A 5-year review of the microbiology of acute complicated bacterial sinusitis at the University of the Witwatersrand

By

Ian Paul Olwoch

M.B.Ch.B. (Makerere University)
M.Med. Anaesthesia (University of Nairobi)

A dissertation submitted in part fulfillment for the degree of Master of Medicine in Otorhinolaryngology of the University of the Witwatersrand.

2007

This dissertation is dedicated

to

my wife,

Jane Mukarugwiza Olwoch,

and

my daughters,

Irene Aciro Olwoch

And

Margaret Alobo Olwoch

DECLARATION

CANDIDATE

This dissertation is my original work and has not been presented for a degree, or other academic award, in any other University or institution of higher learning.

Signed:

Dr Ian Paul Olwoch

MBChB (Makerere), MMed Anaesthesia (Nairobi)

SUPERVISOR

This dissertation is submitted for examination with my approval as University Supervisor.

Signed:

Professor Pradip C. Modi

MBChB (Wits), DCH (SA), MMed (Wits), FCS (SA)

Professor and Head of Department

Department of Otorhinolaryngology

University of the Witwatersrand

ACKNOWLEDGEMENTS

I wish to express my gratitude to all the following:

PROFESSOR PC MODI, my supervisor and academic head, for his guidance support and encouragement throughout the preparation and execution of this study and for his invaluable criticism in the final preparation of this dissertation.

All the members of the academic peer review committee of the Department of Neurosciences for their guidance and valuable criticism.

DR MRI AHMED, the clinical head of Otorhinolaryngology at the Chris Hani Baragwanath Hospital, for facilitating my access to a wealth of data that was vital to the success of this dissertation.

The staff of the:

- Operating theatres
- ENT and neurosurgical wards
- Department of radiology
- National Health Laboratory Services

at the Johannesburg General, Chris Hani Baragwanath, Helen Joseph and Coronation Hospitals for their support in sourcing all the relevant data.

My wife JANE, and daughters IRENE and MARGARET, for their patience, encouragement and deep understanding throughout the process of this study.

CONTENTS

Title	i
Declaration	ii
Acknowledgement	iii
List of tables	vi
List of Figures	x
Summary	x
Introduction	1
Literature review	5
Aims and objectives	11
Material and methods	11
Results	17
Discussion	44
Conclusions	54
References	55
Appendix I: Unfiltered raw data	61
Appendix II: Antibiotic susceptibility and resistance records	67

LIST OF TABLES

Table 1: Categorization of microbiology culture results from 301 patients with acute complicated sinusitis. [Page 17]

Table 2: Age and gender statistics of the study population. [Page 19]

Table 3: Distribution of negative culture reports amongst 226 laboratory culture reports by gender, age and presence of neurosurgical complication. [Page 20]

Table 4: Age analysis of 163 patients in the positive culture population. [Page 21]

Table 5: 233 bacteria and fungi isolated from 163 patients with acute complicated sinusitis expressed as raw data and percentage of total count. [Page 23]

Table 6: Comparative analysis of the frequency of occurrence, of aerobes, facultative anaerobes, anaerobes and fungi in 163 patients with positive culture specimen. [Page 24]

Table 7: Number of different microorganism species isolated per patient within the positive culture population (n = 163). [Page24]

Table 8: 107 bacteria and fungi species isolated as single pathogens from 107 patients with acute complicated sinusitis expressed as raw data and percentage of their total count (n = 107). [Page 25]

Table 9: 86 microorganisms isolated as a pair of co-existing pathogens from 43 patients with acute complicated sinusitis expressed as raw data and percentage of their total count (n = 86). [Page 26]

Table 10: 40 microorganisms isolated as multiple pathogens in 13 patients with acute complicated sinusitis caused by three or more different microorganisms expressed as raw data and percentage of their total count (n = 40). [Page 27]

Table 11: Comparative analysis of the frequency of occurrence of microorganisms between groups of patients with different numbers of microorganism species identified. [Page 28]

Table 12: Comparison of age and age distribution between 117 male and 46 female patients in the positive culture population. [Page 29]

Table 13: Comparative distribution of microorganisms by patients' gender of 234 microbiological isolates from 117 male and 46 female patients. [Page 30]

Table 14: Comparison of age and age distribution between paediatric (<= 15 years) and adult (> 15 years) patients in the positive culture population. [Page 32]

Table 15: Comparative distribution of microorganisms by patients' age in 234 microbiological isolates from 93 paediatric (<= 15 years) and 70 adult (> 15 years) patients. [Page 33]

Table16: Comparative analysis of age, age distribution and population size between patients presenting with intracranial complications and those without intracranial complications. [Page 35]

Table 17: Comparative distribution of microorganisms isolated from 31 patients with intracranial complications as compared to 132 patients without intracranial complications. [Page 36]

Table: 18: Comparative analysis of age, age distribution and population size between patients presenting at the Johannesburg Hospital (JH) and those at Chris Hani Baragwanath Hospital (CHB). [Page 38]

Table: 19: Comparative distribution of microorganisms between 69 patients at Johannesburg General Hospital (JH) and 93 patients at Chris Hani Baragwanath Hospital (CHB). [Page 39]

Table 20: Recorded incidence of antibiotic sensitivity of some common pathogens isolated from monomicrobial specimen. [Page 41]

Table 21: Profile of the distribution of Streptococcus milleri and other bacteria in 43 patients from the study population. [Page 42]

Table 22: General profile of antibiotic resistance: Antibiotic and antibiotic groups recorded against the number of recorded instances of microbial resistance. [Page 43]

LIST OF FIGURES

Figure 1:

Age distribution of 226 patients in the study population. [Page 19]

Figure 2:

Age distribution of 163 patients in the positive culture population.
[Page 22]

SUMMARY

This study retrospectively analysed the bacteriology of 226 patients who were admitted, with acute complicated sinusitis, to the University of the Witwatersrand's ENT complex over a 5-year period, between the 1st January 2002 and 31st December 2006. There were 159 male and 67 females (ratio 2.4:1) aged between 1 and 74 (mean 16.5 ± 0.7) years. 116 (51.3%) patients were 15 years and younger and 110 (48.7%) were above the age of 15 years.

All 226 patients had one or more of an orbital, soft tissue or bony complication and underwent open sinus surgery by way of an external frontoethmoidectomy approach (or ethmoidectomy) with maxillary sinus puncture and sinus washout. Intracranial complications were present in 37 (16.4%) patients of whom 12 required drainage of a subdural empyema and, one required drainage of a brain abscess.

233 microorganisms were isolated for analysis from positive cultures obtained from 163 (72.1%) patients (1.4 isolates per specimen) and 63 (27.9%) cultures were negative. Aerobic and facultative anaerobes accounted for 199 (85.4%) of the isolates whilst anaerobes accounted for 31 (13.3%) and fungi for 3 (1.3%). 107 (65.4%) of the positive culture specimens were monomicrobial whilst 56 (34.6%) contained 2 to 4 different species of microorganism. The proportion of anaerobes was notably higher ($p<0.05$) polymicrobial specimen than in monomicrobial specimen.

The most commonly isolated aerobic microorganisms were *Streptococcus milleri* (18.5%), *Staphylococcus aureus* (12.4%), β-haemolytic *streptococci* groups A, C, F, and G (10.3%), coagulase negative *staphylococcus* (8.6%) and *Haemophilus influenzae* (8.6%). In contrast, *Streptococcus pneumoniae* (2.6%) and *Moraxella catarrhalis* (0.4%) were not major pathogens.

Peptostreptococcus (6.4%) and *Prevotella* (4.7%) species were the most common anaerobes.

The profile of isolates was not influenced by gender or by the presence of intracranial complications. However, age and location did have a significant ($p<0.05$) impact. *Haemophilus influenzae* was more significant ($p<0.05$) in patients aged 15 years and younger. *Streptococcus milleri* was the most common isolate (28.3%) at the Chris Hani Baragwanath Hospital but ranked 5^{th} (2.3%) at the Johannesburg Hospital. β-haemolytic *streptococci* and coagulase negative *staphylococcus* ranked 1^{st} (20.8%) and 2^{nd} (14.8%) respectively at the Johannesburg Hospital but only 4^{th} (4.8%) and 5^{th} (2.8%) respectively at the Chris Hani Baragwanath Hospital.

Penicillin, ampicillin and erythromycin were effective against *Streptococcus milleri*, β-haemolytic *streptococci*, *Streptococcus pneumoniae* and streptococcal species. Cloxacillin was effective against *Staphylococcus aureus* and coagulase negative *staphylococci*. Methicillin-resistant *Staphylococcus aureus* was isolated in 3 patients (1.3%). *Haemophilus influenzae* was resistant to ampicillin in 22.2% cases in which it was the sole pathogen.

A 5-year review of the microbiology of acute complicated bacterial sinusitis at the University of the Witwatersrand

INTRODUCTION

Acute sinusitis defines a state in which there is rapid onset, progression and persistence of signs and symptoms caused by inflammatory disease within the paranasal sinuses. Viruses and bacteria are largely responsible for the development of acute sinusitis. Often an initial viral inflammation of the sinuses is superseded by invasion with a variety of bacterial pathogens and the development of complications at adjacent and/or remote sites. Management of acute complicated sinusitis requires an understanding of the anatomy of the sinuses and the microbiology of the associated pathogens.

Embryology

The paranasal sinuses are airspaces within the bones of the face and skull that are transposed as relations around the nasal cavity. There are four paired sinuses namely the maxillary, ethmoid, frontal and sphenoid sinuses. The paranasal sinuses develop as outpouches of the nasal cavity and remain in communication with the nasal cavity through narrow openings (or *ostia*). The maxillary and ethmoid sinuses are present at birth; the frontal and sphenoid sinuses begin to develop after the ages of 2 and 7 years, respectively. The sinuses attain adult size between the age of 12 and 18, with the sphenoid sinus being the last to mature.

Physiology

The paranasal sinuses are lined with pseudostratified ciliated columnar epithelium which is in continuity with the mucosa of the nasal cavity. The epithelium also contains non-ciliated columnar cells, basal cells and mucus-secreting goblet cells. The cilia in each sinus beat in a specific direction that results in orderly movement of mucus and debris around the sinus and ultimately through the sinus ostium and into the nasal cavity.

Normally the paranasal sinuses are relatively sterile with low titers of bacteria of less than 1000 colony-forming units per milliliter of mucus. The sterility of the cavities is maintained in part by the mucociliary clearance system, the immune system of the body and nitric oxide production within the sinuses (Palm J, Lidman C, Graf P *et al*., 2000). Factors that prevent or delay the clearance of secretions from the paranasal sinuses result in the accumulation of secretions and subsequent colonization of the sinuses by pathogenic microorganisms by invasion from without and/or proliferation from within.

