

**ANTIBIOTIC SENSITIVITY OF *STAPHYLOCOCCUS AUREUS* ISOLATED
FROM PATIENTS ATTENDING RUIRU DISTRICT HOSPITAL, KENYA
AUGUST TO NOVEMBER 2012**

ABSTRACT

Aim: To determine the sensitivity of *Staphylococcus aureus* to commonly used antibiotics in patients with skin, soft tissue and upper respiratory tract infections.

Study Design: Cross sectional

Place and Duration of Study: Samples were obtained from Ruiru District Hospital, Kenya between August and November 2012. The antibiotic sensitivity tests were done at the Laboratories of Jomo Kenyatta University of Agriculture and Technology at Juja, Kenya.

Methodology: The study included 100 in and outpatients with infections on clinical diagnosis, cellulitis, wound infection, ulcers, septic bruises, abscess (including furuncle / boil/ superficial skin abscess). A questionnaire was used to collect patient demographic data from patient records and cultures from the hospital laboratory collected and transported to the Jomo Kenyatta University Laboratories for identification of staphylococcal colonies by culture and biochemical tests. Disc diffusion test was used to determine *in vitro* antibiotic sensitivities of the *S. aureus* isolates as per the Kirby-Bauer diffusion technique

Results: The results indicate that the isolates were very resistant (10% sensitivity) to methicillin and gentamycin, moderately resistant (less than 40% sensitivity) to Morepenem, Erythromycin, Oxacilin, Ampicilin, Penicillin, Cotrimoxazole and Augmentin but sensitive to minocycline (83.3%). The isolates were also sensitive to Cefurozime, Ciprofloxacin, Chlorophenicol and Lincomycin (75, 58.3, 50 and 41.6% sensitivity respectively). In this regard, antibiotics such as Gentamycin, chloramphenicol, co-trimoxazole and ampicillin, on the WHO and Kenyan essential drugs list are unlikely to offer help to the patients in Ruiru District hospital. Minocycline would thus be the antibiotic of choice against *Staphylococcus* infections followed by cefuroxime (75%) and ciprofloxacin (58.3%) as the next alternative drugs of choice.

Keywords: antibiotic, bacteria, sensitivity, resistance, *S. aureus*,

14 1. INTRODUCTION

15

16 The use penicillin as an antibiotic was first described by Sir Alexander Fleming (1)
17 and since then, antibiotics have been important therapeutic agents for mankind. In
18 the past years there has been marked increase in the number of antibiotics prescribed
19 as well as evolution of new antibiotics. Simultaneously there has been irrational and
20 excessive use of antibiotics for chemotherapy as well as growth in livestock which
21 has led to development of antibiotic resistance and even multiple drug resistance
22 bacteria.

23

24 In most case, the initial antimicrobial prescribed for treatment of an infection is
25 chosen on the basis of clinical impression after the physician is convinced that an
26 infection exists and has made a tentative etiological diagnosis on clinical grounds.
27 Rarely in developing countries such as Kenya are specimens are obtained for
28 laboratory isolation of the causative agent and sensitivity testing to inform the
29 antibiotic of choice. However, the identification microorganisms that are known to
30 be susceptible to certain antibiotics in an area permit the selection of optimally
31 effective drugs. The commonly performed tests are disks diffusion susceptibility
32 tests (2).

33

34 *Staphylococcus*, a member of the Firmicutes, was first identified in 1880 in
35 Aberdeen, United Kingdom, by the surgeon Sir Alexander Ogston in pus from a
36 surgical abscess in a knee joint (3). One species, *Staphylococcus aureus* is frequently
37 found as part of normal bacteria flora and is estimated that between 20-40% of the
38 human population are long-term carriers in reservoirs in the anterior nares and thus
39 produce nasal secretions and can infect others (4, 5, 6).

