E3 Journal of Biotechnology and Pharmaceutical Research Vol. 6(1), pp. 001-008,May, 2017
Available online at http://www.e3journals.org
ISSN 2141-7474 © E3 Journals 2017
DOI: http://dx.doi.org/10.18685/EJBPR(6)1_EJBPR-16-010

Full length research paper

Effect of Gentamicin and Amoxicillin on methicillin resistant *Staphylococcus aureus* (MRSA) against different time and concentrations

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Accepted 10 January, 2017

***Staphylococcus aureus (S. aureus*) is a gram positive coccal bacterium which is normally a skin flora but may cause opportunistic infections such as skin and soft tissue infections, bacteremia and necrotizing fasciitis. Twenty (20) clinical specimens were collected from healthy (10) persons and unhealthy (10) persons. These samples were collected from different sources such as ear, wound, vagina swab and urine. A total of (10) *S. aureus* isolates was obtained and screened for methicillin resistance by using oxacillin disc (10kg). Ten *S. aureus* were found to be methicillin resistant. Sensitivity test of these methicillin resistant *Staphylococcus aureus* (MRSA) revealed resistance to all penicillin derivatives and to a greater extent gentamicin, argumetin and ofloxacin. The effect of time duration on the killing kinetics of gentamicin, amoxicillin and a combination of the two MRSA was also determined. Result showed that MRSA was susceptible to gentamicin at a range of (2.5 – 4.2) at a concentration of 1000mg/ml and (2.0 – 4.3) at a concentration of 500mg/ml and amoxicillin at a range of (1.4 – 3.1) at a concentration of 1000mg/ml and (1.4 – 2.9) at a concentration of 500mg/ml of the antibiotics and the combination of these antibiotics which has a range of (3.3 – 3.8) at a concentration of 1000mg/ml and (2.7 – 3.7) at a concentration of 500mg/ml will give a synergy and it can be used against MRSA.**

Keywords: Methicillin-resistant, *Saphylococcus aureus,* Resistance, Susceptibility, Antibiotics, Gentamicin and Amoxicillin

INTRODUCTION

Staphylococcus aureus is a gram-positive coccal bacterium and is frequently found in the nose, respiratory tract, and on the skin. It is often positive catalase and nitrate reduction. Although *S. aureus* is not always pathogenic, it is a common cause of skin infections such as abscesses, respiratory infections such as sinusitis, and food poisoning. An estimated 20% of the human populations are long-term carriers of *S. aureus* which can be found as part of the normal skin flora and in the nostrils (Cole *et al.,* 2001). *Staphylococcus aureus* is a normal inhabitant of the healthy lower reproductive tract of women (Senok *et al.,* 2009 and Hoffman, 2012).

According to *(*Biedenbach *et al., 2002) S. aureus* was the most common cause of nosocomial

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bacteremia in North America (prevalence, 26.0%) and Latin America (prevalence, 21.6%) and was the second most common cause of nosocomial bacteremia in Europe (prevalence,19.5%). Furthermore *S. aureus* was found to be common cause of early onset Bacteremia in a study involving 6697 patients with blood stream, infections who were identified in hospitals during 2002-2003 (Shorr *et al.,* 2006). The spread of drug resistant pathogens is one the most serious threats to the successful control of microbial diseases. Methicillin-resistant *Saphylococcus aureus (MRSA)* is responsible for several difficult-to-treat infections in humans. MRSA is any strain of *Staphylococcus aureus* that has developed, through horizontal gene transfer and natural selection, multi-resistance to beta-lactam antibiotics, which include the penicillin (methicillin, dicloxacin, nafcillin, oxacillin etc) and cephalosporin which are commonly used to treat Staphylococci infections. It is also called oxacillin–resistant *Staphylococcus aureus* (ORSA) (McDougal *et al.*, 2003). Methicillin-susceptible *Staphylococcus aureus* (MSSA) are those strains that are unable to resist these antibiotics.

