococcus aureus* were multidrug-resistant *Staphylococcus aureus* (MRSA) [9]. In South American countries the rates vary greatly in Argentina and Peru the prevalence of MRSA is 46% and 78% respectively while in some countries such as Brazil it is 37% [10]. European countries are experiencing a continuous growth in the predominance of MRSA with rates varying from 20 to 50% reported in *Staphylococcus aureus* infections [11-15] (cases of Greece, Italy, Spain, England, Ireland, Belgium and France). In Northern Europe, the frequency of MRSA is much lower, estimated at less than 1% in Iceland, the Netherlands and the Scandinavian countries [11].

In Africa, the same diversity is found. The prevalence of MRSA in Africa varies from 10 to 57% with, in general, a lower frequency (less than 10%) in the Maghreb countries (Tunisia, Algeria, Morocco), and a high prevalence in Sub-sahara Africa [9,16]. The aim of this study was to determine the antibiotic resistance phenotypes of different species belonging to *Staphylococcus* genus, isolated at the China-Guinea Friendship Hospital of Kipé in Conakry.

2. Material and methods

This is a retrospective study from July 1, 2012 to December 31, 2016, carried out at the Sino-Guinean Friendship Hospital (HASIGUI). A total of 226 strains of Staphylococci isolated from 226 patients were studied. The body fluid samples analyzed were: urine (155), pus (31), vaginal secretions (13), semen (12), cerebrospinal fluid (4), blood (4), stool (3), axillary swabs (1), nasal (1), pharyngeal (1) and bony (1). Cytobacteriological examinations were performed fresh by observation under a light microscope (Microscope XS-213, Nanjing BW Optics Co., Ltd., Jiangsu, China) followed by Gram staining of the slides examined. A kit for staining bacteria by the Gram-Hücker method (RAL Diagnostics, Martillac, France) was used. The sample was then cultured on different agar media: Columbia agar with sheep blood 5% (Liofilchem, Roseto DA, Italy), nutrient agar (Liofilchem, Roseto DA, Italy), Chapmann (Biomérieux, Marcy l'Etoile , France) and CLED (Biomérieux, Marcy l'Etoile, France). Incubation was carried out for 18-24 hours in the GRP 9080 oven (Sumsung Laboratory Instrument CO., Ltd, Shanghai, China). Uniform bacterial colonies isolated from the cultures were stained by the Gram method in order to verify their purity, a key step preceding analyzes with the Vitek 2 Compact 15 automated system (Biomérieux, Marcy Etoile, France).Bacterial identification, antibiograms and determination of minimum inhibitory concentrations (MIC) were carried out using the Vitek 2 compact 15 automated system (Biomérieux, Marcy Etoile, France). The Vitek 2 GP cards were used for bacterial identification, and the Vitek 2 GP67 cards were used for the antibiograms and the determination of the minimum inhibitory concentrations (MIC) expressed in µg / ml, with the Vitek 2 Compact 15 automaton (bio-Mérieux France). The Advanced Expert System (AES) software enabled the detection of antibiotic resistance phenotypes using the Vitek2 Compact 15. We used again the API system for identification and antibiograms.

3. Results

The results of this present study showed that the male sex was predominant and represented 59.29% against 40.71%. The sex ratio (Male/Female) equals 1.45. The mean age of the patients was 47.5% ± 21years [1-91years] and the most common age group (34.51%) was that of 60 years and over (Figure 1).The distribution according to different department showed that 32.74% (74/226) of patients came from other hospital structures in the capital Conakry; 26.11% (59/226) from Cardiology, followed by Neurology (10.62% = 24/226), Visceral Surgery (8.41% = 19/226),

Traumatology (8.41% = 19/226) (Table I). The distribution of Staphylococci strains according to original body fluids showed that urine was by far the body fluids analyzed (68.58% = 155/226), followed by pus (13.72% = 31/226) (Table 2).

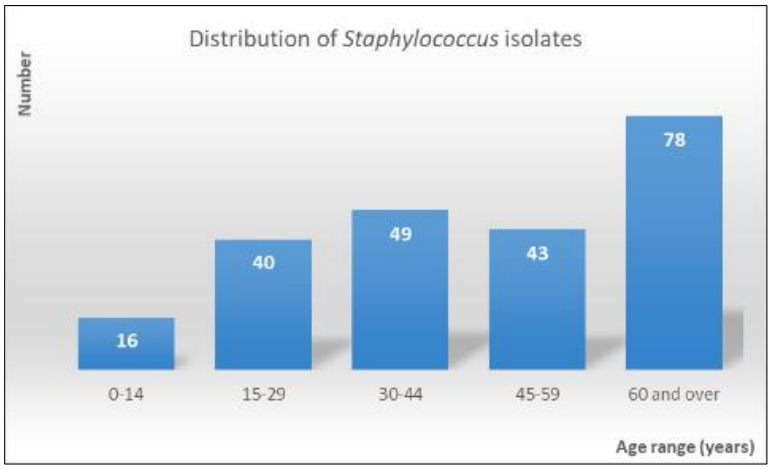

Figure 1 Distribution of *Staphylococcus* isolates according to age range

Table 1 Distribution of *Staphylococcus* isolates according to the services of origin