40

41 Although *S. aureus* is not always pathogenic, disease-associated strains promote
42 infections by producing potent protein toxins, and expressing cell-surface proteins
43 that bind and inactivate antibodies. *S. aureus* is the most common species of
44 staphylococcus causing Staph infections causing a range of illnesses, from minor
45 skin infections, boils (furuncles), cellulitis, folliculitis, carbuncles, scalded skin
46 syndrome, and abscesses, to life-threatening diseases such as pneumonia, meningitis,
47 osteomyelitis, endocarditis, toxic shock syndrome (TSS), bacteremia, and sepsis. Its
48 incidence ranges from skin, soft tissue, respiratory, bone, joint, endovascular to
49 wound infections. *S. aureus* is one of the five most common causes of nosocomial
50 infections and is often the cause of postsurgical wound infections especially in
51 people with weakened defense systems due to viral infection, chronic illness or in
52 patients undergoing major surgery. Each year, some 500,000 patients in American
53 hospitals contract a staphylococcal infection (7).

54

55 Bacteria either have intrinsic mechanism for antibiotic resistance which they develop
56 through mutation and selection processes or acquire resistance through genetic
57 transfer from other bacteria in the vicinity. Joshua and Esther Lederberg showed
58 penicillin and streptomycin resistant bacteria existed before penicillin treatment (8).

It was believed that penicillin may have emerged as a defense mechanism for the bacteria in their habitats as in case of penicillase rich *Staphylococcus aureus* living with penicillin producing Trichophyton. The prevalence of antibiotic resistant bacteria has not only increased with time but also multi resistance in respect to antibiotics of similar or different mechanism of action. Despite the importance of antibiotic resistance, no comprehensive data base is available regarding the status of clinical isolates in certain areas due to the dynamic nature of emergence and distribution of resistance.

Widespread use of antibiotics both inside and outside of medicine has however played a significant role in the emergence of resistant bacteria leading to development of multi drug resistant strains and the spread of resistance between bacterial species. (9). This has been by misuse, underuse and overuse of antibiotics by doctors as well as patients. Of particular importance is over the counter dispensing of antibiotics without prescriptions. Furthermore, patients taking less than the recommended dosage or failing to complete their doses within the prescribed timing results in decreased concentration of antibiotics in the blood stream and tissues. In this regard, an insufficiently long course of antibiotic allows the more resistant bacteria present to survive and be selected leading to more resistant strains and a possible relapse with a more severe infection that is more difficult to treat. A large number of people do not finish a course of a once daily antibiotic, 10% to 44 % saying that this is because they felt better (9).

There are various mechanisms of antibiotic resistance for instance; penicillin resistance mediated by penicillinase (a form of β -lactamase) production renders β -lactam antibiotics, such as methicillin, nafcillin, oxacillin, cloxacillin, dicloxacillin, and flucloxacillin ineffective. On the other hand, resistance to methicillin mediated via the mec operon, codes for an altered penicillin-binding protein (PBP2a or PBP2') that has a lower affinity for binding β -lactams (penicillins, cephalosporins, and carbapenems) allowing resistance to all β -lactam antibiotics. Glycopeptide resistance on the other hand is mediated by acquisition of the vanA gene. In aminoglycoside antibiotics, such as kanamycin, gentamycin, there are three main mechanisms of aminoglycoside resistance which are currently: aminoglycoside modifying enzymes, ribosomal mutations, and active efflux of the drug out of the bacteria (10, 11).

There are *S. aureus* strains resistant to many commonly used antibiotics. The β -lactamase-resistant penicillins (methicillin, oxacillin, cloxacillin, and flucloxacillin) were developed to treat penicillin-resistant *S. aureus*, and are still used as first-line treatment. Methicillin was the first antibiotic in this class introduced in 1959 developed only two years later, the first case of MRSA was reported in England (12). Despite this, MRSA generally remained an uncommon finding, even in hospital settings, until the 1990s, when there was an explosion in MRSA prevalence in hospitals, where it is now endemic. In the UK, only 2% of all *S. aureus* isolates are sensitive to penicillin, with a similar picture in the rest of the world (13).