Definitions

Sinusitis describes a state in which pathogenic microorganisms colonize the mucosal lining of the paranasal sinuses and cause an inflammatory disorder. Viruses, bacteria, fungi and protozoa may cause the disease by infecting any one, or combination, of the sinuses. The term *rhinosinusitis,* used interchangeably with the term *sinusitis*, depicts the disease state as a continuum of inflammation between the nasal and sinus mucosae. When 2 or more paranasal sinuses are simultaneously infected, the term *pansinusitis* is often used. Complications of paranasal sinus disease occur when the disease extends to involve bone, the adjacent orbit and cranial cavities and their respective contents.

Treatment

The mainstay of treatment of patients with sinusitis is medical and is directed towards alleviating the symptoms and eliminating the invading organism where possible. The treatment of sinusitis associated with complications constitutes both a medical and, in certain cases, a surgical emergency.

At the University of the Witwatersrand's ENT complex, patients with acute complicated sinusitis are referred to the department of Otorhinolaryngology usually when surgical intervention is anticipated. Prompt medical treatment with or without surgery must be initiated. This includes the use of antibiotics prior to obtaining laboratory identification of the offending pathogen(s). Observed differences in the local prevalence of bacterial pathogens and the continued emergence of antibiotic-resistant strains of bacteria influence the choice of antibiotic used to initiate treatment (Ali A, Kurien M, Mathews SS, Mathew J., 2005; Oxford LE, McClay J. 2005; Butler JC, Hofmann J, Cetron MS, Elliot JA, Facklam RR, Breiman RF.1996).

The decision to conduct this study is prompted by the need to know the prevalent bacteria associated with complicated sinusitis and their antibiotic sensitivity patterns as seen at the University of the Witwatersrand's ENT complex.

LITERATURE REVIEW

Bacterial sinusitis is a common disease of worldwide distribution that affects people of all ages. The course of the disease in patients with bacterial sinusitis is varied, ranging from mild and insidious to debilitating and potentially life-threatening (Ali A, Kurien M, Mathews SS, Mathew J. 2005; Oxford LE, McClay J 2005). Bacterial sinusitis is usually preceded by an episode of viral sinusitis caused by viruses responsible for the common cold. These include such viruses as the *adenovirus, rhinovirus, influenza virus, parainfluenza virus* and *respiratory syncytial virus*. The resultant sinus mucosal inflammation causes oedema of the mucosa and obstruction of the sinus ostia and a concomitant reduction in ciliary action.

It is classified into five clinical categories according to the duration of the signs and symptoms of disease and the frequency with which they occur (Piccirillo JF, 1998). These categories include:

- <u>Acute sinusitis</u> in which symptoms and signs of the disease resolve completely and do not exceed 4 weeks duration,
- <u>Recurrent acute sinusitis</u> in which 2 to 4 episodes of acute sinusitis occur per year with at least 8 weeks interval between each episode,
- <u>Subacute sinusitis</u> in which symptoms of the disease persist for more than 4 weeks but not beyond 12 weeks,
- <u>Chronic sinusitis</u> in which insidious symptoms persist for over 12 weeks,

- <u>Acute-on-chronic sinusitis</u> in which a patient with chronic sinusitis experiences and acute exacerbation of symptoms.

The presenting signs and symptoms in patients with sinusitis are those in keeping with an inflammatory disease of the upper respiratory tract. The findings include fever, headache, vomiting, nasal obstruction and discharge. When complications occur other more ominous signs occur, the clinical presentation being determined by the site and extent of the complications. Involvement of the orbit and brain would result in the development of features such as facial and periorbital swelling, proptosis, mood changes, seizures.

Infection of the paranasal sinus is associated with serious complications as a result of the spread of the disease into adjacent and remote sites. Spread of the disease from the sinuses occurs through areas of osteitic bone destruction, congenital or acquired bony defects, or by way of septic thrombophlebitis of communicating veins (Osguthorpe JD, Hochman M, 1993). The complications of sinusitis fall into four categories namely orbital, intracranial, bone and soft tissue. The highest occurrence of complications of sinusitis is recorded in young male patients during the cold winter season (Oxford LE, McClay J, 2002).

Orbital complications are the most common complication of sinusitis (Ali A, Kurien M, Mathews SS, Mathew J, 2005; Oxford LE, McClay J, 2005; Schramm VL, Myers EN, Kennerdell JS, 1978), usually occurring as a result of ethmoid sinusitis (Arjmand EM, Lusck RP, Muntz HR, 1993). The

Chandler Classification describes 5 types of orbital complications (Chandler JR, Langenbrunner DJ, Stevens ER., 1970):

- Preseptal cellulitis
- Orbital cellulitis
- Subperiosteal abscess
- Orbital abscess
- Cavernous sinus thrombosis

In the pre-antibiotic error, permanent sequelae including blindness occurred in 20% of patients with orbital complications (Gamble RC, 1933). Over the years incidence of permanent orbital complications has reduced to around 6-10.5% (Patt BS, Manning SC, 1991; Schramm VL, Myers EN, Kennerdell JS, 1978) with some centres now reporting incidences as low as 1.8% (Oxford LE, McClay J, 2005).

Intracranial complications are most commonly secondary to acute frontal sinusitis and may include meningitis, cerebritis, epidural and subdural empyemas, cerebral abscess and thrombosis of venous sinuses (Ali A, Kurien M, Mathews SS, Mathew J. 2005; Clayman GL, Adams GL, Paugh DR *et al* 1991; Oxford LE, McClay J. 2005; Remmler D, Boles R. 1980). With appropriate management the outcome of the disease will range from complete resolution to transient or permanent neurological deficit, seizures or even death (Younis RT, Lazar RH, 2002).

Bony complications include osteomyelitis of the frontal and maxillary sinus, frontal subperiosteal abscess and frontal pyocoele (Ali A, Kurien M, Mathews SS, Mathew J. 2005).

Periorbital and facial cellulitis are the predominant soft tissue complications.

The microbiology of bacterial sinusitis has been studied extensively in relation to the causative organisms. The invading bacterial pathogens, in both acute and chronic sinusitis, include a variety of aerobic, facultative and anaerobic organisms. The most common pathogens found in patients with acute bacterial sinusitis are aerobic and facultative anaerobes that include *Streptococcus pneumoniae*, *Haemophilus influenzae* and *Moraxella (Branhamella) catarrhalis* (Brook, 2002; Brook I, Frazier EH, 2004; Jousimies-Somer HR, Savolainen S, Ylikoski JS, 1988; Tellez I, Alba LMD, Reyes MG, Patton E, Hesles H dl G., 2006). Anaerobic organisms, such as *Propionbacterium acnes* and *Peptostreptococcus* species, are found in as many as 31% of patients with acute bacterial sinusitis (Brook I, 2005). Isolates from patients with chronic sinusitis were found to have a mixture of both aerobic and anaerobic bacteria with a preponderance of anaerobic bacteria such as *Prevotella* species, *Fusobacterium* species, *Peptostreptococcus* species (Brook I, 1981). The aerobic bacteria isolated from patients with chronic sinusitis included *Haemophilus influenzae*, *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* (Brook I, 2002; Frederick J, Braude AI, 1974; Kamau JK, Macharia IM, Odhiambo PA, 2001).

Patients with bacterial pansinusitis are more likely to have a mixture of both aerobic and anaerobic bacteria. Furthermore a study on 155 patients with sinusitis demonstrated that the likelihood of anaerobic bacteria being present was significantly high when multiple sinuses were concurrently diseased (Brook I, 2004)

There appears to be a different frequency pattern of bacteria isolated from patients with complicated sinusitis as compared to those presenting without complications. The profile of offending bacteria also differs in reports from different centres. Ali A *et al* (2005) isolated *Staphylococcus aureus* in 66.6% of patients. Other organisms cultured in this study included *Enterobacter* species, *Streptococcus* species, *Protavella* species and *Bacteriodes*. None of the isolates included *Haemophilus influenzae* and *Moraxella catarrhalis*.

Special mention needs to be made of a group of streptococcal bacteria now known as the *Streptococcus milleri* group of bacteria. This group is made up of three species namely *Streptococcus intermedius*, *Streptococcus consellatus* and *Streptococcus anginosus*. Their role as pathogens human pathogens was not recognized until recently mainly because of difficulties in their laboratory identification and because of confusion surrounding their taxonomy and nomenclature (Ruoff KL, 1988). Oxford and McClay (2005) identified the *Streptococcus milleri* group of bacteria as being the most frequent bacteria isolated from children with complicated sinusitis. In their study ά-haemolytic *Streptococci* species, *Staphylococcus aureus* and *Streptococcus pneumoniae* followed in descending order of frequency. *Haemophilus influenzae* was isolated from only one case, representing 0.9% of bacterial isolates. *Moraxella catarrhalis* was not found in this study.

Acute sinusitis is extremely common and is the reason for which many patients seek medical attention. Most often the illness is of viral origin and about 2% of cases may become complicated by acute bacterial sinusitis (Lauer J, 2003). In the absence of obvious bacterial complications it is not possible to distinguish between viral and bacterial sinusitis on clinical grounds alone. Despite the knowledge that viral infections are the predominant cause of sinusitis many physicians continue to prescribe antibiotics as part of their first-line of treatment (Gonzales R, Steiner JF, Sande MA., 1997). Over the years the use and abuse of antibiotics has led to the emergence of antibiotic-resistant strains of bacteria such a penicillin-resistant *Streptococcus pneumoniae* (Butler JC, Hofmann J, Cetron MS, Elliot JA, Facklam RR, Breiman RF, 1996, Hofmann J, Cetron MS, Farley MM, Baughman WS, Facklam RR, Elliot JA *et al*., 1995), Methicillin-resistant *Staphylococcus aureus* and *Pneumococci* (Dowell SF, Schwartz B 1997; Kunin CM, 1993).

AIMS AND OBJECTIVE

The aim of the study is to:

- Describe the frequency of the types of microorganisms isolated from patients with acute complicated sinusitis at the teaching hospitals of the University of the Witwatersrand
- Document the antibiotic susceptibility and resistance of the isolated microorganisms
- Make recommendations on the choice of antibiotic to be used to initialize treatment prior to obtaining laboratory bacterial culture and sensitivity results.

MATERIALS AND METHOD

Ethics Approval

This study was approved by the Standards and Ethics Committee of the University of the Witwatersrand.

Study Location

The study was conducted at the four university teaching hospitals namely Johannesburg General, Chris Hani Baragwanath, Helen Joseph and Coronation Hospitals.

Study Period

The study extended over a period of 5 years; starting from the 1st January 2002 and ending on the 31st December 2006.

Study Population

The study includes all patients who underwent paranasal sinus surgery as part of their management for acute complicated sinusitis and on whom sinus specimen microbiology analysis was performed.

Data Collection

Patients were identified from three sources within each hospital, namely the:

- ENT and neurosurgery emergency theatre operation registers
- ENT and neurosurgery ward admission registers
- Radiology CT scan registers.

The operating theatre emergency registers were used as the primary reference to identify patients who were recorded as having had sinus surgery as an emergency procedure. Both the ENT and neurosurgery registers were searched so as to include those patients with acute sinusitis who additionally suffered intracranial complications and may therefore have been registered as patients outside the ENT department.