Provenance	Frequencies	Percentage (%)
External health structure	74	32.74
Cardiology	59	26.11
Neurology	24	10.62
Visceral surgery	19	8.41
Traumatology	19	8.41
Neurosurgery	11	4.87
Emergencies	10	4.42
Thoracic surgery	7	3.10
Acupuncture/rehabilitation	3	1.33
Total	226	100

Table 2 Distribution of *Staphylococcus* isolates according to biological secretions

Nature of samples	Number	Percentage (%)
Urine	155	68.58
Pus	31	13.72
Vaginal secretions	13	5.75
Sperm	9	3.98
Cerebrospinal fluid	4	1.77
Blood cultures	4	1.77

prostatic secretions	3	1.33
Stools	3	1.33
Armpit swab	1	0.44
Nasal swab	1	0.44
Bone harvesting	1	0.44
Pharyngeal swab	1	0.44
Total	226	100

Table 3 Staphylococci species isolated from different biological fluids

Staphylococci species	**Number (%)**
Staphylococcus aureus	59 (26.11)
Staphylococcus epidermidis	35 (15.49)
Staphylococcus xylosus	34 (15.04)
Staphylococcus haemolyticus	31 (13.72)
Staphylococcus lentus	13 (5.75)
Staphylococcus hominis	9 (3.98)
Staphylococcus intermedius	4 (1.77)
Staphylococcus saprophyticus	3 (1.33)
Staphylococcus simulans	3 (1.33)
Staphylococcus agalactiae	2 (0.88)
Staphylococcus lugdnensis	2 (0.88)
Staphylococcus caprae	1 (0.44)
Staphylococcus warneri	1 (0.44)
Staphylococcus kloosi	1 (0.44)
Staphylococcus spp	28 (12.39)

Table 4 Antibiotic resistance phenotypes detected in different strains of *Staphylococcus* species

Antibiotic families	**Phenotypes detected**
Bêta-lactams	Production of bêta-lactamases, modification of PLP(mec)
Aminosides	Resistance KAN TOB GEN (APH(2 '')+AAC(6')
Quinolones	Resistance/Partial resistance
Macrolides/lincosamides/streptogramines	MLSb Contitutive
Oxazolidines	Resistance
Glycopeptides	Resistance (TEC)/savage
Tetracyclines	Partial resistance (Efflux TET K)
Furanes	Savage

Rifamycines	Resistance
Trimethoprim/sulfamides	Resistance

Table 5 Antibiotic susceptibility of different Staphylococci species by Vitek 2 system

Antibiotiques testés	**Sensitive (%)**	**Intermediate (%)**	**Resistance (%)**
Benzylpénicillin	1(1.45)	0(0.00)	68(98.55)
Triméthoprim/sulfaméthoxazole	13(18.84)	0(0.00)	56(81.16)
Oxacillin	14(20.29)	0(0.00)	55(79.71)
Tétracyclin	12(17.39)	3(4.35)	54(78.26)
Erythromycin	26(37.68)	0(0.00)	43(62.32)
Clindamycin	23(33.33)	3(4.35)	43(62.32)
Rifampicin	24(34.78)	2(2.90)	43(62.32)
Vancomycin	24(34.78)	3(4.35)	42(60.87)
Ciprofloxacin	37(53.62)	6(8.70)	26(37.68)
Quinupristin/Dalfopristin	52(75.36)	1(1.45)	16(23.19)
Linezolide	49(71.01)	0(0.00)	20(28,99)
Levofloxacin	37(53.62)	25(36.23)	7(10,15)
Gentamicin	59(85.51)	4(5.80)	6 (8,69)
Tigecyclin	63(91.30)	0(0.00)	6(8,70)
Moxifloxacin	64(92.75)	5(7.25)	0(0.00)
Nitrofurantoine	67(97.10)	0(0.00)	2(2,90)

Table 6 Antibiotic sensitivity of *Staphylococcus aureus* strains identified with the Vitek 2 Compact system (n= 59)

Antibiotics tested	**Sensitive (%)**	**Intermediate (%)**	**Resistance (%)**
Benzylpenicillin	3(5.00)	0(0.00)	56(95.00)
Triméthprim/Sulfaméthoxazole	21(35.00)	0(0.00)	38(65.00)
Vancomycin	24(40.00)	0(0.00)	35(60.00)
Tetracycline	24(40.00)	0(0.00)	35(60.00)
Oxacillin	30(51.00)	0(0.00)	29(49.00)
Clindamycin	32(55.00)	0(0.00)	27(45.00)
Rifampicin	32(55.00)	3(5.00)	24(40.00)
Erythromycin	47(80.00)	0(0.00)	12(20.00)
Ciprofloxacin	50(85.00)	0(0.00)	9(15.00)
Tigecycline	56(95.00)	0(0.00)	3(5.00)
Levofloxacin	47(80.00)	12(20.00)	0(0.00)
Gentamicin	53(90.00)	(10.00)	0(0.00)