103
104 MRSA infections in both the hospital and community setting are commonly treated
105 with non- β -lactam antibiotics, such as clindamycin and co-trimoxazole. Resistance to
106 these antibiotics has also led to the use of new, broad-spectrum anti-Gram-positive
107 antibiotics, such as linezolid. First-line treatment for serious invasive infections due
108 to MRSA is currently glycopeptide antibiotics (vancomycin and teicoplanin). In
109 Kenya, this is restricted for use in level 4 hospitals (14)

110
111 Vancomycin-resistant *S. aureus* (VRSA) also emerged the first case of vancomycin-
112 intermediate *S. aureus* (VISA) reported in Japan in 1996; (15) but the first case of *S.*
113 *aureus* truly resistant to glycopeptide antibiotics was only reported in 2002 (16).
114 Three cases of VRSA infection had been reported in the United States as of 2005
115 (17). MRSA is the most frequently identified antimicrobial drug resistant pathogen
116 in hospitals in the United States, with hospital acquired *S. aureus* infections
117 increasing from 2% in 1974 to 22% by 1995, and 50% in 1997 (18).

118
119 Antibiotic resistance pathogens including *S. aureus* have been observed in Africa.
120 For instance, in a hospital study in Mogadishu, Somalia, multidrug resistance *S.*
121 *aureus* strains were observed (19) while in Nigeria, 40% of ear infections and
122 bronchitis were shown to be resistant (20). Although *S. aureus* is responsible for
123 illnesses ranging from bacteremia to infections of the central nervous system and
124 respiratory tract, the prevalence of resistant isolates has not been documented for the
125 majority of African countries (21).

126
127 In developing countries, the need for antibiotics is driven by high incidence of
128 infectious diseases. There also are complex socioeconomic and behavioral factors
129 such as irrational use of antibiotics by health professionals, unskilled practitioners
130 and lay persons, poor drug quality, unhygienic conditions, poor drug regulation and
131 inadequate surveillance (9). This bacterial exposure culminates in development,
132 selection and spread of resistant organisms contributing to escalating problem of
133 antibiotic resistance worldwide.

134
135 Of all surgical infection cases in Kenya, 30-40% were shown to be due to
136 *Staphylococcus* approximately 50% being abscesses which culminated to mortalities
137 in 30% of those untreated (4, 22). Patients with purulent wounds may infect others
138 by invisible droplets containing bacteria Staphylococci through flies, equipment and
139 fingers and clothing of the nursing and medical staff (22). Resistant strains of
140 Staphylococci are common in Kenyan hospitals and may cause very serious
141 infections particularly in hospitalized patients. It is believed that the excessive use
142 and misuse of antibiotics has contributed towards antimicrobial resistance leading
143 treatment failure and relapses with more severe infections that are more difficult to
144 treat. This is particularly among chronically ill, surgical and hospitalized patients.

145

Determination of antibiotic sensitivity profiles of *S. aureus* in respect to commonly used antibiotics may vary in different hospitals from time to time. An institution specific study on efficacy of antibiotics in treatment of infections caused by *S. aureus* is thus necessary to inform treatment plans that will achieve successful treatment outcomes. Furthermore, nationwide information from such studies can then be used to inform national policy such as the essential drug list. Overall, the emergence and spread of resistances to antibiotics used to treat infections caused by *S. aureus* will be minimized by rational use of antibiotics by health professionals.

To mitigate this resistance, it is important for laboratory identification of *Staphylococcus aureus* and antibiotic sensitivity of isolates from the site of infection or blood culture through commonly used methods which include coagulase (23), agglutination (24) and hybridization tests (25). This will provide comprehensive information on antibiotic sensitivities of *S. aureus* which is lacking in Kenya (26). This study thus aimed at determining among the most commonly dispensed antibiotics, which were the most efficacious in the treatment of *Staphylococcus aureus* infections in patients attending Ruiru District Hospital, Kenya.

2. MATERIAL AND METHODS

This was a cross sectional study done at Ruiru District hospital located in Kiambu County of Kenya using specimens from the hospital laboratory and demographic data from patient records. The study population was both in and outpatient adults (18 years and above) attending the Ruiru District Hospital in the period between August and November 2012. This is a public hospital serving patients with middle to lower social economic status from a rural and peri urban area. Eligible patients for enrolment were those with skin, soft tissue and upper respiratory tract infections on clinical diagnosis, cellulitis, wound infection, ulcers, septic bruises, abscess (including furuncle/boil/superficial skin abscess). A sample size of 100 was determined using the following formula according to Fisher (27)

After obtaining ethical consent from the hospital administration, specimens were taken with sterile Bacron swabs from the hospital laboratory, put on Armies transport media (Oxoid, Unpath, Hemisphere England), transported to the Jomo Kenyatta University Laboratories, cultured on Blood Agar media or Mannitol Salt Agar, and then incubated at 37°C for 18-24 hours. The plates are then examined for typical staphylococcal colonies and gram staining, culture, biochemical tests (catalase, coagulase). The demographic data of the patients from patient records was captured in a questionnaire without including patient details that would jeopardize their privacy and confidentiality.