The ENT and neurosurgical ward admissions registers and the CT scan register were used as secondary references to aid in the identification of those patients whose information in the theatre register was unclear or lacking in details (e.g. missing or partial hospital numbers, misspelled names, illegible entry). These secondary references were also used as a screen to source for patients whose information may not have been identified specifically in the ENT and neurosurgery theatre registers. Those patients screened from this secondary source included those who appeared in the ward register with a diagnosis of sinusitis and those in-patients, from any hospital ward, who appear in the CT scan register as having had a scan of either the paranasal sinuses or the brain with the orbit.

All patients clearly identified from the theatre register were recorded as part of the initial sample population. The patients' information was then used to search the database of the National Health Laboratory Service (NHLS) and all findings were recorded placed into one of the following six categories:

- Positive cultures in which pathogenic microorganisms were identified
- Negative cultures in which the report states that there was "no bacterial growth"
- Histology reports in which a histological analysis but not a microbiological analysis was performed on the specimen
- Rejected specimen in which the specimen received by the laboratory was unsuitable for processing
- No results found in which no results were found in the database
- Incomplete or incorrect information in which patients in the theatre register did not have sufficient information to interrogate the NHLS database

Patients identified exclusively from the secondary references were cross-checked against their recorded laboratory findings and were included in the study population only if certain conditions were met. These conditions for inclusion being that:

- There was a microbiology or histology laboratory report for the identified patient
- The sample analysed was obtained from the paranasal sinuses
- The report clearly stated that the sample was obtained from a patient with a history of acute complicated sinusitis

Those patients selected from the secondary references who did not have sufficient information to search the NHLS database were not included in the study sample.

The following data was recorded for each patient:

- Full name
- Age
- Sex
- Hospital registration number
- Date of operation (specimen collection)
- Type of operation / complication
- Type of isolated microorganisms
- Antibiotic sensitivity and resistance

Laboratory results for microscopy culture and sensitivity were obtained at each hospital from the computer register of the resident NHLS laboratory.

All data was recorded electronically using Microsoft Access database and Microsoft Excel Spreadsheet.

For the purposes of this study, only those patients who were identified as patients with acute complicated sinusitis, on whom sinus surgery was performed and, for whom positive microbiological cultures were obtained were included in the final study population and used for analysis.

Data Analysis and Presentation

Analysis of data was carried out by the MMed candidate (Dr IP Olwoch) at the Department of Otorhinolaryngology Head and Neck Surgery. Standard statistical methods are used. Student's *t* test was used to analyse ordinal data and the Chi Square (X^2) test was used for dichotomous nominal data. A probability (p) value of less than (or equal to) 0.05 is regarded as significant.

The following software applications were used for data manipulation, statistical analysis and presentation:

- Microsoft Access 2003 Database for data storage, retrieval and selection
- Microsoft Excel 2003 Spreadsheet for descriptive data analysis, summary statistics and comparison of sample means
- Web Chi Square Calculator (Ball CN, Connor-Linton J, 2007) for comparison of sample populations
- Microsoft Word 2003 Word Processor for final documentation and presentation

Evaluation of data from identified microorganisms with respect to prevalence, age and gender of patients, and antibiotic sensitivity-resistance patterns was done. Special attention is given to comparative analysis of:

- The bacterial profile in male patients as compared to female patients.
- The bacterial profile in patients under the age of 15-years as compared to those over the age of 15 years.
- The bacterial profile in those patients presenting with intracranial complications as compared to those without.
- The bacterial profile in patients presenting at the different hospitals within the University ENT complex.

RESULTS

A total of 301 patients were identified from the registers of the operating theatres, relevant wards and CT scan department (APPENDIX I) as patients who had undergone surgery for acute complicated sinusitis. The patients' hospital admission numbers were used to search the NHLS database for records of microbiological investigations performed on specimens derived from their paranasal sinuses during the time of surgery. The findings were grouped into 6 categories (Table 1).

Table 1:
Categorization of microbiology culture results from 301 patients with acute complicated sinusitis.

	Result category	**No. of patients**
1	Positive cultures	163
2	Negative cultures	63
3	No results found	42
4	Incomplete information	3
5	Histology report only	29
6	Rejected specimen	1
	TOTAL	**301**

Rejected Patient Records

75 patients, (Table 1: category 3-6), were rejected from the study sample and not included in any further discussion.

Study Population (n = 226)

All patients in the study population underwent open sinus surgery by way of an external frontoethmoidectomy approach (or ethmoidectomy) with maxillary sinus puncture and washout. In addition 37 (16.4%) patients of the study population were diagnosed as having intracranial abscess formations. 13 of these patients underwent concurrent neurosurgical craniotomy for drainage of subdural empyema (n = 12) and brain abscess (n = 1).

All specimens were collected intra-operatively and therefore standard aseptic conditions of collection are presumed to have been applied in all cases. Specimens were analysed at the respective hospitals by the resident NHLS laboratories in accordance with their Standard Operating Procedure Manual. Specimen derived from the sinuses as sinus aspirates (or tissues) are cultured aerobically at 35^{o}C for 24 to 48 hours in:

- 5% horse blood agar
- MacConkey agar
- Chocolate agar
- Thioglycolate broth

and, anaerobically at 35^{o}C for 24 to 48 in 10% horse blood agar and Amikacin blood agar. Direct gram staining and microscopy are performed after 24 hours.

Both positive and negative microbiology culture records were obtained from 226 patients (Table 1: category 1,2). Positive cultures were obtained in 163 (72.1%) cases and 63 (27.9%) records were reported as having "*no bacterial growth*".

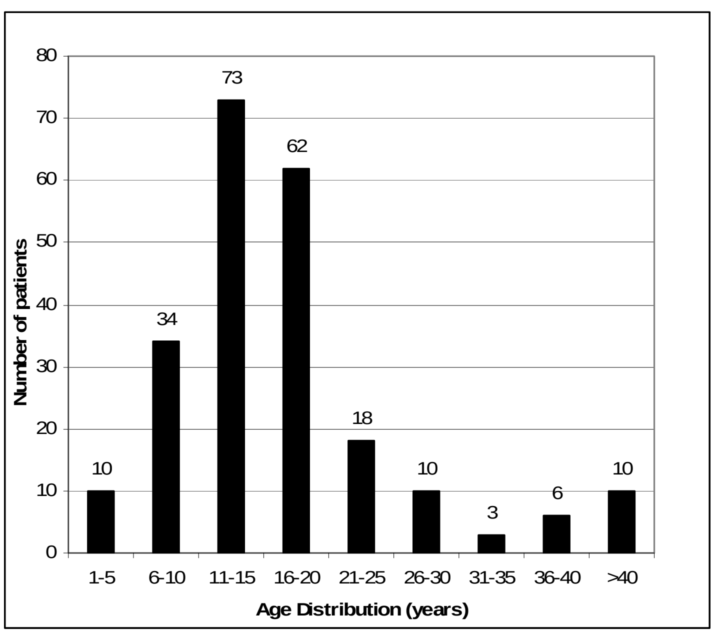
Table 2

Age and gender statistics of the study population.

Statistic	Value
Mean	16.5
Standard Error	0.7
Median	14
Mode	14
Standard Deviation	10.1
Sample Variance	101.8
Kurtosis	6.1
Skewness	2.1
Range	73
Minimum	1
Maximum	74
Count	226
Male	159
Female	67
Male:Female	2.4:1

Figure 1:

Age distribution of 226 patients in the study population.



Analysis of negative cultures (n = 63)

63 records out of 226 (Table 1: category 2), were reported to have had *"no bacterial growth"* thereby accounting for 27.9% of the obtained microbiology culture results.

Table 3:

Distribution of negative culture reports amongst 226 laboratory culture reports by gender, age and presence of neurosurgical complication.

Group (n)	**Frequency of negative cultures**	**% of total (n)**
Male (n = 159)	42	26.4
Female (n = 67)	21	30.3
Adult [>15 years] (n = 92)	23	23.9
Paediatric [<1=15 years] (n = 133)	40	30.1
Neurosurgical (n = 37)	6	16.2
Non-neurosurgical (n = 188)	57	29.7

There is no significant difference (X^2 = 4.17 with 0 d.f., p>0.05) in the occurrance of negative culture results between the groups in Table 1.

Negative culture reports are not included within the analysis of the reports with positive microbiological isolates.

Analysis of positive cultures (n = 163)

163 patients with positive microbiological findings (Table 1: category 1) constituted 72.1% of the accepted study population.

The population of positive comprises of 163 laboratory results derived from 117 male and 46 female patients consistent with a male to female ratio of 2.5:1. The patients' ages ranged from 3 to 74 years with a mean of 16.6 ± 0.8 years. The greater percentage, 57.1%, of the population were under the age of 16 years and 42.9% were 16 years and older.

126 (77.3%) of patients were between the ages of 6 and 20 years of age with the highest incidence of 50 (30.7%) occurring in patients in the 11-15 year age group.

Table 4:
Age analysis of 163 patients in the positive culture population.

Statistic	**Value**
Mean	16.6
Standard Error of Mean (s.e.m.)	0.8
Median	14
Mode	14
Standard Deviation (s.d.)	10.1
Sample Variance (V)	101.0
Kurtosis	7.9
Skewness	2.3
Range (r)	71
Minimum (min)	3
Maximum(max)	74
Count (n)	163
Percentage of population (%)	100

Figure 2:

Age distribution of 163 patients in the positive culture population.

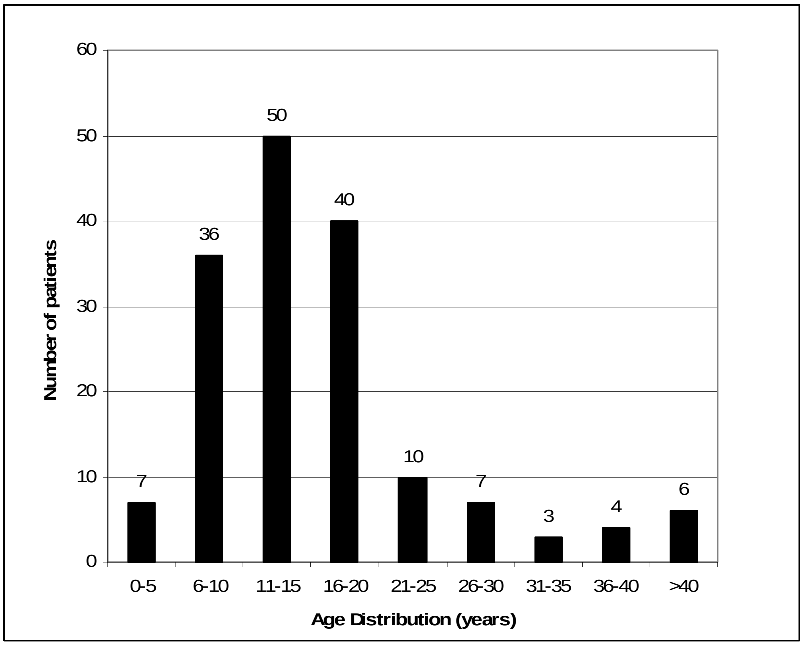


Table 5:

233 bacteria and fungi isolated from 163 patients with acute complicated sinusitis expressed as raw data and percentage of total count.