Moxifloxacin	59(100.00)	0(0.00)	0(0.00)
Quinupristin/Dalfopristin	59(100.00)	0(0.00)	0(0.00)
Linezolide	59(100.00)	0(0.00)	0(0.00)
Nitrofurantoine	59(100.00)	0(0.00)	0(0.00)
Resistance types			
Beta lactamase	Positive 100%	Négative 0%	
Cefoxitin screen	Positive 40%	Négative 60%	
Clindamycin inducible Resistance	Positive 0%	Négative100%	

Table 7 Antibiotic sensitivity profile of *Staphylococcus epidermidis* strains identified using Vitek 2 Compact system

Antibiotics tested	**Sensitive N (%)**	**Intermediate N(%)**	**Resistance N (%)**
Benzylpénicillin	0(0.00)	0(0.00)	35(100.00)
Oxacillin	0(0.00)	0(0.00)	35(100.00)
Erythromycin	6(16.67)	00(0.00)	29(83.33)
Vancomycin	6(16.67)	0(0.00)	29(83.33)
Tétracycline	6(16.67)	0(0.00)	29(83.33)
Rifampicin	6(16.67)	0(0.00)	29(83.33)
Triméthoprim/Sulfaméthoxazole	6(16.67)	0(0.00)	29(83.33)
Clindamycine	12(33.33)	(616.67)	17(50.00)
Quinupristine/Dalfopristine	23(66.67)	0(0.00)	12(33.33)
Linezolide	23(66.67)	0(0.00)	12(33.33)
Ciprofloxacine	17(50.00)	6(16.67)	12(33.33)
Tigecycline	35(100.00)	0(0.00)	0(0.00)
Gentamicin	29(83.33)	6(16.67)	0(0.00)
Levofloxacin	23(66.67)	12(33.33)	0(0.00)
Moxifloxacin	35(100.00)	0(0.00)	0(0.00)
Nitrofurantoine	35(100.00)	0(0.00)	0(0.00)
Resistance types			
Beta lactamases	Positive 100%		Négative 0%
Cefoxitine screen	Positive 83,33%		Négative 16,67%
Clindamycin inducible Resistance	Positive 0%		Négative 100%

Table 8 Antibiotic sensitivity profile of *Staphylococcus xylosus* strains identified using the Vitek 2 Compact system (n=34)

Antibiotics tested	**Sensitive (%)**	**Intermediate (%)**	**Resistance (%)**
Benzylpénicillin	0(0.00)	0(0.00)	34(100.00)
Oxacillin	0(0.00)	0(0.00)	34(100.00)
Erythromycin	0(0.00)	0(0.00)	34(100.00)
Clindamycin	0(0.00)	0(0.00)	34(100.00)
Quinupristin/Dalfopristin	0(0.00)	0(0.00)	34(100.00)
Linezolide	0(0.00)	0(0.00)	34(100.00)
Vancomycin	0(0.00)	0(0.00)	34(100.00)
Tétracyclin	0(0.00)	0(0.00)	34(100.00)
Rifampicin	0(0.00)	0(0.00)	34(100.00) 34(100.00)
Triméthprim/Sulfaméthoxazole	17(50.00)	0(0.00)	17(50.00)
Gentamicin	34(100.00)	0(0.00)	0(0.00)
Ciprofloxacin	17(50.00)	17(50.00)	0(0.00)
Levofloxacin	17(50.00)	17(50.00)	0(0.00)
Moxifloxacin	34(100.00)	0(0.00)	0(0.00)
Tigecyclin	34(100.00)	0(0.00)	0(0.00)
Nitrofurantoine	34(100.00)	0(0.00)	0(0.00)
Resistance types			
Beta-lactamase	Positive 100%	Négative 0(0.0%)	
Cefoxitine screen	Positive 50%	Négative 50%	
R inductible Clindamycin	Positive 0(0.0%)	Négative 100%	

Table 9 Antibiotic sensitivity profile of *Staphylococcus haemolyticus* strains identified using the Vitek Compact 2 system (n=31)

Antibiotiques testés	**Sensitive (%)**	**Intermediate (%)**	**Resistance (%)**
Benzylpenicillin	0(0.00)	0(0.00)	31(100.00)
Oxacillin	3(8.33)	0(0.00)	28(91.67)
Tetracycline	3(8.33)	(4,17)	28(91.67)
Triméthprime/Sulfaméthoxazole	3(8.33)	0(0.00)	28(91.67)
Erythromycine	8(25.00)	00(0.00)	25(75.00)
Ciprofloxacin	10(33.33)	0(0.00)	(66.67)
Clindamycin	10(33.33)	2(5.38)	19(61.29)
Rifampicine	10(33.33)	2(5.38)	19(61.29)
Vancomycin	12(38.00)	1(3,17)	18(58.33)
Gentamicin	25(75.00)	0(0.00)	6(25.00)
Linezolide	(75.00)	0(0.00)	8(25.00)