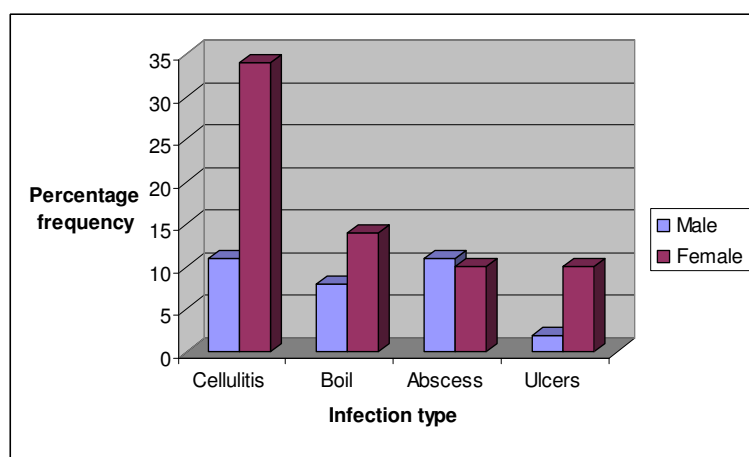
After clearly identifying pathogenic *Staphylococcus aureus*, the disc diffusion test was used to determine *in vitro* antibiotic sensitivities of the isolates as per the Kirby-Bauer diffusion technique (28) in accordance with CLSI (formerly, NCCLS) criteria, 2006 (29).

3. RESULTS AND DISCUSSION

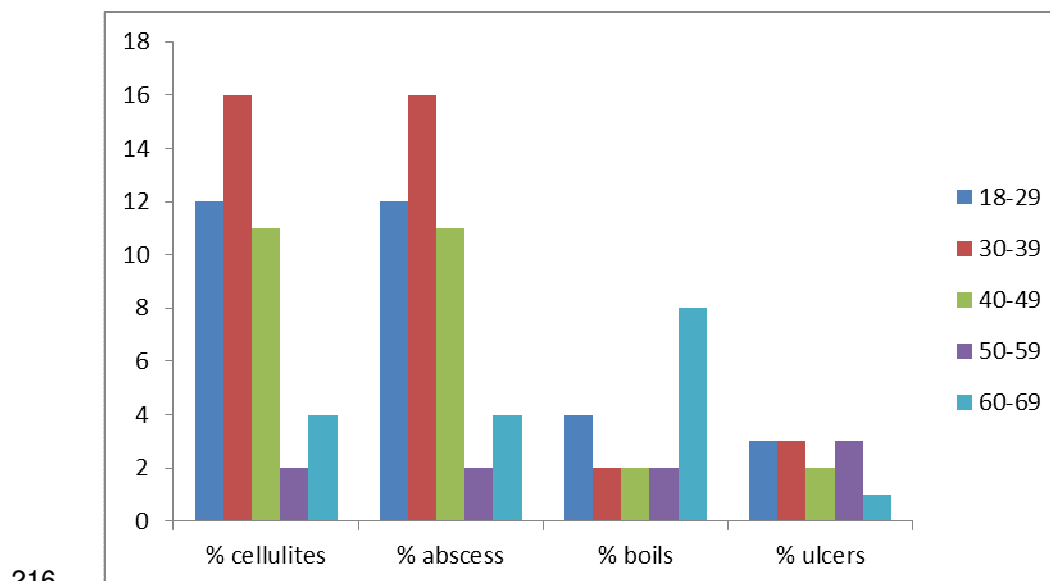
Samples were obtained from a total of 100 patients of mean age 18-69 years; 32 of who were male and 68 females. Among 100 patients sampled, boils, abscesses, cellulitis and ulcers were the major conditions (fig 1) with cellulitis being more prevalent in females than in males. Their ages ranged from 12% of those aged 50-59 2 to 29% of those aged between 30 and 39. Abscesses and cellulitis were most frequently found in patients aged 30-39 while boils were found most frequently in the 60-69 age group (fig 2).

