PATTERN OF OROFACIAL INFECTIVE BACTERIAL MICROORGANISMS AND THEIR ANTIBIOGRAM PROFILES AT KENYATTA NATIONAL HOSPITAL

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DECLARATION

I, Dr. Mwangi James Gatune, duly state that this dissertation is my original work and has not been presented for the award of a degree in any other University.

Signed……. Date …….,……,……

AWARD

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This dissertation is dedicated to my family who gave me a lot of support during my postgraduate studies.

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ABBREVIATIONS

KNH---Kenyatta National Hospital

NSTIs ----Necrotizing soft tissue infections

CFI----- Cervicofacial infections

MRSA----Methicillin Resistant *Staphylococcus aureus*

ARGs----Antibiotic resistance genes

Erm---- Erythromycin methylases

UNGA----United Nations General Assembly

Vitek 2----This is a microbial identification system and antibiotic susceptibility testing.

ABSTRACT

Background: Antibiotic resistance is becoming a global threat to health. In Kenya it is an already acknowledged public health problem. The cost of treating deep neck space infections of odontogenic origin is high. This is compounded by the requirement of highly skilled manpower. Furthermore, complications arising from these infections can be very severe and include facial nerve palsy or even death.

Aim of the study: To determine the range of bacterial pathogens and antibiotic sensitivity patterns among patients presenting with bacterial orofacial infections.

Study site: The Kenyatta National Hospital (KNH), which is a national teaching and referral hospital.

Research Design: This was a cross-sectional study involving 39 patients with orofacial infections who presented to the outpatient dental clinic and the emergency and accident departments.

Material and Methods: A convenient sample of 39 participants was selected. Swabs or pus aspirate specimens from the patients were taken to the University of Nairobi and KNH microbiology laboratories for culture and sensitivity test. For each case two samples were taken; one for anaerobic culture in a medium and the other for aerobic culture without a medium. Molecular identification of microorganisms and antibiotic sensitivity was carried out at the KNH laboratory using the"Vitek 2" machine. The latter is used not only to identify microorganisms but also test for the sensitivity of these microorganisms to antimicrobials.

Results: Thirty nine consenting participants were recruited for the study with an age range of 4-71 years and a mean of 34.33(+/- 17.56). Males accounted for 61.5% of the participants among whom 56.4% were in the 21—40-year age group. Thirty six percent of the respondents sought treatment for periapical abscesses. All the patients who were diagnosed with Ludwig's angina were males. Seventy two percent had used an antimicrobial agent before the samples were taken. The Chi-square test showed a non-stastically significant association between bacterial growth and prior use of antibiotics before samples were taken. Among the antimicrobials used, metronidazole accounted for 32%. Among the samples taken 47.4% showed aerobic microbial growth while among the participants who reported having taken antimicrobials for the infection

before being recruited in the study only 29% had aerobic growth. The sensitivity of the aerobes towards meropenem, amikacin, levofloxacin and ciprofloxacin was found to have been statistically significant using the ordinal regression test.

Conclusions: Most of the bacteria in orofacial infections were found to have been aerobes at 47.4%. There was also a significant percentage of anaerobes at 31.6% while 21% of the infections were found to have been of mixed bacterial origin.

Recommendations: Having found that meropenem and metronidazole were very effective in the management of orofacial bacterial infections, it is recommended that these drugs be used judiciously in the management of infections to avoid resistance in future.

CHAPTER ONE

Introduction and Literature Review

1.0 Introduction

The orofacial region is well endowed with good blood supply. This and immunological structures enable healing especially after minor surgeries. Paradoxically, inflammatory conditions account for more than 60% of all acquired neck masses in Kenya[1]. These conditions are referred to as cervicofacial or orofacial infections (CFI). They involve the orbit, buccal, pharyngeal spaces, and oral cavity floor or hemifacial structures[2]. Their proximity to the airway means that these infections are often life-threatening. Further, they pose a risk since potential fascial spaces can allow spread of these infections intracranially or mediastinally[3]. This often leads to high mortality and/or morbidity [2] when it happens. The valveless venous drainage means that the infections can spread in either the retrograde or antegrade direction. This can help orofacial infections spread into the cavernous sinus with dire consequences. Though the angle of the mandible has good muscular attachments, the thin lingual plate medial to the lower third molar facilitates spread of infection medially. The high attachment of the mylohyoid muscle above the apices of the lower third molar, leads to submandibular space spread of odontogenic infections. This explains why most studies[2,3,4,5] have consistently reported this space as the one frequently affected.

To prevent complications of orofacial infections, adjuvant use of antibiotics becomes of ultimate importance. That means the clinician may administer antimicrobials empirically at the earliest opportunity [1].However, there is accumulating evidence of resistance to the commonly available antibiotics [6,7,8,9]. The available data show conflicting reports of causative microorganism susceptibility to different antibiotics. Most of the patients will have already received drugs like cephalosporins in a primary healthcare setting before seeking treatment in a tertiary referral centre. Furthermore, there is often evidence of attempted surgical intervention. However, the clinical situation worsens hence the referral to a tertiary institution.

The prevention of antimicrobial drug resistance is of paramount importance in the current era[10,11]. One way of achieving this is to make the right choice of antibiotics. This would be achieved by periodical analysis of the antibiogram profiles and this study attempted to shed light in this area.

Success of treatment of oro-facial infections will depend not only on making an empirical choice of an antimicrobial agent, but also on the knowledge of the prevailing causative microorganisms and their resistance to antimicrobials. For instance, evidence exists showing a rise in Methicillin-Resistant *Staphylococcus aureus* (MRSA) colonization among some populations [12,13]. The presence of antibiotic resistance genes (ARGs) confers such resistance to the oral microbiota[14]. This explains the antimicrobial resistance even in individuals not previously exposed to antibiotics. This situation may arise from the widespread use of antibiotics in poultry and livestock[15].Nevertheless, some researchers have argued that only a small proportion of the subgingival microbiota is resistant to penicillins[16]. While most studies have reported that both aerobic and anaerobic bacteria are involved in orofacial infections[5,17,18,19] some literature reveals that roughly 50% of odontogenic infections are caused by anaerobic bacteria alone[7].According to Anthony[19], bacterial specimens obtained extraorally to avoid contamination with the intraoral resident microbes is lacking. Therefore, this study aimed at investigating the associated microorganisms in orofacial infections.

2.0 Literature Review

2.1 Introduction

The discovery of antibiotics, especially penicillin by A. Flemming in 1928, meant that more lives would be saved from infections [20]. Prior to the antibiotics era, lives were lost due to even simple infections of odontogenic origin [5,21]. The death of the Afrorussian renowned poet Pushkin is a classical example[22]. Pushkin died not from the bullet of his wife's suitor but from infection .The mortality due to odontogenic infections in the pre-antibiotics era has been reported as 10-40% [5]. However, according to Bahl et al[4] "modern antibiotic therapy has greatly reduced the complications from spread of these infections". However, it is now well documented that antimicrobial drug resistance is threatening to reverse these gains[23,24,25,26]. Some studies have reported up to 50% microbial resistance to the empirically administered antibiotics[5].Some antibiotics like erythromycin are now considered historical in the management of odontogenic infections by some clinicians[7]. Worse, is the presence of multidrug resistant pathogens in hospital settings [8,27]. However, other studies have found drugs like amoxicillin—even better with clavulanic acid — to still possess high antimicrobial efficacy[3,17,28]. Surprisingly, Farmahan et al[28] found no significant change in antibiotic sensitivity of odontogenic infections in the head and neck over the last 30-40 years in their study. These studies were done in different populations and that perhaps may explain the different outcomes. The fate of orofacial infections not only depends on antimicrobials used but also on the virulence of microorganisms and host factors among others[21].

2.2 Microorganisms

The oral cavity presents a unique environment for oral microorganisms. This is due to the presence of nutrients, secretions, crevices and epithelial debris. It has more than 500 species of bacteria. *Streptococcus*, *Peptostreptococcus*, *Veillonella*, *Lactobacilllus*, *Corynebacterium* and *Actinomyces* account for more than 80% of the cultivatable flora[6]. Notably, different microorganisms cause different pathologies in the oral cavity.