Levofloxacin	10(33.33)	13(41,67)	8(25.00)
Quinupristin/Dalfopristin	(79.16)	(4.17)	(16.67)
Tigecycline	(87.50)	0(0.00)	(12.50)
Moxifloxacin	83.34%	(8.33)	(8.33)
Nitrofurantoine	31 (100)	0(00)	0(0.00)
Resistance types			
Beta lactamase	Positive 100.00%	Négative 0.00%	
Cefoxitin screen	Positive 91.67%	Négative 8.33%	
Clindamycin inducible Resistance	Positive 12.50%	Négative 87.50%	

Table 10 Overall sensitivity profiles for all Staphylococci strains determined by the agar diffusion method (Kirby Bauer) and the Vitek2 Compact system

Antibiotics tested	**Resistance Number (%)**	**Intermediate Number (%)**	**Sensitive Number (%)**	**Total**
Nitrofurantoine	7(3.66)	3(1.57)	181(94.76)	191
Erythromycin	113(60.43)	8(4.28)	66(35.29)	187
Gentamicin	26(16.15)	5(3.10)	130(80.75)	161
Ciprofloxacin	66(42.86)	8(5.19)	80(51.95)	154
Cefalothin	47(32.64)	1(0.69)	96(66.67)	144
Ceftriaxone	14(10.37)	2(1.48)	119(88.15)	135
Norfloxacin	42(32.31)	7(5.38)	81(62.31)	130
Sulfonamides	89(72.95)	4(3.28)	29(23.77)	122
Trimethprim/Sulfamethoxazole	80(74.77)	3(2.80)	24(22.43)	107
Amoxicillin	78(78.00)	5(5.00)	17 (17.00)	100
Clindamycin	61(61.00)	7(7.00)	32 (32.00)	100
Rifampicin	55(55.56)	6(6.06)	38 (38.38)	99
Tetracyclin	56(59.57)	9(9.57)	29 (30.85)	94
Oxacillin	67(72.83)	3(3.26)	22 (23.91)	92
Cefotaxim	7(8.64)	0(0.00)	74 (91.36)	81
Fusidic Acid	33(41.25)	7(8.75)	40(50.00)	80
Kanamycin	35(44.30)	7(8.86)	37(46.84)	79
Levofloxacin	9(12.68)	18 25.35)	44(61.97)	71
Moxifloxacin	1(1.43)	5(7.14)	64(91.43)	70
Vancomycin	46(65.71)	1(1.43)	23(32.86)	70
Penicillin G	88(92.63)	1(1.05)	6(6.32)	95
Doxycycline	17(25.76)	11(16.67)	38(57.58)	66
Ofloxacin	14(21.54)	3(4,62)	48(73.85)	65
Nalidixic Acid	39(65.00)	4(6.67)	17(28.33)	60

Quinupristin/Dalfopristin	15(25,00)	1 (1,67)	44(73,33)	60
Linezolide	10 (17,24)	0(0)	48(82,76)	58
Tigecycline	6(10.91)	0(0)	49(89,09)	55
Amoxicillin /Clavulanic Acide	33(61.11)	3(5.56)	18(33,33)	54
Pefloxacin	6(13.33)	4(8.89)	35(77.78)	45
Neomycine	5(11.36)	2(4.55)	37(84.09)	44
Ampicillin	34 85.00)	3(7.50)	3(7.50)	40
Lincomycin	20(51.28)	5(10.26)	15 (38.46)	39