The morphological and biochemical characterization showed that all samples isolated were identified as pathogenic *Staphylococcus aureus* for they yellow medium sized colonies of gram positive cocci with catalase and coagulase activity.

Fig 1 Sex and infection of the patients from whom *Staphylococcus aureus* was isolated

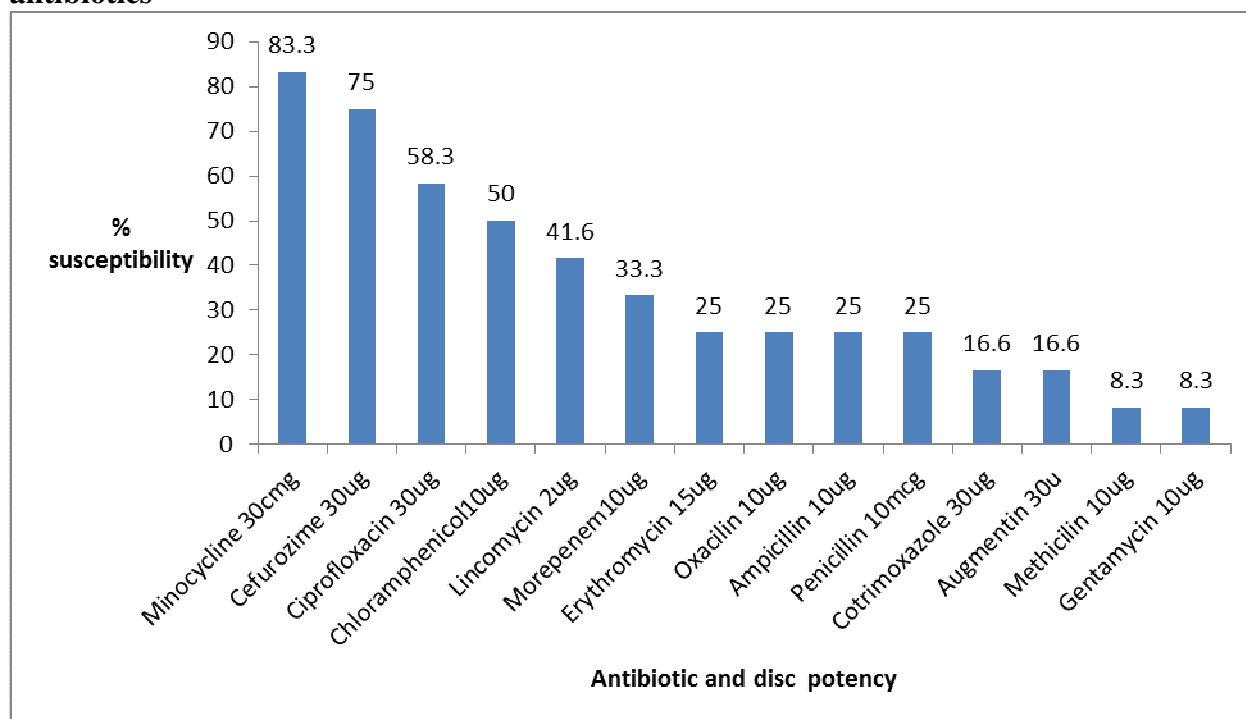


215 **Fig 2 Source of *Staphylococcus aureus* according to age of patients**



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218 As shown in figure 3, the most sensitive antibiotic was Minocycline (83.3%) while
219 the least sensitive was the aminoglycoside Gentamycin and the β -lactam Methicilin
220 (8.3%). Other antibiotics had varying sensitivities; 75% sensitivity to the β -lactam
221 cefuroxime; 58.3% sensitivity to the quinolone ciprofloxacin ; 50% to the
222 bacteriostatic chloramphenicol; 41.6% sensitivity to the lincosamide lincomycin;
223 33.3% to the β -lactam morepenem; 25% the macrolide erythromycin as well as the
224 β -lactams oxacilin, ampicillin, penicillin; co-trimoxazole and Augmentin 16.6%.