2.3 Dental Infections:

2.3.1 Dental Abscess: The term is used to explain the collection of pus in the periapical region or alveolar bone. The incidence in an African population has been found to be 6.4%[29].Dental abscesses are of three main categories: gingival abscess which is found no more than 3mm below

the gingival crevice; periodontal abscess which is located in the periodontal ligament beyond 3mm of the sulcus; periapical abscess — located in the periapical tissues--- is a rather common oral pathology. Dental abscesses have a potential for very serious complications like intracranial spread[30]. These odontogenic infections are of polymicrobial origin consisting of both anaerobic and aerobic bacteria as demonstrated by different authors[5, ,17,31,32]. However, some authors have reported some infections being caused by anaerobic bacteria alone[7,56]. While some authors found the predominant microogranism to have been *Streptococus viridans*[4,28,33] others report *Klebsiella pneumoniae* and Staphylococci species[34]. New bacteria belonging to the *Atopobium* genus have been reported[21]. The inconsistencies about the findings could be due to contamination during collection of samples, prior use of antimicrobials and the different stages of infection at which the patients report. The use of molecular biological techniques like molecular cloning and sequencing using 16s rRNA/ rDNA has yielded a higher prevalence or other microorganisms[31,32]. Shweta and Prakash[21] have argued that a lot of dental abscess-causing bacteria are yet to be identified. Use of molecular techniques have been advocated for in order to yield the "unfamiliar bacteria". However, these molecular methods are limited to the species for which probes are available. Therefore, more data need to be generated putting all these short- comings into consideration.

2.3.2 Ludwig's Angina: This is another familiar dental infection that has a high mortality rate[36,37]. It is a bilateral cellulitis of the sublingual, submandibular and submental spaces following, quite often, odontogenic infections. The condition presents with tender massive swelling, fever, trismus and raised a tongue. Possible complications include airway compromise, carotid arterial rupture, mediastinitis and necrotizing fasciitis among others[35]. It also has polymicrobial aetiology, the commonly isolated organisms being *Staphylococcus*, *Streptococcus* and *Bacteriodes*[37,38]. However, other authors[38,39] have reported *Klebsiella* as commonly isolated while others[36] still report *Spirochetes* as the main causative agent. Therefore, the etiology is not clear yet. Most of these patients develop complications due to self-medication, antibiotics abuse and patronage of unorthodox medical practitioners[37]. Parenteral antibiotics and steroids coupled with surgery is the mainstay management.

2.3.3 Gangrenous Stomatitis (Noma/cancrum oris**)** is one of the infective orofacial lesion in which the specific microorganisms implicated have been difficult to isolate since a large number

of them are uncultivatable. The disease progresses slowly and occurs in poor communities where laboratory facilities are a big challenge. The available data reveals inconsistent findings. For instance, Ashok, et al[40] reported the main causative agent having being *Fusobacterium necrophorum* but *Capnocytophaga porphyromonia* and *Fusobacteria* played no significant role. On the contrary, Baratti-Mayer et al[41] report that *Capnocytophaga*, *Prevotera*, *Neisseria* and *Spirochetes* as being strongly associated with the disease. *Fusobacterium necrophorum* has also been found to be prevalent by Francois et al[42]. The disease is normally treated with antibiotics and surgical reconstruction. However, data are unavailable about resistance to antimicrobials.

2.3.4 Necrotizing fasciitis: This lesion presents as soft tissue destruction that progresses rapidly and can be fatal[43,45]. This condition is now referred to as necrotizing soft tissue infections (NSTIs). It occurs in patients with a systemic condition that leads to immunosuppression if of polymicrobial aetiology. However, when the aetiology is monomicrobial it affects healthy individuals[44]. Like Ludwig's angina, it affects the financially challenged members of society mostly[45] and is of rapid progress. The commonly implicated microorganisms are *Streptococcus haemolyticus* B and *Staphylococcus aureus*[45]. Classification by Sarani *et al*[46] is commonly used. Type I is polymicrobial while type II is monomicrobial caused by group A *Streptococcus* and *Staphylococcus aureus* .Type III is most likely caused by *Clostridium* and *Vibrio* species while type IV is due to fungal infection[43]. Other than debridement of nonviable tissue antibiotics are very useful in containing this potentially fatal condition[44].

Microorganisms vary from region to region as do their susceptibilities[3]. This view has also been pointed out by Ardila *et al*[47]. For instance, isolates from areas dominated by the Masai comunity have been found to demonstrate overall lower antibiotic resistance compared to the rest of Kenya[48].Therefore, each geographical area is supposed to generate its own data about antimicrobial resistance from time-to-time. In Kenya, data on antimicrobial resistance in reference to odontogenic infections suffers paucity.

2.4 Range of Antimicrobial Agents

2.4.1 Penicillins

Penicillins are among the most prescribed drugs in the management of odontogenic infections[2,5,6,7,28].They are active against facultative aerobes and anaerobes hence used in the acute phase of odontogenic infections[6,31]. The resistance to these group of antimicrobials is due to β-lactamase production. However, Singh et al[3] found overall resistance to penicillin at 22% among an Indian population. In their study anaerobes were the ones commonly found to have been resistant, but it has been established that other drugs like metronidazole act better on these microbes[31]. Nevertheless, amoxycillin has been found to be highly susceptible[3,17]. In contrast, a study[5] carried out in Romania reported low sensitivity of bacteria to the commonly prescribed drug amoxycillin. This latter study involved a small sample size of only 10 patients hence the findings cannot be generalized. Another study[17] including 68 Indian patients showed high sensitivity to the routinely used antibiotics such as amoxycillin. Further, Gregoire[7] in an a review article, argued that amoxycillin did not provide any better coverage in treating odontogenic infections than penicillin V. Kimanga[48] reported a resistance to amoxicillin at 86% in Ethiopia. In contrast, a combination of amoxycillin and clavulanic acid has been shown to have a high sensitivity, quite often 100%[3,47]. Though amoxycillin is considered the first choice of antimicrobial agents especially in paediatric dentistry[49], available data are inconsistent about its effectiveness. Ampicillin, another commonly used penicillin has been found to be ineffective at 84.5% in countries like Zimbabwe[48].

2.4.2 Sulphonamides

Sulphonamides were the first antimicrobial agents to be used against pyogenic bacterial infections but resistance has reportedly limited their clinical use[10,48]. Studies contradicting this position are not available. Trimethoprime-sulfisoxazole is currently used in the prevention of opportunistic infections among patients with retroviral disease. This in itself could lead to the emergence of resistant strains. *Viridans streptococci* have been found to be highly resistant to sulfamethoxazole/trimethoprim[33].

2.4.3 Aminoglycosides

Aminoglycosides are not commonly used like penicillins probably due to their toxicity and parenteral administration. They are only effective against aerobic gram negative bacteria.

However, they are synergistic when used with beta-lactams. Few studies, though, exist about their effectiveness. One such study by Bahl *et al*[4] revealed that only 15% of the bacterial isolates were sensitive to gentamicin. Even more worrying was a finding by Farmahan *et al*[28] of only 2% sensitivity to gentamicin. This is consistent with the argument that many resistant strains against gentamicin have emerged[10]. In another Indian study, amikacin was found to have been effective against all the bacterial isolates investigated[3]. Indeed the authors of this latter study note that resistant infections like the ones in ICUs are now treated with amikacin. This is due to its outstanding feature in resisting bacterial aminoglycoside inactivating enzymes[10].Nevertheless, there is a paucity of data on the use of aminoglycosides in odontogenic infections.