4. Discussion

4.1. Sociodemographic characteristics of patients

In this present study, strains of the genus *Staphylococcus* were isolated from various biological secretions from both sexes with a male predominance. Indeed, 59.29% of our patients were male against 40.71% for the female sex. The sex ratio (M/F) was 1.45. The mean age was 47.5 ± 21 years with extremes of 1 year to 91 years. These results are close to those reported in 2015 at the Mohammed V Military Instruction Hospital in Rabat [4]. Indeed, these authors showed that a male represented 64.4% of patients and the sex ratio Male/Female equal to 1.8. Furthermore, the average age of the patients in their study was 43 ± 17 years, close to ours. The distribution of *Staphylococcus* isolates according to age showed that the most represented age group was that of 60 years and over (34.51%), followed by that of 30 to 44 years (21.68%), then 45 to 59 years (19.03%) (Figure1). The distribution of patients according to receipts in HASIGUI's consultation services showed that 26.62% were for cardiology, followed by neurology with 10.62%, visceral surgery and trauma with 8.41% for each of its last two serves. (Table1). The high frequencies of isolation of strains of the genus *Staphylococcus* in patients in the cardiology department are believed to be partly due to the fact that the demands for cytobacteriological examinations (in particular ECBU) are high there. Indeed, Makanéra et al., [17]. in their study conducted in 2017 at HASIGUI had noted that the requests for bacteriological examinations from the Cardiology department represented 41.36% of all bacteriological examinations carried out at the HASIGUI Biomedical Laboratory during our study period (2012-2016). However, it can be seen that 32.74% of the patients came from other hospitals and health structures in the city of Conakry and the interior of the country. This high rate of outpatients at HASIGUI is due to the fact that the HASIGUI biomedical laboratory is considered to be the best equipped in the country since its opening in 2012. As a result, the quality of the analysis results is better. The isolation of strains of the genus *Staphylococcus* in patients out of HASIGUI shows that these strains could be encountered in other health facilities in Conakry. Frequency of body fluids The distribution of strains of the genus *Staphylococcus* according to biological secretions showed that the bacteriological examinations mainly concerned urine (68.58%), followed by samples of pus (13.72%), vaginal secretions (5.75%).), sperm (5.31%) (Table II). M. Frikh et al., Reported in 2015 that the majority of their strains of *Staphylococcus aureus* were isolated from pus (51.30%), blood (13.30%), otitis 10.10% and catheters 9,40% [4]. Regarding the different staphylococci species, the results showed that at least 14 different species belonging to *Staphylococcus genus* were isolated. (Figure 1). However, 28 strains for which only the genus was determined by the API Staph system. have been referred to as *Staphylococcus Spp.* Among the species identified, *Staphylococcus aureus* was the most frequently isolated (26.11%), followed by *Staphylococcus epidermidis* (15.49%), *Staphylococcus xyloxus* (15.04%), *Staphylococcus haemolyticus* (13.72%), and *Staphylococcus spp* (12.39%). The other 10 identified *Staphylococcus* species were in the minority. Indeed, all of these species represented less than 20% of our study population. In 2008, Boukadida et al., found results partly similar to ours. In their series, *Staphylococcus aureus* was also the most frequently isolated species (66%), followed by *Staphylococcus epidermidis* (29.6%) [1]. For the other species, our results were different. In fact, these authors founded 2.6% for *Staphylococcus hominis*, 0.9% for each of the two following species *Staphylococcus capitis* and *Staphylococcus haemolyticus*.

In 2020 the clinical relevance of coagulase-negative staphylococci (CoNS) belonging to *Staphylococcus haemolyticus*, *Staphylococcus hominis*, *Staphylococcus simulans*, and *Staphylococcus warneri* species is increasing. The appearance of automated identification systems improved their detection. Although staphylococci constitute a phylogenetically coherent group there are differences among the species important to clinicians [18,19].

According to the literature, *Staphylococcus* haemolyticus is the second major species among Coagulase negative *Staphylococcus* (CoNS) responsible for health care associated infections [Barros et al, 2015; Hitzenbichler F]. It causes

blood infections, sepsis, and is often isolated from ocular infections [4]. It is also detected as a cause of otitis, peritonitis, and urinary tract infections [20]. It is noteworthy to mention that *Staphylococcus haemolyticus* is known as a species easily acquiring resistance genes.

4.2. Susceptibility profiles of strains of different *Staphylococcus* species

Among the 226 strains isolated in our study, 69 strains were identified with the automatic device and their antibiograms were also performed with the Vitek 2 Compact 15. They constitute our series with the Vitek. The other strains were identified by the API system. Their antibiograms were carried out by the agar diffusion method (Kirby-Bauer). Local, up-to-date epidemiological data on antibiotic resistance in staphylococci are very important to know because, in addition to the orientation of first-line antibiotic therapy, they provide national and international databases with antibiotic resistance data.

4.3. Antibiotic sensitivity profile of strains of *Staphylococcus* aureus identified by Vitek 2 system

In the present study, many strains of *Staphylococcus aureus* showed resistance to the different antibiotics tested. Thus, almost all of our strains were resistance to benzylpenicillin with a frequency of 95.5%. In the present study, *Staphylococcus aureus* strains were resistant to trimethoprim/ sulfamethoxazole (65%), vancomycin (60%), tetracycline (60%) and oxacillin (50%). These results are in part close to those of Rağbetli C et al 2016 who reported in their study that all strains of *Staphylococcus aureus* were resistant to penicillin G [21].

Our results are also close to those reported by Salem ML et al., in 2016 who founded a high rate of resistance of *Staphylococcus aureus* strains to penicillin G which ranging from 96 to 100% [22].

On the other hand, these authors announced that the rate of methicillin-resistant *Staphylococcus aureus* MRSA in the community setting was of the order of 25 to 26% in suppurations, 34.3% in urine culture and 28% in sperm cultures. These authors reported that resistance to Macrolides-Lincosamyne-Streptogramins (MLS), giving the inducible MLSb phenotype, was found in 6% of urinary strains and 27% of strains isolated from suppurations. Aminoglycoside activity was variable; amikacin was active on all strains. Cotrimoxazole activity is low (77% resistance) and no resistance to vancomycin was noted [22].