Microorganisms	No.	%	Microorganisms	No.	%
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram positive cocci**		
Streptococcus milleri	43	18.5%	*Enterococcus durans*	1	0.4%
Group A β-haemolytic streptococci (*S. pyogenes*)	6	2.6%	**Gram positive bacilli**		
Group C β-haemolytic streptococci	11	4.7%	*Lactobacillus* species	1	0.4%
Group F β-haemolytic streptococci	6	2.6%	**Gram negative bacilli**		
Group G β-haemolytic streptococci	1	0.4%	*Eikenella corrodens*	4	1.7%
Streptococcus pneumoniae	6	2.6%	*Proteus mirabilis*	1	0.4%
Viridans streptococci	10	4.3%	**ANAEROBES**		
Streptococcus species	12	5.2%	**Anaerobic cocci**		
Staphylococcus aureus	29	12.4%	*Peptostreptococcus* species	11	4.7%
coagulase negative *staphylococcus*	20	8.6%	*Peptostreptococcus* anaerobius	4	1.7%
MRSA	3	1.3%	**Gram positive bacilli**		
Staphylococcus species	3	1.3%	*Propionbacterium* species	1	0.4%
Gram negative cocci			**Gram negative bacilli**		
Moraxella catarrhalis	1	0.4%	Prevotella species	11	4.7%
Gram positive bacilli			Fusobacterium species	1	0.4%
Corynebacterium species	4	1.7%	Acinetobacter baumanii	1	0.4%
Gram negative bacilli			Bacteroides species	1	0.4%
Haemophilus influenzae	20	8.6%	Photobacter species	1	0.4%
Haemophilus parainfluenzae	2	0.9%	**FUNGI**		
Haemophilus species	1	0.4%	*Candida glabrata*	1	0.4%
Escherichia coli	2	0.9%	*Sacchromyces cerevisiae*	1	0.4%
Klebsiella oxytoca	2	0.9%	Yeast-like organisms	1	0.4%
Klebsiella ozaenae	1	0.4%	**TOTAL**	**233**	**100.0%**
Klebsiella species	4	1.7%	**Summary:**		
Enterobacter cloacae	2	0.9%	**Aerobes**	**192**	**82.4%**
Enterobacter faecalis	1	0.4%	**Facultative Anaerobes**	**7**	**3.0%**
Pseudomonas aeruginosa	1	0.4%	**Anaerobes**	**31**	**13.3%**
Citrobacter koserii	1	0.4%	**Fungi**	**3**	**1.3%**

The five most commonly isolated aerobic microorganisms are *Streptococcus milleri, Staphylococcus aureus, β*-haemolyti*c streptococci* (A, C, F, and G), coagulase negative *staphylococcus* and *Haemophilus influenzae*.

Table 6:

Comparative analysis of the frequency of occurrence, of aerobes, facultative anaerobes, anaerobes and fungi in 163 patients with positive culture specimen

Microorganism group	**Frequency**	**%**
Aerobes only	127	77.9%
Aerobes and Facultative Anaerobes	6	3.7%
Aerobes and Anaerobes	19	11.7%
Anaerobes only	8	4.9%
Facultative Anaerobes only	1	0.6%
Facultative Anaerobes and Anaerobes	0	0.0%
Fungi	2	1.2%
	163	**100.0%**

Table 7:

Number of different microorganism species isolated per patient within the positive culture population (n = 163).

No. of microorganism species per patient	**No. of patients**	**Percentage of patient total (%)**
1	107	65.6
2	43	26.4
3	12	7.4
4	1	0.6
TOTAL:	**163**	**100%**

Table 8:

107 bacteria and fungi species isolated as single pathogens from 107 patients with acute complicated sinusitis expressed as raw data and percentage of their total count (n = 107)

Microorganism	**No.**	**%**	**Micoorganism**	**No.**	**%**
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram negative bacilli**		
Streptococcus milleri	25	23.4%	*Eikenella corrodens*	1	0.9%
Group A β-haemolytic streptococci (*S. pyogenes*)	6	5.6%	**ANAEROBES**		0.0%
Group C β-haemolytic streptococci	5	4.7%	*Prevotella* species	2	1.9%
Group F β-haemolytic streptococci	6	5.6%	*Peptostreptococcus anaerobius*	2	1.9%
Streptococcus pneumoniae	3	2.8%	*Bacteroides* species	1	0.9%
Viridans streptococci	3	2.8%	**FUNGI**		0.0%
Streptococcus species	7	6.5%	Yeast-like organisms	1	0.9%
Staphylococcus aureus	16	15.0%			
coagulase negative *staphylococcus*	8	7.5%	**TOTAL:**	**107**	**100.0%**
MRSA	2	1.9%			
Staphylococcus species	2	1.9%			
Gram positive bacilli			**Summary**		
Corynebacterium species	3	2.8%	**Aerobes**	**100**	**93.5%**
Gram negative bacilli			**Facultative anaerobes**	**1**	**0.9%**
Haemophilus influenzae	9	8.4%	**Anaerobes**	**5**	**4.7%**
Haemophilus parainfluenzae	1	0.9%	**Fungi**	**1**	**0.9%**
Klebsiella ozaenae	1	0.9%			
Klebsiella species	1	0.9%			
Enterobacter cloacae	2	1.9%			

Table 9:

86 microorganisms isolated as a pair of co-existing pathogens from 43 patients with acute complicated sinusitis expressed as raw data and percentage of their total count (n = 86)

Microorganisms	**No.**	**%**	**Microorganisms**	**No.**	**%**
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram positive cocci**		
Streptococcus milleri	13	15.1%	*Enterococcus durans*	1	1.2%
Group C β-haemolytic streptococci	6	7.0%	**Gram positive bacilli**		0.0%
Streptococcus pneumoniae	3	3.5%	*Lactobacillus* species	1	1.2%
Viridans streptococci	3	3.5%	**Gram negative bacilli**		0.0%
Streptococcus species	4	4.7%	*Eikenella corrodens*	2	2.3%
Staphylococcus aureus	8	9.3%	*Proteus mirabilis*	1	1.2%
coagulase negative *staphylococcus*	8	9.3%	**ANAEROBES**		0.0%
MRSA	1	1.2%	**Anaerobic cocci**		0.0%
Staphylococcus species	1	1.2%	*Peptostreptococcus anaerobius*	2	2.3%
Gram negative cocci		0.0%	*Peptostreptococcus* species	9	10.5%
Moraxella catarrhalis	1	1.2%	**Gram positive bacilli**		0.0%
Gram negative bacilli		0.0%	*Propionbacterium* species	1	1.2%
Haemophilus influenzae	8	9.3%	**Gram negative bacilli**		0.0%
Haemophilus species	1	1.2%	*Prevotella* species	3	3.5%
Escherichia coli	1	1.2%	*Fusobacterium* species	1	1.2%
Klebsiella oxytoca	1	1.2%	*Acinetobacter baumanii*	1	1.2%
Klebsiella species	2	2.3%	**FUNGI**		0.0%
Pseudomonas aeruginosa	1	1.2%	*Candida glabrata*	1	1.2%
			Sacchromyces cerevisiae	1	1.2%
			TOTAL:	**86**	**100.0%**
			Summary		
			Aerobes	**62**	**72.1%**
			Facultative anaerobes	**5**	**5.8%**
			Anaerobes	**17**	**19.8%**
			Fungi	**2**	**2.3%**

Table 10:

40 microorganisms isolated as multiple pathogens in 13 patients with acute complicated sinusitis caused by three or more different microorganisms expressed as raw data and percentage of their total count (n = 40)

Microorganism	**No.**	**%**	**Microorganism**	**No.**	**%**
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram negative bacilli**		
Streptococcus milleri	5	12.5%	*Eikenella corrodens*	1	2.5%
Group G β-haemolytic streptococci	1	2.5%	**ANAEROBES**		
Viridans streptococci	4	10.0%	**Anaerobic cocci**		
Streptococcus species	1	2.5%	*Peptostreptococcus* species	2	5.0%
Staphylococcus aureus	5	12.5%	**Gram negative bacilli**		
coagulase negative *staphylococcus*	4	10.0%	*Prevotella* species	6	15.0%
Gram positive bacilli			*Photobacter* species	1	2.5%
Corynebacterium species	1	2.5%			
Gram negative bacilli					
Haemophilus influenzae	3	7.5%	**TOTAL:**	**40**	**100.0%**
Haemophilus parainfluenzae	1	2.5%			
Escherichia coli	1	2.5%	**Summary**		
Klebsiella oxytoca	1	2.5%	**Aerobes**	**30**	**75.0%**
Klebsiella species	1	2.5%	**Facultative Anaerobes**	**1**	**2.5%**
Enterobacter faecalis	1	2.5%	**Anaerobes**	**9**	**22.5%**
Citrobacter koserii	1	2.5%	**Fungi**	**0**	**0.0%**

12 patients had three pathogens isolated from their sinus specimen and 1 patient had 4 pathogens.

The single patient from who 4 pathogens were isolated was found to have *Streptococcus milleri, Viridans streptococci, Haemophillus influenzae* and *Photobacter species*.

Table 11:

Comparative analysis of the frequency of occurrence of microorganisms between groups of patients with different numbers of microorganism species identified.

No. of microorganisms per patient	**Aerobes**	**Facultative Anaerobes**	**Anaerobes**	**Fungi**	**Total**
1	100	1	5	1	**107**
2	62	5	17	2	**86**
3	27	1	8	0	**36**
4	3	0	1	0	**4**
	192	**7**	**31**	**3**	**233**

Comparative analysis of the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi between the four groups of patients was made using the Chi Squared Distribution. A highly significant difference (3 d.f. X^2 = 18.5, $p<0.05$) was noted.

<u>Distribution of aerobes and anerobes in monomicrobial verses polymicrobial isolates</u>

There is a significant difference ($p<0.05$) in the pattern of distribution of aerobic and anaerobic microorganisms between the mono and polymicrobial patient groups. This is most likely attributed to the high proportion of:

- aerobic microorganisms in patients where a single species was isolated
- anaerobic microorganisms in the polymicrobial isolates

Patients with monomicrobial isolates accounted for 107 of 163 (65.4%) of the positive culture population whilst patients with polymicrobial isolates accounted for the remaining 56 of 163 (34.6%).

Table 12:

Comparison of age and age distribution between 117 male and 46 female patients in the positive culture population.