242 **Fig 3. Sensitivity profiles of *Staphylococcus aureus* isolates to selected**
 243 **antibiotics**



244
 245
 246 Although cellulitis was seen in all age groups, it was more prevalent in females than
 247 males ($p < 0.001$). It may be that cellulitis has a pre-direction for specific population
 248 based upon demographic factors such as sex.

249
 250 The isolates were identified as *Staphylococcus aureus*, the most commonly isolated
 251 human bacterial pathogen found in skin and soft-tissue infections as well as sepsis
 252 (30). In 2009, Omuse (31) reported that 34% blood stream infection between 2003
 253 and 2008 at the Aga Khan University hospital in Nairobi, Kenya were due to *S.*
 254 *aureus*. Maina et al (32) reported that from skin and soft tissue infections from
 255 patients in Nairobi hospitals, 65% of the boil isolates were *S. aureus* and so were
 256 23.3% of abscess cultures, 52.9% of cellulitis cultures and 44% of ulcer cultures.

257
 258 Unlike the UK where only 2% of all *S. aureus* isolates were reported in 2001 to be
 259 sensitive to penicillin (13), in this study the prevalence of sensitive isolates was 25%.
 260 In respect to methicillin, the 91.7% methicillin resistance (8.3% susceptibility)
 261 observed in *Staphylococcus aureus* in this study is much higher than the 24.2%
 262 found in hospital associated *S. aureus* in Texas in 2001 (33). Earlier studies in
 263 American hospitals had tracked the increase of methicillin resistant *S. aureus* from
 264 2.4% in 1975; 29% in 1991; to 50% in 1997 (34, 18). In addition to resistance to
 265 methicillin, the resistance patterns observed in the present study to the
 266 aminoglycoside gentamycin (8.3% susceptibility), the β -lactam/clavulaninic acid
 267 combination augmentin (16.6 % susceptibility) and other β -lactams morepenem

(33.3% susceptibility) oxacilin, ampicilin, penicillin (25% susceptibility) can be compared with studies in varying countries. Boyee (1998) earlier reported that methicillin resistant bacteria are usually resistant to β -lactams such as erythromycin, clindamycin, and frequently to gentamycin and ciprofloxacin. Unlike this observation (35) however, the isolates in this study were moderately resistant to ciprofloxacin (58.3%) as well as lincomycin a lincosamine similar to clindamycin (41.6%).

275

In 2009, 49%, 44%, 39% and 50% of isolates *S. aureus* from chronic wounds in a study in India were found to be resistant to ciprofloxacin, methicillin, oxacillin and vancomycin respectively (36). Later in 2011, in another study (37), resistance of MRSA to penicillin (100%), augmentin (70.83%), erythromycin (66%), tetracycline (62.5%), cefotaxime (66%), cephalexin(58%) was reported. Unlike this study in India, all MRSA strains in the present study were sensitive to vancomycin.

282

There are limited studies on antibiotic resistance in Africa in general and Kenya in particular. Vlieghe et al. (38) systematically reviewed published literature on bacterial resistance in Central African countries; Cameroon, Chad, Gabon, São Tomé e Príncipe, Congo-Brazzaville, Democratic Republic of the Congo, Central African Republi, Angola and Equatorial Guinea. What was observed was methicillin-resistant *S. aureus*, high-level Penicillin-resistant *Streptococcus pneumoniae* and extended-spectrum beta-lactamases among Gram-negative pathogens. Another analysis Kimang'a (39), observed there was resistant bacteria to Ampicillin, Amoxycillin, Chloramphenicol, Streptomycin, Spectinomycin, Cotrimoxazole, Trimethoprim-Sulfisoxazole, Kanamycin, Tetracycline and Gentamycin in different parts of Africa.