According to Tacconelli *et al.,* 2009 the populations at risk of MRSA infection are people who are frequently in crowded places especially with shared equipment and skin to skin contact; people with weak immune systems (HIV/AIDS, lupus or cancer sufferers; transplant recipients, severe asthmatics etc); Diabetics, intravenous drug users, users of quinolone antibiotics, the elderly, college student living dormitories (Lipsky *et al.,* 2010); Women with frequent urinary tract or kidney infections due to infection in the bladder, people staying or working in health care facility for an extended period of time, people who spend time in coastal waters where MRSA is present, such as some beaches in Florida and the West coast of United States (Tacconelli *et al.,* 2009). Prisons, military barracks and homeless shelters can be crowded and confined, and poor hygiene practices may proliferate, these putting inhabitants at increased risks of contacting MRSA. Many MRSA infections occur in hospitals and health care facilities. Infections occurring in this manner are known as health care acquired methicillin resistant *Staphylococcus aureus* MRSA. Health care providers move from patient to patient without performing necessarily hand–washing techniques between patients (Tacconelli *et al.*, 2009).

This present study aims to determine the rate of methicillin resistant among *S. aureus* isolates from the hospitals; to determine the susceptibility of methicillin resistant among *S. aureus* (MRSA) to Amoxicillin and Gentamicin respectively and to determine the susceptibility of Methicillin resistant *S. aureus* (MRSA) to Amoxicillin and Gentamicin combined.

MATERIALS AND METHOD

Study Population

A total of 20 clinical specimens from healthy and unhealthy persons were screened for methicillin resistant *S. aureus*. The specimens were from various clinical specimen sites such as urine, pus, vagina, semen, ear and wound.

Materials Used

Conical flasks, beakers, Petri dishes, test tubes, wire loop pipette, syringe, forceps, cotton wool were used. Other materials include nutrient agar, mackonkay agar, slides, sterile swab stick, and universal bottle/container. Reagents used were, hydrogen peroxide solution, human plasma, gram stain, normal saline, amoxicillin, gentamicin drugs and sensitivity discs.

Microbiological Methods Used

Standard microbiological methods were followed to detect *S. aureus*. The samples were inoculated onto mackonkay agar and incubated at 37^0C for 18 – 24hrs. Colonies with pink colour appearance, round and smooth end were suspected for staphylococcus species.

Biochemical Tests

Morphological and characterisation of tests isolates were carried out on each of the test isolates to confirm their identity as labelled. Classification of colonies as *S. aureus* was verified using the following biochemical tests; catalase test, oxidase test, indole test, citrate utilization test, motility test, coagulate test, triple sugar iron (TSI) test.

Gram Staining

A smear of culture was made on a clean grease free slide by emulsifying a colony in a drop of sterile normal saline, the smear was heat fixed by passing over flame. The smear was stained with crystal violet for 5minutes and washed off with running water. The smear was flooded with Lugol's iodine for 5minutes

TABLE 1: Distribution of Sites of Isolates

SPECIMENS	NUMBER EXAMINED
Urine	(n = 4)
HVS	(n = 3)
Nose	(n = 3)
Semen	(n =2)
Wound	(n =2)
Pus	(n =2)
Skin	(n =2)
Ear swab	(n =2)
Total	20

Key: n = Number examined; HVS = High Vagina Swab

TABLE 2: Antibiotic Susceptibility Patterns of MRSA Isolates

Sample size				**No. (mm)**			**Resistant to**				
(20)	GEN	CIP	VAN	AMP	PEN	OXA	CEP	CLO	AUG	CEF	OFLO
	20	5	15	00	00	00	00	00	00	00	00
	S	S	S	R	R	R	R	R	R	R	R

KEY: GEN- Gentamicin; CIP- Ciprofloxacin; VAN- Vancomycin; AMP-AmpicillinPEN-Penicillin; OXA-Oxacillin; CEP-Cephalosporin; CLO-Cloxacillin AUG-Augumetin; CEF-Cefuraxin; OFLO-Ofloxacin; S-Sensitive,R-Resistant

and washed off immediately with water. It was decolourized with acetone for 2minutes and washed off immediately. The smear was counter stained with neutral red for 3–5minutes and washed off, air dried and examined under oil immersion objective (×100). The organism took the colour (blue) of the crystal violet-iodine complex denoting a gram-positive organism.