2.4.4 Macrolides

Macrolides are used as alternatives in case a patient is allergic to penicillins. These are bacteriostatic antibiotics that cover gram-positive and some gram-negative bacilli[6]. Resistance is due to acquisition of erm genes (erythromycin methylases) resulting in the reduced binding to the 50S ribosomal subunit[21]. Clarithromycin and azithromycin have been shown to be effective against gram-positive and gram-negative bacilli respectively[4,6]. One other representative in this class is erythromycin. Previously this was the most commonly prescribed macrolide in dentistry[7,25]. In addition, there are some microorganisms not affected by penicillin but are affected by erythromycin. These include *Campylobacter*, *Legionella* and *Branhamella catarrhalis* among others. The main drawback is that all cocci readily develop resistance to erythromycin[10]. In the study by Singh *et al*[3] only 36.6% of the bacteria were sensitive to erythromycin. Use of this drug in maxillofacial infections has declined since the 1980s due to reduced effectiveness[3]. In the latter study erythromycin was effective against only 38% of the total isolates. Further, recent findings by Chunduri et al[17] have cast some doubt on the usefulness of erythromycin. These kind of data may have led some authors advocating for the latter to be considered a historical antibiotic in dentistry[7,21]. However, other equally recent findings, report a 60% sensitivity to erythromycin[4] hence it cannot be written off yet.

2.4.5 Tetracyclines

Tetracyclines are another group of bacteriostatic antibiotics that have been used in dentistry[6]. Though initially active against many bacterial pathogens, antimicrobial resistance has narrowed

their usefulness[4,6,10,50,51]. However, data on the effectiveness of this class of drugs suffers paucity.

2.4.6. Lincosamide and Glycopeptide. Due to treatment failure with 1st line antibiotics, clinicians often turn to lincosamide and glycopeptide antibiotics[7,26,31]. The representatives are clindamycin and vancomycin respectively. Chunduri et al[17] have advocated the use of clindamycin in severe orofacial infections. This was after they found 100% sensitivity of *Peptostreptococcus* and *Porphyromonas* to clindamycin. These microorganisms are anaerobic and hence are likely to be isolated in the late stages of odontogenic infections. Clindamycin is known to have excellent activity to both gram-positive cocci and anaerobic bacteria regardless of whether they are facultative or obligate[4,7,49]. However, Ardila et al[47] found only 11% of *A. actinomycetemcomitans* having been sensitive to clindamycin and 68% of *P. gingivalis* having been affected.

2.4.7 Metronidazole

Metronidazole is one of the most prescribed drugs by Kenyan dental practitioners and others.[28] This is due to its selective bactricidal activity against anaerobic bacteria. It attains therapeutic concentrations in saliva and cerebrospinal fluid whether administered *per os* or parenterally. That notwithstanding, a recent study by Juncar *et al*[5] found only 8.3% of the isolated microorganisms having been sensitive to metronidazole. These results are, however, drawn from a very small sample of 10 patients with a narrow range of age. In contrast, a sample of 100 patients was investigated by Bahl et al[4] and they found a sensitivity of 85% to metronidazole. A similar finding was reported by Farmahan et al[28] from a different geographical location but similar sample size with a larger range of age at 94 years. Shweta and Prakash[21] found development of resistance to this agent by odontogenic pathogens to have been rare.

2.4.8 Fluoroquinolones

Fluoroquinolones, constitute another group of bactericidal antibiotics that act against both gram-positive cocci and anaerobes. It has been argued that moxifloxacin has the highest rate of bacterial susceptibility among all antibiotics for odontogenic infections[7].This view was confirmed by Ardila *et al*[47] who found a 100% sensitivity to moxifloxacin. But this latter study must be viewed in the light of the fact that the authors investigated two bacteria species only. Ciprofloxacin, one of the commonly prescribed fluoroquinolones, was found to have had a

sensitivity of 70% which was similar for gatifloxacin[4].However, a 2% sensitivity to ciprofloxacin and 14% to flucloxacin was found by Farmahan et al.[28] Levofloxacin has also been found to be a powerful agent against anaerobic bacteria[17].

2.5 Statement of the problem

Antibiotic resistance has become a global health threat [26,52]. This resistance has now become a serious public health problem that has captured the attention of world leaders[11,23,24] and necessitated the convening of a meeting of the United Nations General Assembly (UNGA) in September 2016[11]. Emergence of multidrug resistance has made scientists start investigating alternative therapeutics like bacteriophages[53].

In Kenya it is already an acknowledged public health problem[48]. The cost of treating deep neck space infections owing to an odontogenic source is high. The cost has been found to be $1.1 million for only 71 patients[54]. In addition, treatment of such infections requires highly skilled manpower. This high cost is made worse by prescribing non-indicated antibiotics[26]. Furthermore, complications of these infections can be very severe such as facial nerve palsy which has been reported as a common complication[2]. Prevention of these complications and reduction of treatment cost can be achieved through timely and empirical use of antibiotics. It has been argued that all dentists should be comfortable with prompt diagnosis and management of these types of infections[7]. While this is desirable, a survey to assess the confidence of the first on-call in oral and maxillofacial surgery department found unsatisfactory results[56]. This is of critical importance considering that prescriptions by dental practitioners account for about 10% of all prescriptions[26]. Therefore, this study was designed to provide data that can help the clinician make empirical judgment while treating these infections.

2.6 Research question

What is the spectrum of infective bacteria and their sensitivity patterns to antibiotics in patients presenting with orofacial infections at the Kenyatta National Hospital (KNH)?

2.6.1 Aim of study

To determine the range of bacterial pathogens and antibiotics sensivity patterns among patients presenting with orofacial infections.

2.6.2 Specific objectives

1. To identify the range of bacterial microorganisms present in orofacial infective lesions.

2. To determine the antibiotic sensitivity patterns of the identified microorganisms.

3 .To determine the range of antimicrobial agents received prior to presentation at KNH.

CHAPTER TWO

Materials and Methods

3.1 Research design.

This was a descriptive cross-sectional study of patients with orofacial infections attending KNH.

3.2 Study site

KNH is one of the oldest public health facilities in Kenya, having been founded as the Native Civil hospital in 1901. It serves as a teaching centre for several tertiary institutions in Kenya. Consequently it is used as a referral hospital (level 6) not only by Kenyan patients but also by those from East and Central Africa. Therefore, it is a huge catchment area for patients. The hospital also offers outpatient and emergency services to more than 4 million residents of Nairobi and the neighbouring counties of Kiambu, Kajiado and Machakos.

3.3 Target population

Patients attending the Accident and Emergency and dental departments at KNH with infections.

3.4 Sampling

3.4.1 Sample size

A prevalence of 8% of antimicrobial resistance was adopted from Barasa *et al*[12]. Isolates resistant to oxacillin/methicillin were interpreted as having been resistant to all beta-lactam agents as per the Clinical Laboratories Standard's Institute (2011).The sample size was calculated using Gorstein`s (2007) formula[11] as follows:

$$n = \frac{Z^2 p (1-P) / (DEFF)}{d^2}$$

Where,

Z-score at the level of precision =1.96,

p= expected prevalence in population based on previous studies or pilot studies =0.8,

d= is desired level of absolute precision (0.1)

DEFF is the estimated design effect (50%-0.5).

$$n = \frac{1.96^2 \times 0.8 \times 0.2(0.5)}{0.1^2}$$

$=30.7$

Therefore, a minimum sample of 31 participants was used.

The turnover of patients with orofacial infections at KNH is approximately six in a week.

3.4.2 Sampling

Convenience sampling was used in this study. All the patients seeking both out-patient and in-patient maxillofacial surgery services at the dental clinic and accident and emergency departments of KNH were targeted. Those who declined consent were not included in the study.

3.4.3 Sampling units.

1. Accident and emergency department, KNH

2. Dental outpatient and inpatient departments, KNH

3.5 Ethical considerations

Ethical approval was sought and obtained from the ethics and research committee of KNH/ University of Nairobi (UON) Ethics and Research Committee (KNH-UON ERC): Approval number: **P506/07//2018**.

3.6 Data collection

3.6.1 Variables: Age, gender, regular residence, fascial space involved, causative bacteria, sensitivity to antibiotics and antibiotics taken prior seeking treatment at KNH were studied.

3.6.2 Interview: Face-to-face interview was conducted using a structured questionnaire in order to obtain demographic data (age, gender, and regular residence), fascial space involved and medications being taken by the patient.