In the present study, *Staphylococcus aureus* sensitivity to Trimethoprim/Sulfamethoxazole combination, were different from those reported by Rağbetli C et al 2016, who showed in their study that the resistance rate of *Staphylococcus aureus* strains was 6.1% for Trimethoprim/Sulfamethoxazole combination. However, our results (81% resistance) were close to those reported in 2016 by Salem et al., who found that 77% of *Stapylococcus aureus* were resistant to trimethoprim/sulfamethoxazole combination [22].

In our study, we found 60% resistance both to vancomycin and tetracycline, and 50% to oxacillin. Our results were different from those reported in 2016 by Rağbetli C et al., who found 10.1% resistance to tetracycline but no resistance to vancomycin [21]. However, these authors had not tested the sensitivity to oxacillin.
All the *Staphylococcus aureus* strains studied were sensitive (100%) to nitrofurantoin, levofloxacin, moxifloxacin, the quinupristin/dalfopristin combination and linezolid. These antibiotics could be considered as first-line molecules in the treatment of *Staphylococcus aureus* infections. In 2020, Chen et al reported similar results for Linezolid. However, all their isolates (100%) were susceptible to Linezolid. These authors did not indicate sensitivity of their strains to other antibiotics like nitrofurantoin, levofloxacin, moxifloxacin, Quinupristin/dalfopristin combination [23].

4.4. Antibiotic Susceptibility profile of *Staphylococcus* epidermidis Strains

In this present work, all strains of *Staphylococcus epidermidis* were resistant to benzylpenicillin and oxacillin, while the majority of these strains were resistant to erythromycin, vancomycin, tetracycline, rifampin, and trimethoprim/sulfamethoxazole combination. Hellmark et al., in their study reported in 2009 at the University Hospital of Orebro, had found resistance rates much lower than ours [24]. In these authors reported none resistant to vancomycin. However, they found the following resistance rates: 39% for Rifampicin; 67% for erythromycin [24]. Only Trimethoprim/Sulfamethoxazole gave a resistance rate of 82%, which is quite close to our results. Half of our strains (50%) were resistant to clindamycin.

In addition, these results are close to those of the above-mentioned author, for whom this rate was 67% for Clindamycin [24]. Our strains of *Staphylococcus epidermidis*, on the other hand, showed very good sensitivity to fluoroquinolones. Indeed, 100% of these strains were sensitive both to levofloxacin and to moxifloxacine. In the present study, 66.67%. of *Staphylococcus epidermidis* strains were sensitive to ciprofloxacin. Regarding fluoroquinolones, all the strains of

Staphylococcus epidermidis (100%) sensitive to ciprofloxacin and Moxifloxacin. These results were different from those of Hellmark et al., who reported that 79% for Ciprofloxacin and 64% for Moxifloxacin. The sensitivity of the strains to both quinupristin/dalfopristin combination and tigecycline was 66.67%, whereas all the strains (100%) were susceptible to linezolid.

Pinheiro et al., in his study conducted between 2000 and 2011 reported rates of susceptibility of strains of *Staphylococcus epidermidis* partly similar to ours [25]. With 98.8% for quinupristin/dalfopristin; for tigecycline and linezolid 100% of the strains were sensitive.

4.5. Antibiotic Susceptibility Profile of *Staphylococcus* xylosus Strains

The strains of *Staphylococcus xylosus* in our series showed a very high resistance profile in general. In fact, these strains have shown 100% resistance to benzylpenicillin, erythromycin, clindamycin, quinupristin/dalfopristin, linezolid, vancomycin, tetracycline and rifampicin. On the other hand, they were all shown to be sensitive to moxifloxacin, tigecycline and nitrofurantoin. In the literature, very few publications address the susceptibility profiles of the *Staphylococcus xylosus* species. Therefore, this did not allow us to find other studies to compare our results. Our data could thus be considered as one of the first descriptions of antibiotic susceptibility profiles in this species.

4.6. Antibiotic susceptibility profile of *Staphylococcus* haemolyticus strains

In our series, all strains of *Staphylococcus haemolyticus* were shown to be resistant to Penicillin G. These strains also showed high frequencies of 91.67% resistance for the following antibiotics: oxacillin, tetracycline and trimethoprim/sulfamethoxazole Barros et al. in 2012 in Brazil, resistance rates were found partly close to ours, in particular for penicillin of 95% and for oxacillin 88%; Regarding tetracycline and trimethoprim/sulfamethoxazole, the resistance rates found in their study were lower compared to ours, they were 19% and 53% respectively [26]. On the other hand, we have demonstrated resistance rates of 62.5% for clindamycin and rifampicin. The resistance rate for erythromycin was 75%. Regarding Fluoroquinolones. Ciprofloxacin, levofloxacin and moxifloxacin gave resistance rates of 66.67%, respectively; 25% and 8.33%. Gentamicin gave a resistance rate of 25%. This is different from the results of Tomasz Czekaj et al., who found high resistance rates (92.9%) to ciprofloxacin and gentamicin in Poland between 2008 and 2010. Levofloxacin and moxifloxacin were not tested in their study.