Statistic	**Male**	**Female**
Mean	15.6	19.1
Standard Error	0.7	2.1
Median	14	15.5
Mode	14	13
Standard Deviation	7.7	14.2
Sample Variance	59.3	201.9
Kurtosis	3.8	4.5
Skewness	1.8	1.9
Range	44	71
Minimum	4	3
Maximum	48	74
Count	117	46
Percentage of total	71.8%	28.2%

Analysis of the mean age of the male and female patients was done with Student's t-test for comparison of the two sample means with unequal variances. This showed no significant difference ($t = 1.58$, $p>0.05$) between the mean ages of male and female patients.

Table 13:

Comparative distribution of microorganisms by patients' gender of 234 microbiological isolates from 117 male and 46 female patients.

Microorganism	Male	Female	Microorganism	Male	Female
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram positive cocci**		
Streptococcus milleri	32	11	*Enterococcus durans*	1	0
Group A β-haemolytic streptococci (S. pyogenes)	2	4	**Gram positive bacilli**		
Group C β-haemolytic streptococci	10	1	*Lactobacillus* species	1	0
Group F β-haemolytic streptococci	3	3	**Gram negative bacilli**		
Group G β-haemolytic streptococci	1	0	*Eikenella corrodens*	3	1
Streptococcus pneumoniae	5	1	*Proteus mirabilis*	1	0
Viridans streptococci	9	1	**ANAEROBES**		
Streptococcus species	10	2	**Anaerobic cocci**		
Staphylococcus aureus	18	11	*Peptostreptococcus* species	8	3
coagulase negative *staphylococcus*	15	5	*Peptostreptococcus* anaerobius	4	0
MRSA	2	1	**Gram positive bacilli**		
Staphylococcus species	3	0	*Propionbacterium* species	1	0
Gram negative cocci			**Gram negative bacilli**		
Moraxella catarrhalis	1	0	*Prevotella* species	8	3
Gram positive bacilli			*Fusobacterium* species	1	0
Corynebacterium species	3	1	*Acinetobacter baumanii*	0	1
Gram negative bacilli			*Bacteroides* species	0	1
Haemophilus influenzae	14	6	*Photobacter* species	1	0
Haemophilus parainfluenzae	2	0	**FUNGI**		
Haemophilus species	1	0	*Candida glabrata*	1	0
Escherichia coli	1	1	*Sacchromyces cerevisiae*	1	0
Klebsiella oxytoca	2	0	Yeast-like organisms	0	1
Klebsiella ozaenae	0	1			
Klebsiella species	3	1	**TOTAL:**	**170**	**63**
Enterobacter cloacae	2	0			
Enterobacter faecalis	0	1	**Summary:**		
Pseudomonas aeruginosa	0	1	**Aerobes**	**139**	**52**
Citrobacter koserii	1	0	**Facultative Anaerobes**	**6**	**1**
			Anaerobes	**23**	**9**
			Fungi	**2**	**1**

Comparison of the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi between male and female patients (Table 13) showed no significant difference (X^2 = 0.62, d.f. = 2, p>0.05) between the two groups.

The frequencies of the five most commonly isolated aerobic microorganisms (*refer to page 23*) are compared between the male and female patients and are shown to have no significant difference (X^2 = 1.6, d.f = 4, p>0.05).

The frequencies of *Peptostreptococcus* and *Prevotella* species showed no significant difference (X^2 = 0.2, d.f = 1, p>0.05) between male and female patients.

Table 14:

Comparison of age and age distribution between paediatric (<= 15 years) and adult (> 15 years) patients in the positive culture population.

Statistic	**<= 15 years**	**> 15 years**
Mean	10.8	24.2
Standard Error	0.3	1.3
Median	11	19
Mode	14	17
Standard Deviation	3.1	10.9
Sample Variance	9.8	119.8
Kurtosis	-0.2	5.8
Range	12	58
Minimum	3	16
Maximum	15	74
Count	93	70
Percentage of total	57.1%	42.9%

The difference between the mean ages of the paediatric and adult populations is significant (t = -11.24, d.f. = 161, $p<0.05$).

Table 15:

Comparative distribution of microorganisms by patients' age in 234 microbiological isolates from 93 paediatric (<= 15 years) and 70 adult (> 15 years) patients.

Microorganism	**<=15**	**>15**
AEROBES		
Gram positive cocci		
Streptococcus milleri	28	15
Group A β-haemolytic streptococci (*S. pyogenes*)	3	3
Group C β-haemolytic streptococci	3	8
Group F β-haemolytic streptococci	5	1
Group G β-haemolytic streptococci	0	1
Streptococcus pneumoniae	6	0
Viridans streptococci	5	5
Streptococcus species	9	3
Staphylococcus aureus	18	11
coagulase negative staphylococcus	6	14
MRSA	2	1
Staphylococcus species	0	3
Gram negative cocci		
Moraxella catarrhalis	1	0
Gram positive bacilli		
Corynebacterium species	1	3
Gram negative bacilli		
Haemophilus influenzae	15	5
Haemophilus parainfluenzae	2	0
Haemophilus species	1	0
Escherichia coli	0	2
Klebsiella oxytoca	0	2
Klebsiella ozaenae	0	1
Klebsiella species	0	4
Enterobacter cloacae	2	0
Enterobacter faecalis	0	1
Pseudomonas aeruginosa	0	1
Citrobacter koserii	0	1

Microorganism	**<=15**	**>15**
FACULTATIVE ANAEROBES		
Gram positive cocci		
Enterococcus durans	0	1
Gram positive bacilli		
Lactobacillus species	0	1
Gram negative bacilli		
Eikenella corrodens	4	0
Proteus mirabilis	0	1
ANAEROBES		
Anaerobic cocci		
Peptostreptococcus species	9	2
Peptostreptococcus anaerobius	1	3
Gram positive bacilli		
Propionbacterium species	1	0
Gram negative bacilli		
Prevotella species	7	4
Fusobacterium species	1	0
Acinetobacter baumanii	1	0
Bacteroides species	1	0
Photobacter species	1	0
FUNGI		
Candida glabrata	0	1
Sacchromyces cerevisiae	0	1
Yeast-like organisms	0	1
TOTAL	**133**	**100**
Summary:		
Aerobes	**107**	**85**
Facultative Anaerobes	**4**	**3**
Anaerobes	**22**	**9**
Fungi	**0**	**3**

Comparison of the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi between paediatric and adult patients (Table 15) showed no significant difference ($X^2 = 0.95$, d.f. = 2, $p>0.05$) between the two groups.

The frequencies of the five most commonly isolated aerobic microorganisms (*refer to page 23*) are compared between the paediatric and adult patients and are shown to be significantly different ($X^2 = 11.3$, d.f. = 4, $p<0.05$).

Haemophilus influenzae is significantly more common ($p<0.05$) amongst the paediatric patients and coagulase negative *staphylococcus* is more common ($p<0.05$) amongst the adult patients.

There is no significant difference in the frequencies of occurrance of *Streptococcus milleri, Staphylococcus aureus, β*-haemolytic *streptococci* (A, C, F, and G) between the adult and paediatric groups.

The frequencies of *Peptostreptococcus* and *Prevotella* species showed no significant difference ($X^2 = 0.03$, d.f = 1, $p>0.05$) between the two groups.

Table 16:

Comparative analysis of age, age distribution and population size between patients presenting with intracranial complications and those without intracranial complications.

Statistic	**Intracranial Complications**	
	YES	**NO**
Mean	13.2	17.4
Standard Error	0.5	1
Median	13	15
Mode	10	9
Standard Deviation	2.9	10.9
Sample Variance	8.3	119.8
Kurtosis	0	6
Skewness	0.6	2
Range	12	71
Minimum	8	3
Maximum	20	74
Count	31	132
Percentage of total	19.0 %	81.0 %

No significant difference (t = -3.82, d.f. = 159, p>0.05) is noted between the mean age and age distribution of the patients presenting with additional intracranial complications and those without intracranial complications.

Table 17:

Comparative distribution of microorganisms isolated from 31 patients with intracranial complications as compared to 132 patients without intracranial complications.

Microorganism	**Intracranial complication YES**	**NO**	**Microorganism**	**Intracranial complication YES**	**NO**
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram positive cocci**		
Streptococcus milleri	15	28	*Enterococcus durans*	0	1
Group A β-haemolytic streptococci (S. pyogenes)	1	5	**Gram positive bacilli**		
Group C β-haemolytic streptococci	3	8	*Lactobacillus* species	0	1
Group F β-haemolytic streptococci	1	5	**Gram negative bacilli**		
Group G β-haemolytic streptococci	0	1	*Eikenella corrodens*	2	2
Streptococcus pneumoniae	0	6	*Proteus mirabilis*	0	1
Viridans streptococci	3	7	**ANAEROBES**		
Streptococcus species	2	10	**Anaerobic cocci**		
Staphylococcus aureus	3	26	*Peptostreptococcus* species	5	6
coagulase negative *staphylococcus*	4	16	*Peptostreptococcus anaerobius*	0	4
MRSA	2	1	**Gram positive bacilli**		
Staphylococcus species	0	3	*Propionbacterium* species	0	1
Gram negative cocci			**Gram negative bacilli**		
Moraxella catarrhalis	0	1	*Prevotella* species	5	6
Gram positive bacilli		0	*Fusobacterium* species	0	1
Corynebacterium species	0	4	*Acinetobacter baumanii*	0	1
Gram negative bacilli			*Bacteroides* species	0	1
Haemophilus influenzae	4	16	*Photobacter* species	1	0
Haemophilus parainfluenzae	0	2	**FUNGI**		
Haemophilus species	0	1	*Candida glabrata*	0	1
Escherichia coli	0	2	*Sacchromyces cerevisiae*	0	1
Klebsiella oxytoca	1	1	Yeast-like organisms	0	1
Klebsiella ozaenae	0	1	**TOTAL:**	**53**	**180**
Klebsiella species	1	3	**Summary:**		
Enterobacter cloacae	0	2	**Aerobes**	**40**	**152**
Enterobacter faecalis	0	1	**Facultative Anaerobes**	**2**	**1**
Pseudomonas aeruginosa	0	1	**Anaerobes**	**11**	**20**
Citrobacter koserii	0	1	**Fungi**	**0**	**3**

Comparison of the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi isolated from those patients with intracranial complications and those without (Table 17) showed no significant difference (X^2 = 5.39, d.f. = 2, p>0.05) between the two groups.

The frequencies of the five most commonly isolated aerobic microorganisms (*refer to page 23*) are compared between the neurosurgical and non-neurosurgical patients and are shown to have no significant difference (X^2 = 6.4, d.f = 4, p>0.05).

The frequencies of *Peptostreptococcus* and *Prevotella* species showed no significant difference (X^2 = 0.4, d.f = 1, p>0.05) between the two groups.

Table: 18

Comparative analysis of age, age distribution and population size between patients presenting at the Johannesburg Hospital (JH) and those at Chris Hani Baragwanath Hospital (CHB).

Statistic	**JH**	**CHB**
Mean	18.4	15.3
Standard Error	1.2	1.0
Median	17	13
Mode	9	14
Standard Deviation	10.0	10.0
Sample Variance	99.9	99.8
Kurtosis	1.3	14.8
Skewness	1.3	3.3
Range	45	71
Minimum	3	3
Maximum	48	74
Count	69	93

There is no significant difference (t = -1.96, d.f = 147, $p>0.05$) between the mean age and age distribution of the patients presenting at the two main hospitals.