3.6.3 Specimen collection: The method used by Singh *et al*[3] was mostly used. Extra-oral approach was used whenever possible to avoid contamination with resident oral microbes. The site was prepared with 10% povidone-iodine. Disposable syringes (5ml) with disposable needle 18G was used to aspirate pus from abscesses. In case there was no pus, a sterile cotton swab was used to collect the specimen. In this case the swab was taken before wound debridement and application of antiseptics. The specimens were submitted to the UON Microbiology/

bacteriology department within 1hour after collection for further investigation. The samples for anaerobic study were cultured at the UON laboratory. Samples for aerobic study were cultured then subjected to identification and sensitivity tests by use of the Vitek 2 at KNH microbiology department.

3.6.4 Specimen processing of aerobic culture: The specimens were inoculated into Blood Agar (BA), Chocolate Blood Agar (CBA) and MacConkey agar media then the innoculated plates incubated for 24 hours at 37^{o}C. In order to grow fastidious bacteria like *Streptococcus pneumoniae*, BA and CBA was incubated at 5-10% CO_2 candle jar at 35-37^{o}C for 24 hours.

Anaerobic culture of bacteria was done where fastidious anaerobic agar together with fastidious anaerobic broth were used. Fastidious anaerobic agar was prepared into two bottles where nalidixic acid and vancomycin were added to one batch for isolation of gram negative rods for example *Bateroides fragilis*, and another batch was added nalidixic acid only for isolation of non-sporing anaerobes for example *Peptostreptococcus species*. The plates were cultured and incubated in gas pack anerobic jar at 37^{o}c for 48-72hours. Identification for anerobic bacteria was done by colonial morphological characteristics of the gram stain in order to distinguish between gram negatives and gram positives. Smears were done and air-dried. The smears were then heat fixed by passing over the flame three times. After fixing they were air cooled and put on the staining rack. The smears were covered with the initial stain crystal violet for one minute after which it was rinsed with tap water. Then poured mordant gram's iodine for 30 seconds and rinsed with water. Holding the smear in a slanting manner 50% acetone alcohol was used to decolorize the smear and rinsed with water immediately. After this it was counter stained with neutral red for 2 minutes then placed in a rack to dry. The stained smears were examined using oil immersion at X100 objective microscopically.

Procedure:

2-3ml of hydrogen peroxide solution was placed into a test tube.

Using a glass rod or wooden stick several colonies of the test organism placed into the solution. Active bubbling would indicate a positive catalase test.

Coagulase test was used to identify coagulase positive *Staphylococcus aureus* and coagulase negative *Staphylococcus aureus* (CONS). Slide Coagulase Test Procedure (cell-bound

coagulase): a drop of distilled water was placed on each end of a slide. A colony of the organisms to be tested is emulsified in each drop to make two thick suspensions. A flamed and cooled straight inoculating wire was dipped into the undiluted plasma at room temperature withdrawn and stiring the adhering traces of plasma into the staphylococcal suspension on the slide was done. This was read as positive if clumping of the organisms occur red within 10 seconds. No plasma was added to the second suspension (control).Tube Coagulase Test Procedure (free coagulase): plasma was diluted to 1:10. Three small test tubes were availed and labeled test organism, positive control and negative control. 0.5ml of the diluted plasma was pipetted into each tube. Five drops (about 0.1ml) of the test organism was added into tube labelled positive and 5 drops of sterile broth into the tube labeled negative. Tubes were incubated at 35-37oC after mixing gently. Examination for clotting was done by tilting the tube through 90^{o}. Clotting would occur after an hour, if no clotting occurred after one hour examination was repeated after 30 minutes for upto 6 hours. Clotting indicated positive results (*Staphylococcus aureus*). No clot formation mean coagulase negative. After the gram staining the colonies were subjected to biochemical tests.

Oxidase test was used to identify the Pseudomonas spp. Procedure: a piece of filter paper was be placed in a petri dish and soaked with 2-3 drops of freshly prepared oxidase reagents. Using a piece of stick or glass rod, a colony of the test organism was then smeared on the filter paper. Development of blue-purple colour within a few seconds indicated positive oxidase test.

Voges-proskeur (v-p) test was used to identify *Klebsiella spp.* Procedure: 2ml of sterile phosphate peptone water was innoculated with the test organism and incubated at 35-37oC for 48 hrs. A small amount of creatinine was added and mixed well. 3ml of sodium hydroxide was added and mixed well. The bottle cap was removed and left for one hour at room temperature. Development of a pink colour was indicative of *Klebsiella pneumoniae*.

After culturing of the various aerobic bacteria they were subjected to identification and antimicrobial susceptibility testing by the disc diffusion methods using the “Vitek 2” analyzer. Calibration of this machine was regularly done by the suppliers and a certificate given.

CHAPTER THREE

3.0 Results

3.1 Socio-demographic characteristics.

Thirty nine participants were enrolled into the study among whom 24(61.5%) were males and 15 (38.5%) females. The participants' ages ranged between 4 – 71 years with a mean of 34.33 (SD± 17.56) years (Table 1).The 21—40-year age group accounted for 56.4% of the participants. Notably, males accounted for 62.5% of the participants in this age group. An independent sample *t* test showed that males had a non-statistcally significant higher age (36.25+/- 16.95 years), *t* (37) =0.859, p=0.396.

Table 1: Distribution of participants according to age group and gender

Age (years)	Males	Females	Total
0—20	1	4	5(12.8%)
21—40	15	7	22(56.4%)
41—60	4	2	6(15.4%)
61—70	2	2	4(10.3%)
Over 70	2	0	2(5.1%)
Total	24(61.5%)	15(38.5%)	39(100%)

3.2 Pattern of bacterial orofacial infections

The pattern of infection sites according to gender is illustrated in Table 2. Thirty six percent of the participants presented with periapical abscesses while 23% had submandibular ones.

Table 2: Pattern of infections in the sample

Diagnosis	Male	Female	Total
Periapical abscess	9	5	14(36%)
Submental abscess	3	1	4(10%)
Submandibular abscess	4	6	10(23%)
Ludwig's angina	4	0	4 (10%)
masseteric space abscess	2	2	4(10%)
Periodontal abscess	0	1	1(2.5%)
Post-surgical (nasolabial abscess)	1	0	1(2.5%)
Pretracheal	1	0	1(2.5%)
Pericoronitis	1	0	1(2.5%)
Total	24 (62)	15 (38%)	39(100%)

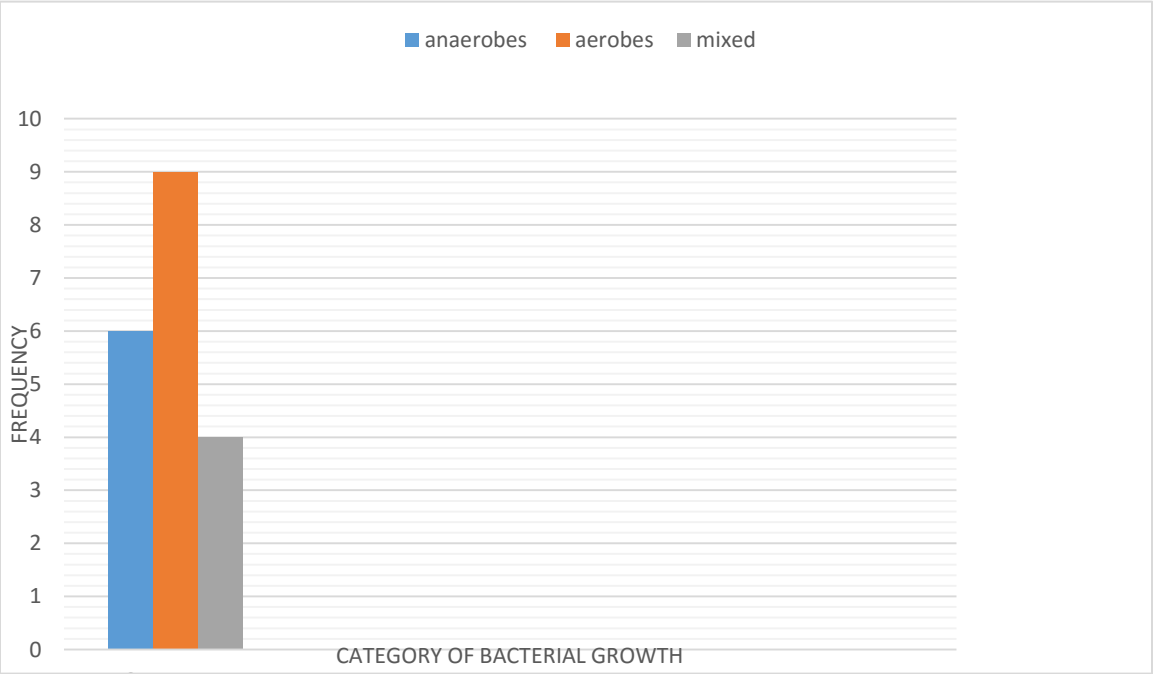
The trend of antibiotic use before presentation to KNH is shown in Table 3 below.