4.7. Antibiotic Resistance phenotypes detected in different staphylococci strains

The table shows different resistance phenotypes detected in different *Staphylococcus* strains using the Vitek2 compact automaton. The different resistance mechanisms are a function of the different antibiotic families. In particular, for the beta-lactam family, we detected the production of beta-lactamases and the modification of penicillin-binding proteins (PLP: mec). For the aminiside family, the following phenotypes: Resistance KAN TOB GEN (APH (2 '') +AAC (6') were detected. For quinolones, the resistance phenotypes detected were either total resistance or partial resistance.

For quinolones, the resistance phenotypes detected were either total resistance or partial resistance, whereas for macrolides/streptogramin/lincosamides, the phenotypes detected were of the MLSb Contitutive type.

For oxazolidines, total resistances were observed, whereas for glycopeptides, resistance (TEC)/savage were observed.

5. Conclusion

This retrospective study involved 226 strains of Staphylococcus, belonging to 15 different species. *Staphylococcus aureus* was the most frequently isolated followed by *Staphylococcus epidermidis* and *Staphylococcus xylosus*. The majority of patients included in the study were at least 60 years old. Most strains were resistant to benzylpenicillin, the trimethoprim/sulfamethoxazole combination, oxacillin and tetracycline. However, they were generally sensitive to nitrofurantoin, moxifloxacin, tigecycline and gentamicin. All of these results show the need for antibiograms to be carried out during bacterial infections, in order to avoid antibacterial therapeutic failures and to limit the spread of germs that are multi-resistant to antibiotics.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Boukadida J, Ben Abdallah H, Boukadida N. Profile and sensitivity to antibiotics of 115 staphylococcal strains implicated in septicemia in a Tunisian general hospital. Bull Soc Pathol Exot. 2003; 96(4):283-5.

[2] Karten B, Robert L, and Christof V.E. Staphylococcus, Micrococcus, and Other Catalase-Positive cocci. Manual of Microbiology; 11th Edition. ASM press. Washington DC 2015: 354-372

[3] Freney J, Kloos WE, Hajek V, Webster JA, Bes M, Brun Y, Vernozy-Rozand C. Recommended minimal standards for description of new staphylococcal species. Subcommittee on the taxonomy of staphylococci and streptococci of the International Committee on Systematic Bacteriology. Int J Syst Bacteriol. 1999; 49 Pt 2:489-502.

[4] Frikh M, Lemouer A, Belfquih B, kiplagat VK, Maleb A, Elouennass M. Susceptibility profiles of *Staphylococcus* aureus isolates: A retrospective study over eight years in a teaching hospital. Moroccan Journal of Medical Sciences. 2016, Volume XX, No. 1; 5-9.

[5] Tong SY, Davis JS, Eichenberger E, Holland TL, Fowler VG Jr. Staphylococcus aureus infections: epidemiology, pathophysiology, clinical manifestations, and management. Clin Microbiol Rev. 2015; 28(3):603-61. doi: 10.1128/CMR.00134-14.

[6] Reacher MH, Shah A, Livermore DM, Wale MC, Graham C, Johnson AP, Heine H, Monnickendam MA, Barker KF, James D, George RC. Bacteraemia and antibiotic resistance of its pathogens reported in England and Wales between 1990 and 1998: trend analysis. BMJ. 2000 Jan 22;320(7229):213-6.

[7] Incani A, Hair C, Purnell P, O'Brien P, Cheng AC, Appelbe A, Athan E. *Staphylococcus* aureus bacteraemia: evaluation of the role of transoesophageal echocardiography in identifying clinically unsuspected endocarditis. Eur J Clin Microbiol Infect Dis (2013) 32:1003–1008.

[8] Holland TL, Arnold C, and Fowler VG. Clinical Management of *Staphylococcus aureus* Bacteremia. JAMA. 2014 October 1; 312(13): 1330–1341.

[9] Sakoulas G, Moellering Jr. RC.Increasing antibiotic resistance among methicillin-resistant *S. aureus* strains. Clin Infect Dis; 2008; 46(suppl5): 360-367.

[10] Pan American Health Organization. Annual report of the Monitoring/ Surveillance Network for Resistance to Antibiotics, 2013. Publication Organization Panamericana, http://www.paho.org/data/index/php/en/mnu-topics/antimicrobial-resistance/306-staphylococces-aureus-resistant-oxacillin.htm [accessed 9 Juin 2017].