Table: 19

Comparative distribution of microorganisms between 69 patients at Johannesburg General Hospital (JH) and 93 patients at Chris Hani Baragwanath Hospital (CHB).

Microorganisms	**JH**	**CHB**	**Microorganisms**	**JH**	**CHB**
AEROBES			**FACULTATIVE ANAEROBES**		
Gram positive cocci			**Gram positive cocci**		
Streptococcus milleri	2	41	*Enterococcus durans*	1	0
Group A β-haemolytic streptococci (*S. pyogenes*)	4	2	**Gram positive bacilli**		
Group C β-haemolytic streptococci	8	4	*Lactobacillus* species	1	0
Group F β-haemolytic streptococci	5	1	**Gram negative bacilli**		
Group G β-haemolytic streptococci	1	0	*Eikenella corrodens*	0	4
Streptococcus pneumoniae	0	6	*Proteus mirabilis*	0	1
Viridans streptococci	4	6	**ANAEROBES**		
Streptococcus species	11	1	**Anaerobic cocci**		
Staphylococcus aureus	10	19	*Peptostreptococcus* species	1	10
coagulase negative *staphylococcus*	13	6	*Peptostreptococcus* anaerobius	4	0
MRSA	0	3	**Gram positive bacilli**		
Staphylococcus species	3	0	*Propionbacterium* species	1	0
Gram negative cocci			**Gram negative bacilli**		
Moraxella catarrhalis	0	1	Prevotella species	1	10
Gram positive bacilli			Fusobacterium species	1	0
Corynebacterium species	3	1	Acinetobacter baumanii	0	1
Gram negative bacilli			Bacteroides species	1	0
Haemophilus influenzae	7	13	Photobacter species	0	1
Haemophilus parainfluenzae	1	1	**FUNGI**		
Haemophilus species	0	1	*Candida glabrata*	1	0
Escherichia coli	0	2	*Sacchromyces cerevisiae*	1	0
Klebsiella oxytoca	1	1	Yeast-like organisms	1	0
Klebsiella ozaenae	0	1	**TOTAL**	**88**	**145**
Klebsiella species	1	3	**Summary:**		
Enterobacter cloacae	0	2	**Aerobes**	**74**	**118**
Enterobacter faecalis	0	1	**Facultative Anaerobes**	**2**	**5**
Pseudomonas aeruginosa	0	1	**Anaerobes**	**9**	**22**
Citrobacter koserii	0	1	**Fungi**	**3**	**0**

Comparison of the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi isolated from patients at Johannesburg General Hospital with those from Chris Hani Baragwanath Hospital (Table 19) showed no significant difference (X^2 = 0.47, d.f. = 1, p>0.05) between the two groups.

The frequencies of the five most commonly isolated aerobic microorganisms are compared between patients at the two hospitals (Table 19). The study shows a significant difference (X^2 = 40.7, d.f = 4, p<0.05) between common organisms the Chris Hani Baragwanath Hospital and Johannesburg Hospital.

The frequencies of isolation of *Streptococcus milleri* and *Haemophilus influenzae* are significantly higher (p<0.05) at the Chris Hani Baragwanath Hospital (Table 19).

The frequencies of isolation of *β*-haemolytic *streptococci* (group A, C, G and F) and coagulase negative *staphylococcus* are significantly higher (p<0.05) at the Johannesburg Hospital. The frequency of isolation of *Streptococcus milleri* at the Johannesburg Hospital is low (p<0.05).

There is no significant difference (p>0.05) in the frequencies of occurrance of *Staphylococcus aureus* at the two main hospitals (Table 19).

The frequencies of *Peptostreptococcus* and *Prevotella* species at the two hospitals (Table 19) showed no significant difference (X^2 = 2.1, d.f. = 1, p>0.05).

<u>Antibiotic Susceptibility and Resistance Patterns</u> (APPENDIX II)

Antibiotic sensitivity and resistance patterns were documented for 129 patients in the positive culture population.

Table 20:

Recorded incidence of antibiotic sensitivity of some common pathogens isolated from monomicrobial specimen.

		Antibiotic			
Microorganism	**No. of test results**	**Penicillin**	**Ampicillin**	**Cloxacillin**	**Erythromycin**
Streptococcus milleri	25	84.0%			
Anaerobes	0	-	-	-	-
Staphylococcus aureus	16	6.3%	-	93.8%	62.5%
β-haemolytic streptococci (A,C,F,G)	11	90.9%	90.9%	-	-
coagulase negative staphylococcus	1	-	-	100%	100%
Haemophilus influenzae	18		66.7%		
Streptococcal species	3	100%	100%		100%
Streptococcus pneumoniae	2	100%	-	-	-
others (22 microorganism species)					
Viridans streptococci	2	Reported as being susceptible to Cefotaxime, Ceftriaxone Vancomycin, Linezolid			

Table 21

Profile of the distribution of *Streptococcus milleri* and other bacteria in 43 patients from the study population.

No.		Accompanying Microorganisms
1	*Streptococcus milleri*	*Haemophilus influenzae*
2	*Streptococcus milleri*	
3	*Streptococcus milleri*	MRSA
4	*Streptococcus milleri*	
5	*Streptococcus milleri*	
6	*Streptococcus milleri*	
7	*Streptococcus milleri*	
8	*Streptococcus milleri*	*Klebsiella* species
9	*Streptococcus milleri*	
10	*Streptococcus milleri*	
11	*Streptococcus milleri*	
12	*Streptococcus milleri*	
13	*Streptococcus milleri*	
14	*Streptococcus milleri*	*Staphylococcus aureus*
15	*Streptococcus milleri*	*Peptostreptococcus* species
16	*Streptococcus milleri*	*Eikenella corrodens*
17	*Streptococcus milleri*	
18	*Streptococcus milleri*	*Staphylococcus aureus*
19	*Streptococcus milleri*	*Eikenella corrodens*
20	*Streptococcus milleri*	
21	*Streptococcus milleri*	
22	*Streptococcus milleri*	
23	*Streptococcus milleri*	
24	*Streptococcus milleri*	
25	*Streptococcus milleri*	
26	*Streptococcus milleri*	*Prevotella* species, *Peptostreptococcus* species
27	*Streptococcus milleri*	*Prevotella* species
28	*Streptococcus milleri*	
29	*Streptococcus milleri*	*Viridans streptococci, Prevotella* species, *Haemophilus influenzae*
30	*Streptococcus milleri*	
31	*Streptococcus milleri*	
32	*Streptococcus milleri*	
33	*Streptococcus milleri*	*Peptostreptococcus* species
34	*Streptococcus milleri*	
35	*Streptococcus milleri*	
36	*Streptococcus milleri*	coagulase negative *staphylococcus*
37	*Streptococcus milleri*	*Escherichia coli, Klebsiella* species
38	*Streptococcus milleri*	coagulase negative *staphylococcus, Peptostreptococcus* species
39	*Streptococcus milleri*	*Viridans streptococci, Prevotella* species
40	*Streptococcus milleri*	coagulase negative *staphylococcus*
41	*Streptococcus milleri*	*Acinetobacter baumanii*
42	*Streptococcus milleri*	
43	*Streptococcus milleri*	

Table 22:

General profile of antibiotic resistance: Antibiotic and antibiotic groups recorded against the number of recorded instances of microbial resistance.

Antimicrobial Agent	**No. of cases**
Cephalosporins	14
1st Cefazolin, Cephaliexin	
2nd Cefuroxime	
3rd Ceftiaxone, Cefotaxime, Ceftazidime	
Macrolides (Erythromycin)	6
Tetracyclines (Tetracycline)	2
Aminoglycosides (Amikacin, Gentamicin, Rifampicin, Tobramycin)	4
Lincosamides (Clindamycin)	4
Cotrimoxazole	9
Chloramphenicol	1
Penicillins (Penicillin,Ampicillin, Amoxycillin, Cloxacillin, Co-amoxiclav, Piperacillin-Tazobactam)	72
TOTAL:	**112**

Resistance to the penicillins as a group of drugs was encountered in 64.3% of cases with resistance to penicillin alone accounting for 41 (36.6%) of cases.

DISCUSSION

In this study we analysed the microbiology findings from 266 patients selected from a pool of 301 who were diagnosed with acute complicated sinusitis (Table 1). The mean age of the patient pool was 16.5 (± 0.7) years. The patients were predominantly male with a male: female ratio of 2.4:1 (Table 2). A peak incidence of 73 (32.3 %) occurred in paediatric patients aged 11-15 years with the next highest of 27.4% (62) being in adolescents and young adults aged 16-20 years (Figure 1).

All patients in this study underwent open sinus surgery as part of their management during which procedure sinus aspirates and tissues were derived for microbiological analysis. We found positive cultures in 163 (72.1%) of cases and negative cultures in 63 (27.9%) of cases which is within the range (20-33.3%) noted other studies (Penttila M *et al* 1997; Mortimore *et al* 1998; Ali *et al* 2005). No significant trends ($p>0.05$) in the occurrance of negative culture results could be established between the patients on the basis of age, gender or neurosurgical complication. However, those with neurosurgical complications appeared to have a slightly lower percentage of negative microbiology cultures at 16.2% (Table 3).

A total of 233 microorganisms were identified from 163 patients (an average of 1.4 isolates per specimen) with positive microbiology culture results (Table 5). Aerobic and facultative anaerobes accounted for 199 (85.4%) of the isolates whilst anaerobes accounted for 31 (13.3%). Two specimens were found to have fungal growths and no bacteria and accounted for 3 (1.3%) of the positive isolates.

When the data is viewed from the perspective of the *patient*, 134 (82.0%) patients had aerobes and/or facultative anaerobes, 19 (11.7%) patients had both aerobic and anaerobic isolates, 8 (4.9 %) had only anaerobic species and 2 (1.3%) had fungi isolated from their sinus specimen (Table 6). It may also suffice to say that 27 (16.6%) of the patients with positive isolates had anaerobes with or without the concurrent presence of aerobes.

The bacteriology of acute sinusitis has been extensively studied. Many reports in medical literature mention the common aerobic microorganisms in acute sinusitis as being *Streptococcus pneumonia, Haemophilus influenzae* and *Moraxella catarhalis* (Wald *et al* 1981; Snyman *et al* 1988; Wald 1992; Penttilla *et al* 1997; Jousimies-Somer *et al* 1988; Brook 2002; Brook, Frazier 2004; Brook 2005(b); Tellez *et al* 2006). *Stapylococcus aureus* and anerobic bacteria are given greater recognition as pathogens in chronic sinusitis (Ramadan H 1995, Brook I, 2002; Frederick J, Braude AI, 1974; Kamau at al 2001; Wald 1992; Brook 2005(b)). However, there are also reports that highlight *Staphylococcus aureus* as an important pathogen in acute sinusitis (Hnatuk LAP *et al* 1994). It is worth noting that all these studies differ from this study in that they were conducted on patients who did not have severe disease associated with complications.