Table 3: Pattern of Antibiotics taken before seeking treatment at KNH

Medications taken prior	Males	Females	Total
Augmentin	3	1	4(11.4%)
Metronidazole	8	5	13(37.1%)
Amoxicillin	2	4	6(17.1%)
Flucloxacillin	2	1	3(8.6%)
Doxycycline	1	0	1(2.9%)
Ceftriaxone	4	2	6(17.1%)
Clindamycin	2	0	2(5.7%)
Total	22	13	35 (100%)

Notably, 18(46.2%) participants reported having used antibiotics before coming to KNH. The frequency of metronidazole intake was at 37.1% while amoxicillin and ceftriaxone at 17.1%. The use of clindamycin was at 5.7%. Of the 39 samples submitted for analysis, 14(36%) showed aerobic microbial growth while 25(64%) did not exhibit any microbial growth during the study (Table 4).

Fig 1: Illustration of bacterial growth:



As illustrated in Fig.1, 47.4% of the microorganisms detected were aerobes and 31.6% were anaerobes while 21% were mixed infections**.**

3.3 Pattern of aerobic bacterial growth

The pattern of aerobic bacterial growth is shown in Table 4.

Table 4: Presence of aerobic bacterial growth among the participants in relation to antibiotics use

	Antibiotics taken prior to antibiotic sensitivity test	No antibiotic taken prior to antibiotic sensitivity test	Total
Bacterial growth	5(29.4%)	9 (41%)	14(36%)
No bacterial growth	12(70.6%)	13(59%)	25(64%)
Total	17(100%)	22(100%)	39(100%)

Among the participants who reportedly had not taken any antibiotics, 41% of the samples were found to have had aerobic bacterial growth. On the other hand, among the respondents who had taken antibiotics only 29.4% of the samples had aerobic bacterial growth.

A Chi-Square test of association showed a non-statistically significant association between bacterial growth and medication taken before sensitivity test $\chi 2$ (1) = 0.958, p = 0.328 (Table 5).

Table 5: Chi-Square test of association between bacterial growth and medication taken before sensitivity test (n = 39) among aerobes.

	Previous Medication			
Characteristics	**No**	**Yes**	χ^2	**p**
None	13(72.2)	12(57.1)	0.958	0.328
Bacterial Growth	5(27.8)	9(42.9)		

Chi-Square test of association was used for all characteristics.

The pattern of aerobic microorganisms are summarized in Table 6.

Table 6: Pattern of aerobic microorganisms

Aerobic microorganisms	Diagnosis	Frequency
Enterococcus faecalis	Periapical absess	1
Streptococcus dysgalactiae	Submental abscess	1
Kocuria krisinae	Periapical	1
Granulicalia adiecens	Submandibular abscess	1
Klebsiella pneumoniae	Submandibular abscess; ludwigs angina	2
Sphingomonas paucimobilis	Submandibular; masseteric space abscess	2
Streptococcus mitis	Pretracheal; masseteric space abscess	2
Staphylococcus epidermidis	Periapical	1
Morganella morganii ssp morgani	Submandibular; submental abscess	2
Enterobacter cloacae ssp cloacae	Submandibular abscess	1

The sensitivity pattern among the aerobes is summarized in Table 7. In all cases meropenem, levofloxacin and amikacin were found to have been sensitive among the aerobes at 100%.

Ordinal regression test comparison of sensitivity and resistance to aerobes to the various antibiotics is shown also in Table 7.

Table 7: Ordinal regression test comparison of sensitivity and resistance to aerobes towards the various antibiotics

Aerobes	Sensitive	Resistant	χ^2	-2 Log Likelihood	Wald	Df	P
Ampicillin	0	5(100)	11.622***	3.748	2233.8	1	< 0.001
Amoxicillin/Clavulanic Acid	1(20.0)	4(80.0)	11.622***	3.748	2233.8	2	< 0.001
Ampicillin/Sulbactam	0	5(100)	11.622***	3.748	2233.8	1	< 0.001
Piperacillin/Tazobactam	4(80.0)	1(20.0)	11.622***	3.748	2233.8	2	< 0.001
Cefazolin	1(16.7)	5(83.3)	14.366***	3.662	2274.5	2	< 0.001
Cefuroxime	0	5(100)	11.622***	3.748	2233.8	1	< 0.001
Cefuroxime Axetil	0	5(100)	11.622***	3.748	2233.8	1	< 0.001
Cefotaxime	2(33.3)	4(66.7)	14.366***	3.662	2274.5	2	< 0.001
Ceftazidime	2(33.3)	4(66.7)	14.366***	3.662	2274.5	2	< 0.001
Ceftriaxone	2(33.3)	4(66.7)	14.366***	3.662	2274.5	2	< 0.001
Cefepime	2(33.3)	4(66.7)	14.366***	3.662	2274.5	2	< 0.001
Aztreonam	2(33.3)	4(66.7)	14.366***	3.662	2274.5	2	< 0.001
Meropenem	6(100)	0	14.366***	3.662	2274.5	1	< 0.001
Amikacin	6(100)	0	14.366***	3.662	2274.5	1	< 0.001
Gentamicin	4(30.8)	9(69.2)	5.966	7.816	0.111	2	0.739
Ciprofloxacin	3(50.0)	3(50.0)	14.366***	3.662	2274.5	2	< 0.001
Nitrofurantoin	4(80.0)	1(20.0)	11.622***	3.748	2233.8	2	< 0.001
Trimethoprim/Sulfamethoxazole	1(14.3)	6(85.7)	17.300***	3.562	2052.4	2	< 0.001
Benzylpenicillin	0	1(100)	2.096***	3.999	2292.6	1	< 0.001
Levofloxacin	2(100)	0	4.294***	3.947	2447.1	1	< 0.001
Erythromycin	6(46.2)	7(53.8)	9.003	5.919	1.199	2	0.273
Linezolid	2(100)	0	2.294***	3.947	2447.1	1	< 0.001
Teicoplanin	2(100)	0	4.294***	3.947	2447.1	1	< 0.001
Vancomycin	1(50.0)	1(50.0)	4.294***	3.947	2447.1	2	< 0.001
Clindamycin	1(100)	0	2.096***	3.999	2292.6	1	< 0.001
Cefoxitin	4(100)	0	9.042***	3.823	2411.1	1	< 0.001

Ordinal Regression test was used for all aerobes.

****p<0.001*

As illustrated in Table 7, the aerobic bacteria in the orofacial infective lesions were found to have had a statistically significant level of resistance towards ampicillin, amoxicillin/clavuanic acid, ceftriaxone, cefuroxime among others.

On the other hand, the sensitivity of the aerobes towards meropenem, amikacin, levofloxacin and ciprofloxacin was found to have been statistically significant.

Ordinal regression test comparison of sensitivity and resistance of anaerobes towards the various antibiotics is shown in Table 8.