294

An investigation of eight African hospitals noted comparatively higher levels of MDR MRSA in Kenya, Nigeria and Cameroon, with more than 60 percent of isolates exhibiting resistance to at least three antibiotics (21). In Kenya, there was MRSA at 28% of all *S. aureus* tested in Nairobi city hospitals in 1997 with MRSA susceptibility to gentamicin and tetracycline extremely low, at 15 and 8%. In addition, 2006, MRSA was found in 33 percent of *S. aureus* isolates in nosocomial infections at Kenyatta National Hospital in Kenya (40). A study during the same year on the public health threat of bacterial infections and antibiotic resistance at Kenyatta National Hospital found the prevalence of MRSA to be 40 percent of all *S. aureus* infections (31). Later, a study in 2009 reported that *S. aureus* isolated from healthcare facilities in western Kenya showed 25% resistance to commonly used antibiotics (41). A situational analysis of 2011 documented that at the Kenyatta National hospital *S. aureus* resistance was 40% to methicillin, 85% to gentamycin and 94 % to tetracycline (26). Even more recently, a study of skin and soft tissue isolates from patients attending Nairobi hospitals reported in 2013 that 84.1% were MRSA (32).

311

312 In Kenya, the bacterial infections that contribute most to human disease are often
 313 those in which resistance is most evident in antibiotics most frequently used with
 314 increased use of antibiotics appearing to correlate with increased antibiotic resistance
 315 (26, 42). When considering antibiotic use in Kenya, penicillins are the most
 316 prescribed antibiotic class at 31 % of the overall mean, (43, 44). Tetracyclines were
 317 the second most frequently consumed antibiotic class of which doxycycline was the
 318 most popular. Contrimoxazole consumption increased from 1997 to 1999 possibly
 319 due to its prophylactic use among an increasing HIV positive population.
 320 Aminoglycoside consumption also rose steadily after 1999, of which
 321 gentamicin accounted for 78 percent of the mean annual amount. While
 322 macrolide use remained stable after 1999, Cephalosporin use from 1999
 323 increased in 2000 but later dropped in 2001.

324

325 The multi-drug resistant (MDR) *S. aureus* towards routinely used antibiotics as
 326 observed in this study is similar to Kimang'a, (39) who reported that 71% *S. aureus*
 327 isolates from Kenya demonstrated multiple drug resistance. This phenomenon may
 328 be attributed to widespread availability for Gentamycin, Methicilin (8.3%), co-
 329 trimoxazole, oxacilin (16.6 %) and erythromycin (25%) observed in this study to be
 330 least effective are recommended for use as a first level antibiotics thus are available
 331 in the numerous health centres categorized as level 2 (45, 14). In addition, the most
 332 effective cefuroxime (75%) and chloramphenicol (50%) are only found as second
 333 level drugs in level 4 district hospitals. However, ciprofloxacin with bacterial
 334 sensitivity of 58.3% was also widely available as a first level drug in health centres
 335 and Augmentin which is available as a first level drug only in district hospitals was
 336 not effective (16.6% sensitivity).

337 Other factors that could be associated with antibiotic resistance of the *S. aureus*
 338 isolated could be improper use and patients not taking complete antibiotic course of
 339 treatment as prescribed. These habits are prevalent where there is dispensing of
 340 antibiotics over the counter (OTC) without the requisite prescriptive precautions.
 341 Such dispensing is particularly common among low and middle income such as
 342 found in the population likely to attend Ruiru District Hospital.

343

344 It has been noted that such indiscriminate use of antibiotics by over-the-counter
 345 access, not only gives rise to resistant strains of bacteria, but also provide
 346 opportunity for conjugative transfer of resistant plasmids to susceptible bacteria as
 347 has been observed in β -lactams and aminoglycosides (46, 47, 48). It may be possible
 348 that there may be sub-standard and counterfeit antibiotics in the market that may also
 349 work towards development of resistance as in the case reported in antimalarial drugs
 350 circulating in the markets of developing countries (49). Furthermore, there are
 351 suggestions that antibiotic resistance observed in pathogens isolated from humans
 352 may emanate from the livestock where the most popular antibiotic use reported was
 353 tetracycline (55%) followed by sulfonamides (21%) aminoglycosides (7%), β -
 354 lactam (6 %), quinolones (0.6 %) macrolides (0.2 percent) and tiamulin (43).