In this study *Streptococcus milleri* was the most frequently isolated microorganism accounting for 43 (18.5 %) isolates. Only recently has *Streptococcus milleri* been recognized as a human pathogen accounting for its absence in earlier reports (Ruoff KL, 1988). Next in descending order of frequency were *Staphylococcus aureus* 29 (12.4%), β-haemolytic *streptococci* 24 (10.8%), coagulase negative *staphylococcus* 20 (8.6%) and *Haemphilus influenzae* 20 (8.6%). *Streptococcus pneumoniae* accounted for only 6 (2.6%) of the isolates and only one isolate containing *Moraxella catarrhalis* (0.4%) was identified.

Four retrospective studies on the bacteriology of acute complicated sinusitis, were conducted on a study population with a similar profile to this study. Two studies (Mortimore S, Wormald PJ, Oliver S. 1998; Oxford LE, McClay J. 2005) found *Streptococcus milleri* to be the most frequently isolated microorganism and concurred with the findings of this study. In their patients with orbital and intracranial complications, Mortimore *et al* (1998) similarly observed that *Staphylococcus aureus* (25%) was the next most frequent isolate, that there was a low frequency of *Streptococcus pneumoniae* (4%) and *Moraxella catarrhalis* (0.0%) was notably absent. Oxford and McClay (2005) ranked *Staphylococcus aureus* and coagulase negative *staphylococci* third and fourth respectively. The two other studies (Rosenfeld EA 1993, Ali *et al* 2005) both identified *Staphylococcus aureus* and anaerobes as the predominant isolates.

Anaerobic bacteria are generally associated with chronic sinusitis. *Peptostreptococci, Prevotella, Fusobacterium, Propionbacterium* and *Bacteroides* are the anaerobes most frequently encountered and reported in many articles (Ramadan H 1995, Brook 1981, 2002, 2004). There does not appear to be any consistent pattern in the order of frequency with which they appear. Anaerobes were isolated 31 times (13.3%) in this study, and the most frequently isolated anaerobes were *Peptostreptococci* 15 (6.4%) and *Prevotella* species 11 (4.7%). Similarly Brook (2005) isolated *Peptostreptococci* in 4 (8.5%) of patients with acute sinusitis. Oxford and McClay (2004) reported an 18.6% occurrance of anaerobes and identified *Prevotella* 4 (8.3%) and *Bacteroides* 2 (4.2%) species as the most common. Similarly Ali *et al* (2005) isolated *Prevotella* 1 (8.3%) and *Bacteroides* (8.3%). A study on children with intracranial abscesses (Rosenfeld E, Rowley 1993) isolated *Bacteroides* species in 3 out of 4 positive culture specimens. Mortimore *et al* (1998) reported a much lower frequency of 1.6% of anaerobes and made no mention of the identity of the species. The pattern of anaerobes encountered in this study closely resembles that seen in patients with chronic sinusitis.

<u>Monomicrobial and Polymicrobial Isolates</u>

Brook 2004 demonstrated the distribution of microorganisms between the various sinuses was not uniform with the possibility of some sinuses being free of pathogens. The number of isolates within each positive culture specimen varied (Table 7). Single microbial species were isolated from 107 (65.6%) specimen whilst polymicrobial isolates, numbering 2 to 4 species per specimen, were found in 56 (34.4%) of cases. Those patients with monomicrobial isolates had a significantly ($p<0.05$) higher proportion of aerobic isolates than those with polymicrobial isolates. Polymicrobial isolates were found to be associated with a significantly higher ($p<0.05$) occurrance of anaerobic microorganisms (Tables 8, 9, 10, 11). Polymicrobial specimen and the prominence of anaerobes suggests the presence of chronic disease (Ramadan H 1995, Brook 1981, 2002, 2004).

Male and Female Patients

There was no significant difference ($p>0.05$) between male and female patients in the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi (Table 13). There are no studies which suggest there is any difference in the microbiology of sinusitis between male and female patients.

Paediatric and Adult Populations

93 (57.1%) of the study population were 15 years and younger (Table 15). No statistically significant difference ($p>0.05$) was shown between paediatric and adult patients in the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi.

There was a difference in the priority order of the frequency of occurrence of aerobic bacteria in the paediatric patients. *Streptococcus milleri* (21.1%, n = 28) and *Staphylococcus aureus* (13.5%, n = 18) remained in the top two positions with the third and fourth positions being occupied by *Haemophilus influenzae* (11.3%, n = 15) and β-haemolytic *streptococci* (8.3%, n =11). In the adult patients the frequent aerobes were the same as those common to the whole patient population.

Haemophilus influenzae occurred more frequently ($p<0.05$) in the paediatric group (11.3%, n = 15) as compared to the adult group (5.0%, n = 5). Two studies within the same region (Snyman *et al* 1988, Mortimore *et al* 1998) find a higher frequencies of *Haemophilus influenzae*, in 6 (22.2%) and 9 (16.0%) of isolates, as compared either age group in this study.

On the other hand coagulase negative *staphylococcus* occurred more frequently ($p<0.05$) in the adult patients (14.0%, n = 14) than in the paediatric patients (4.5%, n = 6). *Moraxella catarrhalis* was identified in one (0.8%) isolate in the paediatric group in contrast to other studies (Penttilla *et al* 1997, Wald *et al* 1981, Brook *et al* 2005b, Tellez *et al* 2006) that show *Moraxella catarrhalis* to be an important pathogen in children and adults.

<u>Neurosurgical and Non-neurosurgical Cases</u>

There was no significant difference ($p>0.05$) between in the relative distribution of aerobes, facultative anaerobes, anaerobes and fungi in patients with intracranial complications as compared to those without such complications (Table 17).

There were three observations worth noting from the comparative analysis of patients with intracranial complications. This study finds *Streptococcus milleri* to be the predominant pathogen in patients with intracranial complications. This finding is also reported by Mortimore *et al* (1998) and Oxford and

McClay (2005). The second is that anaerobes account for 20.8% (n = 11) of the isolates from patients with intracranial complications as compared to 11.1% (n = 20) in those without intracranial complications. Several reports (Brook 2005c; Rosenfeld 1994, Mortimore *et al* 1998, Oxford, McClay 2005, Ali *et el* 2005) agree that anaerobes are commonly isolated from patents with intracranial complications. The third observation is that *Streptococcus pneumoniae* was not isolated from patients with intracranial complications.

Johannesburg and Chris Hani Baragwanath Hospitals

The Johannesburg Hospital and Chris Hani Baragwanath Hospitals are located to the north and south respectively, of the Johannesburg city centre and are separated by distance of about 30 kilometres. Most of the data collected in this study was derived from these two hospitals. The frequencies of the five most commonly isolated aerobic microorganisms (*refer to page 23*) occurring in patients at these two hospitals (Table 19) are found to be significantly different ($p<0.05$). This finding emphasizes the importance of having to know the local prevalence of microorganisms in ones area of practice (Lauer J 2003).

The order of selected common microorganisms *(refer to page 23)* isolated at Johannesburg hospital occur in the order listed below:

- *β*-haemolytic *streptococci,* 18 (20.5%)
- coagulase negative *staphylococcus,* 13 (14.8%)
- *Staphylococcus aureus,* 10 (11.4%)
- *Haemophilus influenzae,* 7 (8.0%)
- *Streptococcus milleri,* 2 (2.3%)

In contrast, the top order of the same selected common *(refer to page 23)* isolated microorganisms at the Chris Hani Baragwanath Hospital are:

- *Streptococcus milleri,* 41 (28.3%)
- *Staphylococcus aureus,* 19 (13.1%)
- *Haemophilus influenzae,* 13 (9.0%)
- *β*-haemolytic *streptococci,* 7 (4.8%)
- coagulase negative *staphylococcus,* 4 (2.8%)

The frequencies of isolation of *Streptococcus milleri* 41 (28.3%) and *Haemophilus influenzae* 13 (9.0%) were noted to be significantly higher ($p<0.05$) at the Chris Hani Baragwanath Hospital. The frequencies of isolation of *β*-haemolytic *streptococci* (group A, C, G and F) 18 (20.5%) and coagulase negative *staphylococcus* 13 (14.8%) are significantly higher ($p<0.05$) at the Johannesburg Hospital. The frequency of isolation of *Streptococcus milleri* 2 (2.3%) at the Johannesburg Hospital is low ($p<0.05$). The frequencies of *Staphylococcus aureus, Peptostreptococcus* and *Prevotella* species at the two hospitals showed no significant difference ($p>0.05$).

Ruoff (1988) pointed out that *Streptococcus milleri* has similar characteristics to the *β*-haemolytic *streptococci* (A, C, F and G) with which it is often mistaken to be. It is possible that this may partially explain the high frequency of *β*-haemolytic *streptococci* 18 (20.5%) coupled with the low frequency of *Streptococcus milleri* 2 (2.3%) seen at the Johannesburg Hospital (Table 19).

Children under the age of 16 years accounted for 40.6 % of the patients at the Johannesburg Hospital and 68.8% at the Chris Hani Baragwanath Hospital making the child to adult ratio 2:3 and 2:1 in the two hospitals respectively. The proportionally larger adult population of the Johannesburg Hospital would account for the higher occurrance of coagulase negative *staphylococci*. In a similar fashion, the higher proportion of children at Chris Hani Baragwanath Hospital would account for the significantly higher ($p<0.05$) occurrance of *Haemophilus influenzae* at this hospital.

Antibiotic Susceptibility and Resistance

Antibiotic susceptibility and resistance records were obtained for 129 patients. Susceptibility tests were not consistently reported for all common antibiotics and therefore significance levels of microorganism susceptibility and resistance to antibiotics were not tested in this study. With the results available certain trends were observed from which reasonable inferences could be made from specimen that contained single organisms.

Streptococcus milleri was found to be highly susceptible to penicillin, ampicillin and erythromycin. *Streptococcus milleri* is recorded as being sensitive to penicillin in 84% of tested cases (Table 20) with the remaining 16% being tested against cephalosporins. No penicillin resistance to *Streptococcus milleri* is reported in this study. Unfortunately this apparent benefit is offset by the fact that 18 of the 43 specimens that contained *Streptococcus milleri* were polymicrobial and contained penicillin resistant microorganisms in all cases (Table 21).

Penicillin, ampicillin and erythromycin were highly effective against *β*-haemolytic *streptococci*, *Streptococcus pneumoniae* and streptococcal species.

Cloxacillin was a highly effective agent against *Staphylococcus aureus* and coagulase negative staphylococci. Methicillin-resistant *Staphylococcus* was isolated in specimens from 2 children and 1 adult and was found to be susceptible to vancomycin.

Haemophilus influenzae was resistant to ampicillin in 2 of 9 cases in which it was the sole pathogen.