Table 8: Ordinal regression test comparison of sensitivity and resistance of anaerobes towards the various antibiotics

Anaerobes	Sensitive	Resistant	χ^2	-2 Log Likelihood	Wald	df	P
Amoxyllin	8(72.7)	3(27.3)	0.583	7.711	0.320	2	0.571
Erythromicin	6(54.5)	5(45.5)	6.670	5.881	0.197	2	0.657
Gentamycin	3(27.3)	8(72.7)	2.815	6.290	0.489	2	0.484
Ciprofloxacin	8(72.7)	3(27.3)	0.583	7.711	0.320	2	0.571
Ampicillin	7(63.6)	4(36.4)	0.525	7.769	0.905	2	0.341
Penicillin	1(9.1)	10(90.9)	1.183	6.398	1.508	2	0.220
Tetracycline	5(45.5)	6(54.5)	1.263	7.704	2.159	2	0.142
Meropenem	9(81.8)	2(18.2)	1.093	7.510	0.000	2	0.579
Metronidazole	9(81.8)	2(18.2)	1.093	7.510	0.000	2	0.579
Ceftriazone	7(63.6)	4(36.4)	2.113	7.567	0.000	2	0.348
Cefuroxime	8(72.7)	3(27.3)	3.553	7.247	0.320	2	0.571
Augmentin	10(90.9)	1(9.1)	1.183***	6.398	704.6	2	< 0.001

Ordinal Regression test was used for all anaerobes.

****p<0.001*

Anaerobes were found to have had a statistically significant level of sensitivity towards augmentin. Notably, the anaerobes had a sensitivity towards meropenem and metronidazole at 81.8% each.

Table 9: Pattern of antimicrobial sensitivity among anaerobes (n =11)

	Characteristics n (%)			
Anaerobes	**Intermediate Sensitive**	**Sensitive**	**Intermediate Resistant**	**Resistant**
Erythromicin	0	6(54.5)	0	5(45.5)
Gentamycin	0	3(27.3)	3(27.3)	5(45.4)
Ciprofloxacin	2(18.2)	6(54.5)	0	3(27.3)
Ampicillin	5(45.4)	2(18.2)	0	4(36.4)
Penicillin G	0	1(9.1)	4(36.4)	6(54.5)
Tetracycline	2(18.2)	3(27.3)	0	6(54.5)
Meropenem	0	9(81.8)	0	2(18.2)
Metronidazole	0	9(81.8)	0	2(18.2)
Ceftriazone	4(36.4)	3(27.2)	0	4(36.4)
Cefuroxime	6(54.5)	2(18.2)	0	3(27.3)
Augumentin	5(45.5)	5(45.5)	0	1(9.1)

An Independent Samples *t* Test showed that participants who had previous medication had a non-statistically significantly higher age (34.63 $\pm$ 16.26 years) compared to those who had not taken previous medication (34.05 $\pm$ 19.14 years), $t(37) = 0.102$, $p = 0.919$. Similarly, the test showed that participants who had no microorganism growth had a non-statistically significant higher age (36.84 $\pm$ 19.80 years) compared to those who had microorganism growth (29.86 $\pm$ 12.01 years), $t(36.670) = 1.370$, $p = 0.179$.

Figure 2: Ordinal regression scatter plot graph comparing sensitivity and resistance to Augumentin

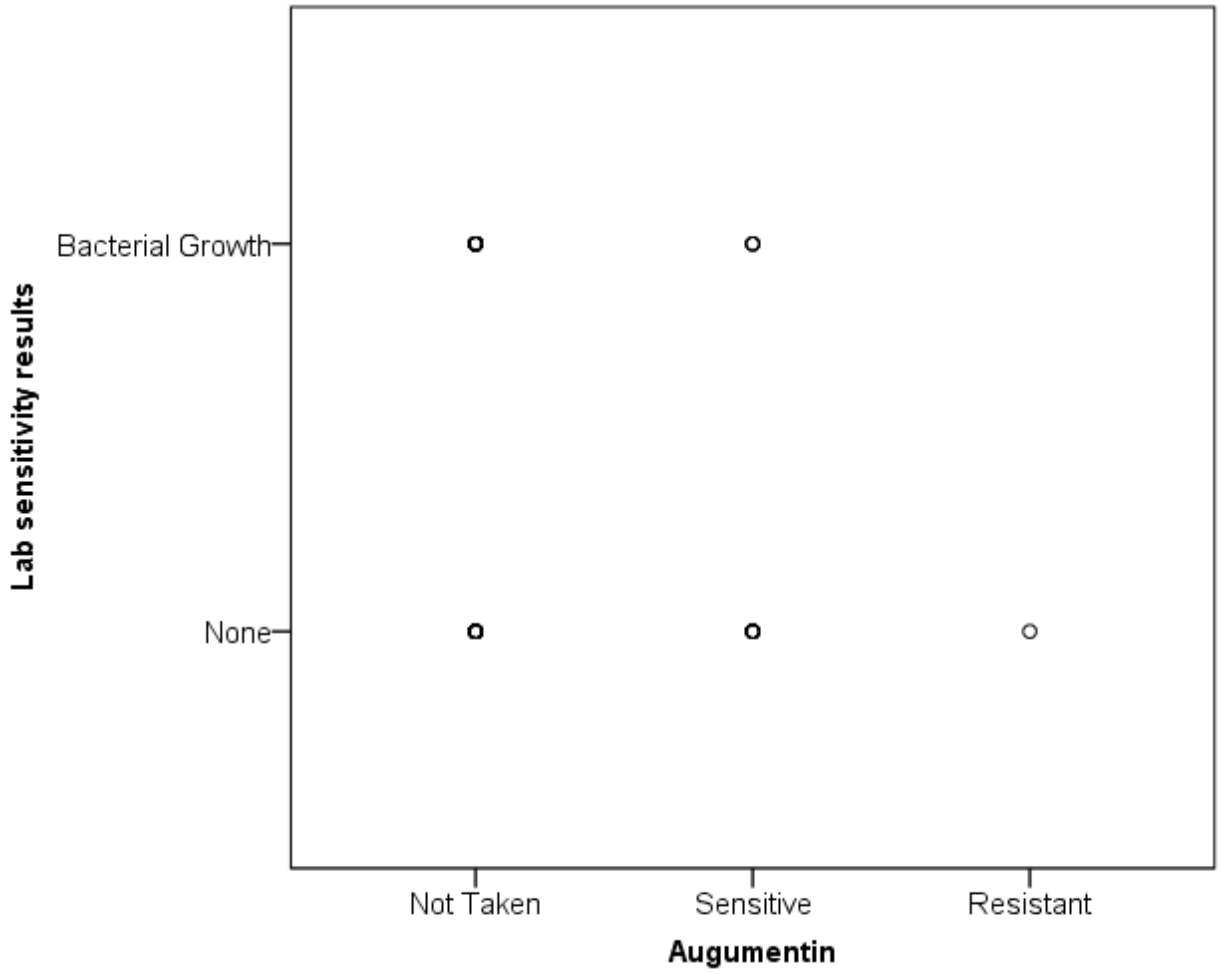


Table 10: Comparison of the mean age differences by aerobes sensitivity pattern (n = 14).