[11] Forestier E, Rémy V, Mohseni-Zadeh M, Lesens O, Jauhlac B, Christmann D, et al., Methicillin-resistant Staphylococcus aureus bacteremia: recent epidemiological and therapeutic aspects. Rev Med intern. 2007; 28:746-55.

[12] Cosgrove SE, Y. Qi, Kaye K.S , Harbarth S , Karchmer A , Carmeli Y. The impact of methicillin resistance in Staphylococcus aureus bacteremia on patient outcomes: mortality, length of stay, and hospital charges. Infect Control Hosp Epidemiol. 2005; 26 :166–74.

[13] Decousser JW, Pina P, Picot F, Delalande C, Pangon B, Courvalin P, Allouch P; ColBVH Study Group. Frequency of isolation and antimicrobial susceptibility of bacterial pathogens isolated from patients with bloodstream infections: a French prospective national survey. J Antimicrob Chemother. 2003;51(5):1213-22.

[14] Del Giudice P, Blanc V, Durupt F, Bes M, Martinez J-P, Counillon E, et al. Emergence of two populations of methicillin-resistant Staphylococcus aureus with distinct epidemiological, clinical and biological features, isolated from patients with communityacquired skin infections. Br J Dermatol. 2006, 154: 118–24.

[15] Libert.M , Elkholti.M , Massaut.J , Karmali.R , Mascart.G , Cherifi.S. Risk factors for meticillin resistance and outcome of Staphylococcus aureus bloodstream infection in a Belgian university hospital. J Hosp Infect. 2008; 68: 17-24.

[16] Ben Lahlou Y., Gildas Comlan A., Maleb A., Lemnouer A., Elouennass M. Epidemiology and resistance profile of gram positive bacteria at Mohammed V Military teaching hospital of Rabat, Morocco. Journal Marocain des Sciences Médicales. 2020; Tome 22 (N° 2) : 20-24

[17] Makanera A., Condé M., Diallo MA, Condé M., Camara D., Barry AO., Diakité T. 2017. Sensitivity profile of *Sphingomonas paucimobilis* strains isolated from various biological secretions at the China-Guinea Friendship Hospital. Rev CAMES, 05; 2424-7235.

[18] Szemraj M, Grazul M, Balcerczak E, Szewczyk EM. Staphylococcal species less frequently isolated from human clinical specimens - are they a threat for hospital patients? BMC Infect Dis. 2020; 11;20(1):128.

[19] Lamers RP, Muthukrishnan G, Castoe TA, Tafur S, Cole AM, Parkinson CL. Phylogenetic relationships among *Staphylococcus* species and refinement of cluster groups based on multilocus data. BMC Evol Biol. 2012; 12:171.

[20] Takeuchi F, Watanabe S, Baba T, Yuzawa H, Ito T, Morimoto Y, et al. Whole- genome sequencing of *Staphylococcus* haemolyticus uncovers the extreme plasticity of its genome and the evolution of human-colonizing staphylococcal species. J Bacteriol. 2005;187(21):7292–308.

[21] Rağbetli C, Parlak M, Bayram Y, Guducuoglu H, Ceylan N. Evaluation of Antimicrobial Resistance in *Staphylococcus* aureus Isolates by Years. Interdiscip Perspect Infect Dis. 2016; 2016:9171395.

[22] Salem ML, Ghaber SM, Baba SE, Maouloud MM. Antibiotic susceptibility of community-acquired strains of *Staphylococcus* aureus in Nouakchott Region (Mauritania). Pan Afr Med J. 2016, 27;24:276.

[23] Chen, H., Du, Y., Xia, Q. et al. Role of linezolid combination therapy for serious infections: review of the current evidence. Eur J Clin Microbiol Infect Dis 39, 1043–1052 (2020). https://doi.org/10.1007/s10096-019-03801-x

[24] Hellmark B, Unemo M., Nilsdotter-Augustinsson A. and B. So¨derquist Antibiotic susceptibility among *Staphylococcus* epidermidis isolated from prosthetic joint infections with special focus on rifampicin and variability of the rpoB gene. Clin Microbiol Infect 2009; 15: 238–244

[25] Pinheiro L., Ivo Brito C., Pereira VC, Oliveira A., Bartolomeu AR., , Henrique Camargo CH. Susceptibility Profile of *Staphylococcus* epidermidis and *Staphylococcus* haemolyticus Isolated from Blood Cultures to Vancomycin and Novel Antimicrobial Drugs over a Period of 12 Years. Microbial Drug Resistance; 2016; 22 (4): 283-293.

[26] Barros EM, Ceotto H, Bastos MC, Dos Santos KR, Giambiagi-Demarval M. *Staphylococcus* haemolyticus as an important hospital pathogen and carrier of methicillin resistance genes. J Clin Microbiol. 2012 Jan;50(1):166-8.

[27] Czekaj T, Ciszewski M, Szewczyk EM. *Staphylococcus* haemolyticus - an emerging threat in the twilight of the antibiotics age. Microbiology (Reading). 2015 Nov;161(11):2061-8.