Sensitivity Test

With the help of a sterile wire loop, colonies of these *Staphylococcus aureus* strains were streaked on Petri–dishes containing nutrient agar and excelling (10µg) discs were placed on agar plates and incubated overnight. Observations were made and recorded. For susceptibility test to other antimicrobials 10ml of test isolates were seeded on nutrient agar plates on the inoculated plates. These were then incubated overnight at 37^0C.

Determination of Effect of Gentamicin and Amoxicilli on Staphylococcus

A serial dilution of the two antibiotics (gentamicin and amoxicillin) was carried out to provide different concentrations of 1000g/ml, 500g/ml, 250g/ml, and 125g/ml for each of the drugs. 10ml of these isolates from the different time intervals of 1, 2, 3, 4, 5 hours then 24hours. These plates were incubated overnight at 37^0C. Growth was observed and colonies counted.

RESULT

A total of 10 methicillin resistance *S. aureus* were isolated from 20 specimens. The distribution of these MRSA according to specimen is shown in table 1. Table 2 shows the antibiotic susceptibility pattern of the 10 MRSA isolates. The result revealed that all MRSA were resistant to more than 5 different antibiotics including penicillin, amoxicillin, cloxacillin, oxacillin and cephalosporin.

Table 3 shows effect of gentamicin against MRSA isolates. The result showed that gentamicin has more killing effect on MRSA and this was at a very high concentration of 1000mg/ml and 500mg/ml and after incubation period of 24hours. Table 4 shows effect of different concentrations of amoxicillin on MRSA. The result revealed that amoxicillin has very little effect on MRSA. Table 5 shows the effect of different concentrations on the combination of both drugs were only effective at very high concentrations of 1000mg and 500mg and at 24hrs only.

TABLE 3: Effect of Gentamicin on MRSA Isolates

Concentration at (1000mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	+(2.5)	+(2.6)	+(3.2)	+(3.5)	+(3.7)	+(4.0)	+(4.1)	+(4.2)	-	-

Concentration at (500mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	+(2.0)	+(2.5)	+(3.0)	+(3.3)	+(3.4)	+(3.6)	+(4.1)	+(4.3)	-	-

Concentration at (250mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-

Concentration at (125mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-

KEY: - ⟶ Resistant , + (2.0 – 4.3) ⟶ Sensitive

TABLE 4: Effects of Amoxicillin on MRSA over a Period of Time

Concentration (1000mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	+(1.4)	+(2.3)	+(2.5)	+(2.6)	+(3.1)	-	-	-	-	-

Concentration at (500mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	+(1.0)	+(2.2)	+(2.9)	-	-	-	-	-	-	-

Concentration at (250mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-

Concentration at (125mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
]]]]] 24	-	-	-	-	-	-	-	-	-	-

KEY:- → Resistant, + (1.0 – 3.1) → Sensitive

TABLE 5: Effect of the Combination of Gentamicin and Amoxicillin on MRSA over a Period of Time

Concentration at (1000mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	+(3.3)	+(3.8)	-	-	-	-	-	-	-	-

Concentration at (500mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	+(2.7)	+(3.7)	-	-	-	-	-	-	-	-

Concentration at (250mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-

Concentration (125mg/ml)

Time (hrs)	No. of isolates									
	1	2	3	4	5	6	7	8	9	10
	Zone of inhibition × 10cm									
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-

KEY: - ⟶ Resistant, + (2.7 – 3.8) ⟶ Sensitive

DISCUSSION

This study shows an alarming high incidence of MRSA infection among healthy and unhealthy patients. The prevalence rate is found to be 48%, which is much higher than most of the reports where MRSA prevalence ranged between 28.4% in out-patients to 33.5% to in-patients (Rybak and Laplante, 2005). Susceptibility test carried out has shown that MRSA are resistant to all penicillin derivatives.