Aerobes	n (%)	Sensitive		Resistant				
		M	*SD*	*M*	*SD*	*Df*	*t* test	*P*
Ampicillin	5(12.8)	.						
Amoxicillin/Clavulanic Acid	5(12.8)	40.00	.	35.25	11.76	3	0.361	0.742
Ampicillin/Sulbactam	5(12.8)	.						
Piperacillin/Tazobactam	5(12.8)	37.25	11.70	32.00	.	3	0.401	0.715
Cefazolin	6(15.4)	29.00	.	36.20	10.40	4	0.632	0.562
Cefuroxime	5(12.8)	.						
Cefuroxime Axetil	5(12.8)	.						
Cefotaxime	6(15.4)	37.00	11.31	34.00	10.58	4	0.322	0.764
Ceftazidime	6(15.4)	37.00	11.31	34.00	10.58	4	0.322	0.764
Ceftriaxone	6(15.4)	37.00	11.31	34.00	10.58	4	0.322	0.764
Cefepime	6(15.4)	37.00	11.31	34.00	10.58	4	0.322	0.764
Aztreonam	6(15.4)	37.00	11.31	34.00	10.58	4	0.322	0.764
Meropenem	6(15.4)	.						
Amikacin	6(15.4)	.						
Gentamicin	13(33.3)	36.00	9.90	36.78	13.45	11	0.103	0.920
Ciprofloxacin	6(15.4)	27.00	6.25	43.00	2.65	4	4.086*	0.015
Nitrofurantoin	5(12.8)	34.00	10.58	45.00	.	3	0.930	0.421
Trimethoprim/Sulfamethoxazole	7(17.9)	29.00	.	34.50	10.19	5	0.500	0.631
Benzylpenicillin	1(2.6)	.						
Levofloxacin	2(5.1)	.						
Erythromycin	13(33.3)	42.00	23.06	29.86	13.17	11	1.190	0.259
Linezolid	2(5.1)	.						
Teicoplanin	2(5.1)	.						
Vancomycin	2(5.1)	.						
Clindamycin	1(2.6)	.						
Cefoxitin	4(10.3)	.						

Independent-Samples t test was used for all aerobes.

**p<0.05*

Resistance to ciprofloxacin was found to have been statistically significant with increasing age of the participant among the aerobes (Table 10). Similarly, tetracycline resistance was found to have been statistically significant with age among the anaerobes (Table 11).

Table 11: Comparison of the mean age differences by anaerobes sensitivity characteristics (n = 11).

		Sensitive		Resistant				
Anaerobes	**n (%)**	***M***	***SD***	***M***	***SD***	***Df***	***t* test**	***P***
Amoxicillin	11(28.2)	39.00	20.26	39.67	5.86	9	0.054	0.958
Erythromycin	11(28.2)	42.00	23.06	35.80	6.72	9	0.577	0.578
Gentamycin	11(28.2)	42.33	29.54	38.00	12.86	9	0.356	0.730
Ciprofloxacin	11(28.2)	39.00	20.26	39.67	5.86	9	0.054	0.958
Ampicillin	11(28.2)	34.43	16.85	47.50	16.38	9	1.249	0.243
Penicillin	11(28.2)	44.00	.	38.70	18.01	9	0.281	0.785
Tetracycline	11(28.2)	29.20	11.63	47.50	17.26	9	2.012*	0.035
Meropenem	11(28.2)	39.78	18.75	36.50	10.61	9	0.233	0.821
Metronidazole	11(28.2)	39.78	18.75	36.50	10.61	9	0.233	0.821
Ceftriazone	11(28.2)	35.29	18.41	46.00	14.33	9	0.996	0.345
Cefuxomine	11(28.2)	39.13	20.22	39.33	6.43	9	0.017	0.987
Augumentin	11(28.2)	38.90	18.06	42.00	.	9	0.164	0.874

Independent-Samples t test was used for all aerobes.

**p<0.05*

Table 12: Association between anaerobes sensitivity and demographic characteristics (n = 14)

		Previous Medication			
Aerobes	**Sensitivity**	**No**	**Yes**	**Fisher's Exact Test**	**P**
Gentamicin	Sensitive	3(60.0)	1(12.5)	3.259*	0.031
	Resistant	2(40.0)	7(87.5)		
Erythromycin	Sensitive	2(40.0)	4(50.0)	0.124	0.725
	Resistant	3(50.0)	4(60.0)		

Fisher's Exact Test was used for all characteristics.

* $p < 0.05$.

Sensitivity to gentamicin was found to have been significantly higher among those who had taken medication previously.

CHAPTER FOUR

Discussion

This study found out that males are more affected than females at 61.5%. This finding is consistent with another African study where 63.6% of participants with cervicofacial infections were males[2]. Further, studies done in the developed countries still show the same pattern[28]. The findings are also consistent with a study from Southern America at 53.5%[55]. However, a retrospective study carried out in the United Kingdom showed that more females were affected[56]. Nevertheless, there is overwhelming evidence that a significantly higher number of males suffer from maxillofacial bacterial infections[57,58,59]. Poor oral hygiene and oral health neglect among the male gender have been postulated as one of the reasons[55]. The mean age was found to have been 34.33(+/- 17.56) years which is consistent with the findings of other authors[2,28,55,56,57,59]. Therefore, it is now well established that orofacial infections of bacterial origin occur mostly in the 3rd and 4th decades of life.

The most common diagnosis made among the participants was periapical abscess at 36%. This finding is consistent with researches done elsewhere. For instance, Siqueira and Rocas[60] reported that acute apical abscess was the commonest form of dental abscess. However, majority of reported data found the submandibular space to have been the most frequently involved[2,4,28,59,61].

In the current study, 35.9% of the 39 samples submitted had bacterial growth. Several studies show a low percentage of bacterial growth among the samples submitted for analysis. This kind of trend has been explained by Haque *et al*[62] who argued that 50% of the normal human oral flora are uncultivatable. This could imply, therefore, that majority of the infections may be caused by normal flora once the host immunity has been affected. In an 8-year retrospective study, Veronez *et al*[55] found out that all the culture and antibiogram results were negative. This kind of result has been explained by Siqueira and Rocas [60] who argued that the large number of oral bacteria are difficult to culture. Further, the authors point out that 40- 70% of oral bacterial species remain to be cultivated and phenotypically characterized. The low number of bacteria cultured in the current study could also be due to self-medication with antibiotics prior to hospital presentation. However, in an African study done by Molomo *et al*[57] it was found that out of the 127 samples submitted for analysis 122 pathogens were successfully cultured. In this current study a Chi-square test showed a non-statistically significant association among the

participants who had reportedly used antibiotics prior to sensitivity test and those who had not. Therefore, low bacterial growth could have been due to the use of antibiotics prior to the sensitivity tests.

While no aerobic microorganism was obviously dominant, *Morganella morganii* of the species *Morgana, Klebsiella pneumoniae, Streptococcus mitis* and *Sphingomonas paucimobilis* were found to have been common in this study. In contrast, Chunduri *et al*[17] found 64% of the microorganisms to have been *Streptococci viridans*. Bahl *et al*[4], too, found the microorganism to have been the most frequent. Further, Farmahan *et al*[28] and Molomo et al[57] also found that the commonest bacteria isolated to have been *Streptococci*. The detection of "unfamiliar" aerobic microorganism in this study could be due to the use molecular identification methods. This view has been supported by Siqueira and Rocas [60]. Indeed, Haque et al [62] in a review article found out that non-culture techniques identified bacteria that are rarely reported in studies that use culture techniques only. One of the "unfamiliar" bacteria isolated in this study was *Kocuria kristinae*. Documented cases of infection by this gram positive bacteria are limited[63,64]. Identification of this bacteria has only been possible by use of the Vitek 2 in the current study and others[64,65,66]. This bacteria causes infection in immunosuppressed patients or the ones having indwelling devices[63,64]. Though Lakshmikantha et al[63] think that the microorganism is an upcoming pathogen, it could also be that it has been under-reported due to the use of traditional methods of culturing of bacteria[56].

Among the anaerobes identified, *Peptostreptococcus* and the *Peptococcus ssp* were the commonest. However, Bahl *et al*[4] and Chunduri et al[17] reported *Bacteroides* and *Prevotella* as the commonest causative agents. Majority of the microorganisms in the present study were aerobes at 47.4% while only 21% were mixed infections. Farmahan *et al*[28] also found a high prevalence of aerobic microorganisms presence at 74% in a sample of 102 cases. Molomo et al[57] in a sample of 127 also found majority of the causative bacteria to have been aerobic. In contrast, Bahl *et al*[4] found 60% of the 100 respondents they studied to have been mixed infections. Therefore, the findings of this study are consistent with other findings in that most of the causative microorganisms are aerobic.