355 The strong association between boils and abscess in skin and wound cultures as well
356 as education level and gender with *S. aureus* infection was difficult to explain except
357 as it may relate to low socio-economic status and thus hygiene standards of the
358 people in this area. Such associations of antibiotic resistance with socio-economic
359 status have been observed in the previous studies (4, 50).

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361

362 4. CONCLUSION

363

364 Antibiotic resistance may take the form of a spontaneous or induced genetic
365 mutation, or the acquisition of resistance genes from other bacterial species by
366 horizontal gene transfer via conjugation, transduction, or transformation. Many
367 antibiotic resistance genes reside on transmissible plasmids, facilitating their transfer.
368 Exposure to an antibiotic naturally selects for the survival of the organisms with the
369 genes for resistance.

370

371 Even in conditions of abject poverty and poor infrastructure and services,
372 antibiotics have worked wonders. These gains are now seriously jeopardized by
373 the emergence and spread of microbes that are resistant to most commonly
374 available and effective first line antibiotics. In most of sub-Saharan Africa,
375 available antibiotics are already limited and thus any breach on the first line
376 listed antibiotics leads to near total loss of treatment choices for many severe
377 ailments.

378

379 This study has confirmed that like in others parts of Kenya, there are *S. aureus*
380 isolates that are resistant to commonly used antibiotics. Overuse, misuse and
381 underuse through lack of access, inadequate dosing, poor adherence, and
382 substandard antimicrobials may have contributed to its emergence and spread.
383 Furthermore, comprehensive local data on usage and antibiotic resistance needed to
384 give a true reflection of the situation in Kenya and to form policy such as the
385 essential drug list is lacking (26)

386

387 The study was based on various antibiotics commonly used for treatment of
388 *Staphylococcus aureus* infections indicates that microbes were very resistant (less
389 than 10% sensitivity) to methicillin and gentamycin, moderately resistant (less than
390 40% sensitivity) to Morepenem, Erythromycin, Oxacilin, Ampicilin, Penicillin,
391 Cotrimoxazole and Augmentin but sensitive to minocycline (83.3%). *Staphylococcus*
392 isolated were also sensitive to Cefurozime, Ciprofloxacin, Chlorophenicol and
393 Lincomycin (75, 58.3, 50 and 41.6% sensitivity respectively). In this regard,
394 Gentamycin, chloramphenical, co-trimoxazole and ampicilin some of which are on
395 the WHO and Kenyan essential drugs list are unlikely to offer help to the patients in
396 Ruiru District hospital. Minocycline would thus be the antibiotic of choice against
397 *Staphylococcus* infections followed by cefuroxime (75%) and ciprofloxacin (58.3%)
398 as the next alternative drugs of choice. These antibiotics however, should be used
399 carefully to avoid development of resistant *Staphylococcus aureus* strains.

These findings should be compared to the status of antibiotics susceptibility in treatment of *S. aureus* in different regions of the country. There is thus need for further research including establishment of prevalence and resistance patterns of *Staphylococcus aureus* in other geographic locations.

If this situation is similar country wide, these findings purpose a major change in antibiotic therapy for treatment of *Staphylococcus aureus* infections. With *S. aureus* resistant to β -lactam antibiotics, the antimicrobials of choice would be sulfa drugs (like co-trimoxazole), tetracyclines (like doxycycline, minocycline and clindamycin), but the drug of choice for treating MRSA is vancomycin. In this case however, since the isolates were also resistant to co-trimoxazole and lincomycin, the antibiotic of choice would be minocycline and it is thus recommended and the essential drug list be subsequently reviewed.

Noting that currently sensitive microbes could also develop resistance to effective antibiotics, there is need for strictly enforcing quality and regulatory strategies, regularly updating prescription guidelines and emphasizing continued medical and public education to alleviate irrational use of antibiotics by health care professional, unskilled practitioners and patients. Where resources and expertise is available, the ultimate would be determination of bacterial antibiotic sensitivity prior to selection of treatment after isolation from a patient.

CONSENT (WHERE EVER APPLICABLE)

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Ethical approval for the study was obtained from the Medical Superintendent at Ruiru District Hospital.

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