The treatment of staphylococcal infection is generally carried out with a group of antibiotics called β – lactams which include methicillin, oxacillin, penicillin, and amoxicillin. MRSA is however generally resistant to these antibiotics. MRSA is one of a number of greatly feared strains of *S. aureus* which have become resistant to most β – lactam antibiotics. For this reason, vancomycin, a glycopeptides antibiotic is commonly used to combat MRSA. Vancomycin inhibits the synthesis of peptidoglycan, but unlike β – lactam antibiotics, glycopeptides antibiotic target and bind to amino acid in the cell wall, preventing peptidoglycan cross linkages from forming (Waters *et al.,* 2011). Reduced susceptibility to Vancomycin has occurred in strains of MRSA and infections were associated with significant morbidity requiring prolong antimicrobial therapy. Modification of bacterial cell wall proteins in response to prolonged Vancomycin exposure was likely responsible for the emergence of glycopeptides resistance in these isolates (CDC, 1999).

In the present study, all the *S. aureus* isolates were sensitive to vancomycin and gentamicin according to Table 2. This suggested that should any of these isolates cause infections in the patients or individuals, those concerned could be effectively treated with any of these antibiotics just as Table 3 which show gentamicin has a higher killing effect at a range of (2.5 – 4.2) at a concentration of 1000mg/ml and (2.0 – 4.3) at a concentration of 500mg/ml compared to amoxicillin which had only little effect but only at a very high concentration of 1000mg/ml at a range of (1.4 – 3.5) and (1.4 – 2.9) at a concentration of 500mg/ml in table 4. The concentration of 1000mg–500mg inhibited the growth of the microorganisms.

In general, these isolates lowered rates of resistance to amoxicillin, cephalosporin in comparison with two previous studies which were conducted in Nigeria. For example, Ajoke *et al.,* (2012) reported a high rate of resistance to tetracycline and amoxicillin while Onanuga and Temedie (2011) observed resistance to chloramphenicol. The difference in antibiotic resistance pattern among the *S. aureus* isolates in these studies may be due to differences in the availability and ease of access to antibiotics in places where the studies were carried out. Table 5 which shows the effect of combination of gentamicin and amoxicillin and showed that all the isolates were not sensitive, but the zone of inhibition were higher than gentamicin and amoxicillin zone of inhibition when used separately, which has a range of (3.3 – 3.8) at a concentration of 1000mg/ml and (2.7 – 3.7) at a concentration of 500mg/ml.

The emergence of methicin-resistant *Staphylococcus aureus* (MRSA) in hospitals as well as the community is a signifant and costly public health concern (Haran *et al.,* 2012). It is reasonable to assume that resistance alone is the chief determinant of clinical outcome, in that an infected patient who is prescribed the wrong antibiotic for an infection simply does not get better. This is not necessarily the case, however. There appear to be other factors that contribute towards the poorer outcome of patients who did not receive the right drug, or indeed, enough of the right drug, to eradicate their infection. Resistant Gram-positive bacteria such as MRSA express a number of virulence determinants, which might explain why patients with MRSA infections are more likely to suffer protracted courses of infection, or even die, if they do not receive appropriate therapy at the first attempt (Kollef, 2003)

CONCLUSION

In conclusion, it was observed that gentamicin was susceptible, that is had a higher killing effect on MRSA and at a very high concentration. MRSA was also susceptible to amoxicillin but at a very high concentration but not effective as that of gentamicin. The combination of these antibiotics will give synergy which shows the same killing effect as the use of only gentamicin. This result agrees with other reports that penicillin derivatives have little or no effect on MRSA.

RECOMMENDATION

The following should be taken into consideration to help stop the spread of further MRSA infections. The use of gentamicin only is preferably compared to using the combination which gives a poor synergy. The prescription of drugs or antibiotics by doctors should be followed which consequently leads to fewer misuse of antibiotics. The misuse, incomplete or inappropriate use of antibiotic dosage resulting to bacteria mutation and antibiotic resistance should be stopped, checked and corrected. Government should enlighten the public both old and young on misuse of

antibiotics, which may help to lower antibiotic resistance of *S. aureus* isolates.