In the current study the Ordinal Regression test showed that the aerobic bacteria in the orofacial infective lesions had a statistically significant level of resistance towards ampicillin,

amoxicillin/clavuanic acid, ceftriaxone, cefuroxime among others. On the other hand, the sensitivity of the aerobes towards meropenem, amikacin, levofloxacin and ciprofloxacin was found to have been statistically significant according to the Ordinal Regression test.

Among the anaerobes, meropenem and metronidazole were found to have been sensitive of 81.8% each. Further, the anaerobes were found to have been at statistically significant level of sensitivity towards augmentin. Surprisingly, amoxicillin/clavulanic acid was found to have had only 20% intermediate sensitivity among the aerobes and 45.5% sensitivity among the anaerobes. The same finding has been reported in Ethiopia[65]. However, this is inconsistent with earlier studies done which reported high sensititvity to amoxicillin/clavulanic acid[4,17,47]. The low sensitivity amoxicillin/clavunic acid (20%) could be due to over-prescription in our set up. The finding of high efficacy of metronidazole in this study is consistent with other studies[21,28]. Independent samples *t* test showed a statistically significant increase of drug resistance with age for ciprofloxacin and tetracycline.

CONCLUSION

1. Most of the bacteria in orofacial infections were found to have been aerobes at 47.4%, whence there was also a significant percentage of anaerobes at 31.6% while 21% of the infections were found to have been of mixed bacterial origin.
2. The sensitivity of the aerobes in the orofacial infections towards meropenem, amikacin, and levofloxacin was found to have been statistically significant at 100%.
3. The sensitivity of anaerobic bacteria in the orofacial infections was found to have been high towards meropenem, metronidazole and augmentin.
4. The commonly used antimicrobial before seeking professional treatment was found to have been metronidazole at 37.1%.

RECOMMENDATIONS

1. Having found that meropenem and metronidazole were very effective in the management of orofacial bacterial infections, it is recommended that there should be strict observation of antimicrobial stewardship regarding the use of these drugs. This would be useful in helping to avoid antimicrobial resistance of these drugs.
2. Since the aerobic bacteria in the orofacial infective lesions were found to have a statistically significant level of resistance towards ampicillin, amoxicillin/clavuanic acid, ceftriaxone, cefuroxime it is recommended that these drugs should be used cautiously in life-threatening maxillofacial infections like Ludwig's angina.

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Appendix A: Participant's data

Serial no: …….

My name is Dr Gatune from the department of oral and maxillofacial surgery, University of Nairobi. Am going to ask you a few questions regarding your health.

1. How old are you now? Age:……..(in years)

Gender: …….

2. Which is your regular residence? Regular residence:……(Estate)
3. Did you take any drugs prior to this interview? If yes, which ones? Previous medications taken: …….

Fascial space involved: ……..

Lab sensitivity results: ……

Appendix B: Consent Form (English Version)

I am Dr James Gatune from the department of Oral and Maxillofacial Surgery Kenyatta National Hospital/ University of Nairobi. Am conducting a survey to find out the antibiotics which are effective in treating mouth, face and neck infections. The findings of this survey could be used by clinicians to make empirical judgment in the choice of the antibiotics for treatment of these infections.

I am requesting you to kindly participate in this survey by signing this form in the space shown below. The information concerning you and your illness will be confidential. For this reason your name will not be required. In case you are not willing to participate you will not be denied any treatment that you deserve. I will take a specimen from the infected site by using either a cotton swab or withdrawing pus for laboratory studies.

Risks and discomforts.

Getting pus from the abscess can hurt for a few seconds from the needle prick like when you get a mosquito bite.

Thank you very much for your time and patience.

I can be reached on Tel 0728487612 or email: jame.sgatune.mwangi@gmail.com

For those 18 years and above

I ……. Confirm that I have understood the relevant parts of this survey and do hereby give consent of participating. I accept too, willingly provide information regarding my illness to be used in this process. I also accept that the information can be used as a baseline for consecutive studies on the same topic.

For those below 18 years

Signature…….. Date…….

I ……. (parent/guardian's name) give consent for …….. (Child's name) to participate the survey conducted by Dr Gatune.

Signature…… Date ……

Appendix C Assent Form for minor

My name is Dr James Gatune. I am from the department of Oral and Maxillofacial Surgery University of Nairobi / Kenyatta National Hospital. I am doing a research on the bacteria that cause your illness and the effective drugs that can be used in treating these bacteria. I am kindly requesting you to participate in this research.

This study will help us improve treating diseases like yours.

When withdrawing pus it may hurt a little like a mosquito bite but this lasts for a few seconds only.

Please talk this over with your parent or guardian before you decide whether to participate or not. I have asked your parent or guardian to give you permission for you to participate.

If you do not want to participate in the research no one will punish you for it.

If you agree, sign your name below. Thank you very much for your time and patience.

…… (Child's name)

Signature ……. (Of child) Date……

Appendix D: Consent Form (Swahili Version)

Jina langu ni Daktari James Gatune kutoka idaraya Oral and Maxillofacial Surgery kwenye hospitalikuuya Kenyatta/chuo kikuu cha Nairobi. Ninafanya utafiti wa kutakakujua ni antibiotiki gani ambazo zinanguvu ya kutibu magonjwa ya mdomoni, shingo na uso. Matokeo ya utafiti huu yawezakutumika na madaktari katikakufanya uamuziwa antibiotiki wanazotumia kutibu magonjwa ya ainahii.

Ninaomba ushiriki katikautafiti huu kwa kutiasahihi yako kwenye fomu sehemuiliyoachwa hapo chini. Habar ininayoipata kukuhusu na kuhusuugonjwawakoniyasiri, Kwa sababu hii, jinalakohalitahitajika. Iwapohutatakakushirikikatikautafitihuu, hutanyimwamatibabuunayofaakupata. Nitachukua sampul ikutoka sehemu iliyo ambukizwa kwa kutumia pambausufi au kwakutoausaha. Sampuli hiii tachambuliwa katika maabara.

Usumbufu

Kutoa usahakwenye uvimbekunawezakusababisha uchungu kama unaopata baadaya kuumwa na mbu.

Asante kwamuda wako.

Kwa wale waliohitimumiaka 18 kuendelea:

Mimi……..ninia thibitisha kuwa nimeelewa sehemu husikaza utafiti huu nanimekubali kushiriki. Ninakubali, kwa hiari yangu kuwa ninatoahabari kuhusu ugonjwa wangu, itakayotumiwa katika utafitihuu. Pia nina kubali kuwa habari nitakayo toa inaweza kutumika katika tafitizingine kuhusu madahii.

Kwa wale waliochiniyamiaka 18:

Sahihi……. Tarehe…….

Mimi……(jina la mzazi/mlezi) nimepeana ruhusakwa…….. (jina la mtoto) kushiriki katikautafiti unaofanywana Daktari Gatune.

Sahihi……. Tarehe…….

Appendix E: Assent Form for minors

Jina langu ni Daktari James Gatune, kutoka idara ya Oral and Maxillofacial Surgery kwenye hospitali kuu ya Kenyatta/chuo kikuu cha Nairobi. Ninafanya utafiti kuhusu kiumbekinachosababisha ugonjwa wako na dawa zinazo weza kutumika kutibu magonjwa yaina hii. Nina omba ushirirki katika utafiti huu.

Matokeo ya utafiti huu ya tatuwezeshakutibumagonjwa yaa ina hii vizurizaidi.

Nitakapo kuwa nikitoa usaha, una weza kuhisi uchungu kidogo kama unaokupataunapo umwa na mbu, lakini nikwasekunde chache.

Tafadhali zungumza na mzazi au mlezi wako kuhusu utafiti huu kabla ya kuamua iwapo utashiriki au la. Nimemwomba mzazi au mlezi wako akuperuhusa yakushiriki.

Iwapo hutatakakushiriki katika utafiti huu, hakuna atakayekuadhibu kwasababu hiyo.

Iwapo unakubalikushiriki, tafadhali andika jina lako nautiesahihi katika seheuiliyoachwahapochini.

Asante sana kwa muda wako.

Jina la mtoto…….

Sahihi ya mtoto…….

Tarehe……