REFERENCES

Ajoke OI, Okeke IO, Odeyemi OA, Okwori AE (2012). Prevalence of Methicillin – Resistant Staphylococcus aureus from Healthy Community Individuals Volunteer in Jos South, Nigeria. *JMBFS* 1:1389 - 1405

Biedenbach DJ, Moet GJ, Jane RN (2002). "Occurrence and Antimicrobial Resistance Pattern Comparisons among Blood Stream Infection Isolates from the sentry Antimicrobial Surveillance Program (1997 – 2002) *Diagn. Microbial. Infect. Dis* 50: 56 – 59.

Centre for Disease Control (1999). Four Paediatrics Deaths from Community Acquired Methicillin Resistant *Staphylococcus aureus*. Minnesota and North Dakota (1997 – 1999). *JAMA.* 282(12):1123-1125.

Cole AM, Tahk S, Oren A, Yoshioka D, Kim YH, Park A, Ganz T (2001). "Determinants of *Staphylococcus aureus* nasal carriage". Clin Diagn Lab Immunol 8(6):1064-1069.

Haran KP, Godden SM, Boxrud D, Jawahir S, Bender JB, Sreevatsan S (2012).Prevalence and Characterization of *Staphylococcus aureus*, Including Methicillin-Resistant *staphylococcus*, Isolated from Bulk Tank Milk from Minnesota Dairy Farms. J. of Clin. Microbio. 50(3): 688 - 695

Herwaldt LA (1999). Control of Metrically resistant *staphylococcus aureus.* American J. of Med. Microbiol 106: 115 – 185.

Hoffman B (2012). Williams gynecology, Medical 2nd edn. New York. McGraw-Hill. p65

Kluytmans J, Van-Belkum A, Verbrugh H, Van-Belkum V (1997). "Nasal carriage of *staphylococcus aureus: epidemiology*, underlying mechanisms, and associated risks." Clin. Microbiol. Rev. 10(3): 505-520.

Kollef MH (2003). Appropriate Empirical Antibacterial therapy for Nosocomial Infections. *Drugs* 63:2157-2168.

Lipsky BA, Tabak YP, Johannes RS, Vo L, Hyde L, Weigelt JA (2010). "Skin and soft tissue infections in hospitalised patients with diabetes: culture isolates and risk factors associated with mortality, length of stay and cost." Diabetelogia 53(5): 914-923.

Losley RM, Cohen ML (1992). Multiple Antibiotic resistant *S. aureus*: introduction, transmission and evolution of nosocomial infection. Annals of Internal Medicine 97: 317 – 333.

McDougal LK, Steward CD, Killgore GE (2003). Pulsed – Field Gel Electrophoresis Typing of Oxacillin – Resistant *Staphylococcus aureus* isolates from the United States; establishing a national database. J. Clin Microbial: 41:5113.

Monnet DL (1998). Methicillin resistant *Staphylococcus aureus* and its relationship to antimicrobial use: possible implication for control. *Infect. Contr. Hosp. Endemic* 19: 552 - 561

Onanuga A, Temedie TC (2011). Multidrug–resistant Intestinal *Staphylococcus aureus* among self medicated healthy adults in Amassoma, South–South Nigeria. Jour. Health Population Nutr. 29: 446 – 453.

Rybak MJ, Laplante KL (2005). Community Associated Methicillin Resistant *Staphylococcus aureus*. A Review Pharmacotherapy. 25:74-85.

Senok AC, Verstraelen H, Temmerman M, Botta GA, Senok AC (2009). "Probiotics for the treatment of bacterial vaginosis". Cochrane Database Syst Rev. Retrieved on 13th July, 2016

Shorr AF, Tabak YP, Kallan AD, Liu LZ, Kollef MH (2006). Health Care associated blood stream infection: a distinct entity? Insights from a large US database. Crit Care Med 34: 2588-2595.

Talconelli E, De Angelis G, De Waure C, Cataldo MA, La Torre G, Cauda R (2009). Rapid Screening Tests for Methicillin Resistant *Staphylococcus aureus* at hospital admission: systemic review and meta–analysis. *Lancet. Infect. Dis* 9(9): 546 – 554.

Waters AE, Contente-Cuomo, T, Buchhagen J, Liu CM, Watson L, Pearce K (2011). "Multidrug – Resistant *Staphylococcus aureus* in US Meat and Poultry" Clin. Infect. Dis: 52(10) 1227 – 1230