A simple count of the number of reported instances of antibiotic resistance was tabulated (Table 22). The penicillins, cotrimoxazole and the cephalosporins had the highest frequency. Snyman *et al* (1988) reported a similar trend and additionally pointed out that 100% of anaerobes were susceptible to metronidazole. In this study some anaerobes were found to be susceptible to clindamycin and no susceptibility testing to metronidazole was recorded.

CONCLUSION

Streptococcus milleri, Staphylococcus aureus, β-haemolytic *streptococci*, coagulase negative *staphylococci, Haemophilus influenzae* and the anaerobes, *Peptostreptococci* and *Prevotella* species, are important causative pathogens found in patients presenting with acute complicated bacterial sinusitis to the Witwatersrand ENT complex.

The frequent isolation of *Staphylococcus aureus*, coagulase negative *staphylococci* and anaerobes suggests acute exacerbation of chronic sinusitis to be a common presenting form of the disease.

Haemophilus influenzae appears to be a more important pathogen in children than in adults.

Streptococcus pneumoniae and *Moraxella catarrhalis* are not major pathogens in patients with acute complicated sinusitis at the University of the Witwatersrand ENT complex.

Initial antibiotic therapy, prior to obtaining culture and sensitivity results, should include antibiotics that cover:

- *Streptococcus milleri, β*-haemolytic *streptococci, Staphylococcus aureus,* coagulase negative *staphylococci* and anaerobes in children and adults
- *Haemophilus influenzae* especially in children

REFERENCES

Ali A, Kurien M, Mathews SS, Mathew J. Complications of infective rhinosinusitis: experience from a developing country. *Singapore Med J* **2005**; 46:540-544

Arjmand EM, Lusck RP, Muntz HR. Pediatric sinusitis and subperiosteal abscess formation: diagnosis and treatment. *Otolaryngol Head Neck Surg* **1993**; 109:886-894

Ball CN, Connor-Linton J. Web chi square calculator. www.georgetown.edu/faculty/ballc/webtools/web_chi.html Department of Linguistics, University of Georgetown **2007**

Brook I. Bacteriological features of chronic sinusitis in children. *JAMA* **1981**; 246:967-969

Brook I. Bacteriology of acute and chronic frontal sinusitis. *Arch Otolaryngol Head Neck Surg* **2002**; 128:583-585

Brook I. Discrepancies in the recovery of bacteria from multiple sinuses in acute and chronic sinusitis. *J Med Microbiol* **2004**; 53:879-885

Brook I, Frazier EH. Microbiology of recurrent acute rhinosinusitis. *Laryngoscope* **2004**, 114: 129-131 .

Brook I. Bacteriology of acute and chronic ethmoid sinusitis. *J Clin Microbiol* **2005**; 43 (7):3479-3480

Brook I. Microbiology of acute exacerbation of chronic sinusitis. *Ann Otol Rhinol Laryngol* **2005b**; 114:573-576

Brook I. Microbiology of intracranial abcesses and their associated sinusitis. Arch *Otolaryngol Head Neck* **2005c**; 131:1017-1019

Butler JC, Hofmann J, Cetron MS, Elliot JA, Facklam RR, Breiman RF. The continued emergence of drug-resistant Streptococcus pneumoniae in the United States: An update from the Centers for Disease Control and Prevention's Pneumococal Sentinel Surveillance System. *J Infect Dis* **1996**; 174:986-993

Chandler JR, Langenbrunner DJ, Stevens ER. The pathogenesis of orbital complications of sinusitis. *Laryngoscope* **1970**; 80:1414-1428

Clayman GL, Adams GL, Paugh DR *et al*. Intracranial complications of paranasal sinusitis: a combined institutional review. *Laryngoscope* **1991**; 101:234-239

Dowell SF, Schwartz B. Resistant pneumococci: protecting patients through judicious use of antibiotics. *Am Fam Physician* **1997**; 55:1647-1654

Frederick J, Braude AI. Anaerobic infection of the paranasal sinuses. *N Engl J Med* **1974**; 290:135-137

Gamble RC. Acute inflammation of the orbit in children. *Arch Ophthalmol* **1933**; 10:483-497

Gonzale R, Bartlett JG, Besser RE, Cooper RJ, Hickner JM, Hoffman JR, Sande MA. Princiles of appropriate antibiotic use for treatment of acute respiratory tract infections in adults: background, specific aims and methods. *Ann Intern Med* **2001**; 134:479-486

Gonzales R, Steiner JF, Sande MA. Antibiotic prescribing for adults with colds, upper respiratory tract infections and bronchitis by ambulatory care physicians. *JAMA* **1997**; 278:901-904

Hofmann J, Cetron MS, Farley MM, Baughman WS, Facklam RR, Elliot JA *et al*. The prevalence of drug resistant Streptococcus pneumoniae in Atlanta. *N Engl J Med* **1995**; 333:481-486

Hnatuk LAP. Macdonald RE, Papsin BC. Isolated sphenoid sinusitis: The Toronto Hospital for Sick Children experience and literature review. *J Otolaryngol* **1994**; 23:36-41

Jousimies-Somer HR, Savolainen S, Ylikoski JS. Bacteriological findings of acute maxillary sinusitis in young adults. *J Clin Microbiol* **1988**; 26:1919-1925

Kamau JK, Macharia IM, Odhiambo PA. Bacteriology of chronic maxillary sinusitis at Kenyatta National Hospital, Nairobi. *East Afr Med J* **2001**; 78(7):343-5

Kunin CM. Resistance to antimicrobial drugs – a worldwide calamity. *Ann Intern Med* **1993**; 118:557-561).

Lauer J. Acute community-acquired sinusitis: A review of epidemiology and management. *Infect Med* **2003**; 20(1):44-48

Mortimore S, Wormald PJ, Oliver S. Antibiotic choice in acute and complicated sinusitis. *J Laryngol Otol* **1998**; 112:264-268

Osguthorpe JD, Hochman M. Inflammatory sinus diseases affecting the orbit. *Otolaryngol Clin North Am* **1993**; 26:657-671

Oxford LE, McClay J. Complications of acute sinusitis in children. *Otolaryngol head neck Surg* **2005**; 133:32-37

Palm J, Lidman C, Graf P *et al*. Nitric oxide is reduced in patients with HIV. *Acta Otolaryngol* **2000**; 120:420-423

Penttilla M, Savolainen S, Kiukaannieme H, Forsblom B, Jousimies-Somer. Bacterial findings in acute maxillary sinusitis: European study. *Acta Otol (Stockh)* **1997**; supppl 529:165-168

Patt BS, Manning SC. Blindness resulting from the orbital complications of sinusitis. *Otolaryngol Head Neck Surg* **1991**; 104:789-795

Piccirillo JF, Acute rhinosinusitis: Staging, diagnosis/outcomes assessment. *Infect Med* **1998**; 15:16-25

Ramadan H. What is the bacteriology of chronic sinusitis in adults? *Am J Otolaryngol* **1995**; 16(5):303-306

Remmler D, Boles R. Intracranial complications of frontal sinusitis. *Laryngoscope* **1980**; 90:1814-1824

Rosenfeld EA, Rowley AH. Infectious intracranial complications of sinusitis, other than meningitis, in children: 12 year review. *Clin Infect Dis* **1994**; 18:750-4

Ruoff KL. Streptococcus anginosus (“Streptococcus milleri”): The unrecognized pathogen. *Clin Microbiol Rev* **1988**; 1:102-108

Schramm VL, Myers EN, Kennerdell JS. Orbital complications of acute sinusitis: evaluation, management and outcome. *Otolaryngol* **1978**; 86:221-230

Tellez I, Alba LMD, Reyes MG, Patton E, Hesles H dl G. Microbiology of acute sinusitis in Mexican patients. *Arch Med Res* **2006**; 37:395-398

Younis RT, Lazar RH, Anand VK. Intracranial complications of sinusitis: a 15-year review of 39 cases. *ENT J* **2002**; 81:636-644

Wald ER, Milmoe GJ, Bowen A'D, Ledesma-Medina J, Salamon N, Bluestone CD. Acute maxillary sinusitis in children. *N Eng J Med* **1981**; 304(13):749-754

Wald ER. Microbiology of acute and chronic sinusitis in children. *J Allery Clin Immunol* **1992**; 90:452-460

APPENDIX: I

Key:

C: Coronation Hospital

J: Johannesburg General Hospital

B: Chris Hani Baragwanath Hospital

HJ: Helen Joseph Hospital

NPRF: No postoperative results found

UNFILTERED RAW DATA								
Hospital	**Month**	**Year**	**Gender**	**Age**	**Hospital Reference**	**Neurosurgery**	**Aerobic Organisms**	**Anaerobic Organisms**
B	1	2002	F	10	GT08914876	No	HISTOLOGY	
J	10	2002	M	17	GT00003915	Yes	coagulase negative staphylococcus, Streptococcus group C	
J	11	2002	F	44	GP00009426	No	NO BACTERIAL GROWTH	
B	1	2002	M	15	GT08657938	No	NO BACTERIAL GROWTH	
B	6	2002	M	17	GT08822814	No	HISTOLOGY	
B	6	2002	M	21	GT08856416	No	HISTOLOGY	
B	7	2002	F	10	GT08860806	No	HISTOLOGY	
HJ	10	2002	M	20	030882	No	NPRF	
B	8	2002	M	17	GT08858541	No	HISTOLOGY	
B	8	2002	M	12	GT08875047	No	HISTOLOGY	
B	1	2002	M	8	GT08910260	No	HISTOLOGY	
J	11	2002	F	8	GT00020680	No	NO BACTERIAL GROWTH	
J	10	2002	M	0	GT00049171	No	NPRF	
J	4	2002	F	21	2775626	No	Staphylococcus aureus	
B	9	2002	F	19	GT08867395	No	HISTOLOGY	
J	1	2002	M	0	2751127	No	NPRF	
J	3	2002	M	18	2761871	No	Klebsiella oxytoca, Streptococcus viridans	
B	8	2002	F	15	GT08627226	No	HISTOLOGY	
J	3	2002	F	37	2767157	No	NPRF	
J	10	2002	M	37	GT00012416	No	Streptococcus group G, Staphylococcus aureus, Corybacterium species	
J	6	2002	M	28	2784384	Yes	NPRF	
J	7	2002	M	16	2793646	No	Streptococcus group F	
J	7	2002	F	47	2751363	No	NO BACTERIAL GROWTH	
J	10	2002	M	17	GT00003915	No	Coagulase negative staphylococcus, Streptococcus group C	
J	10	2002	F	0	GT00	No	NPRF	
J	3	2002	M	28	2763946	No	NPRF	
J	2	2003	M	29	GT00077876	No	NO BACTERIAL GROWTH	
J	3	2003	F	18	GT00089475	No	coagulase negative staphylococcus	
J	3	2003	M	37	GT00029674	No	NO BACTERIAL GROWTH	
J	9	2003	M	71	GP00018553	No	NPRF	
J	9	2003	F	14	GT00148482	No	NO BACTERIAL GROWTH	
J	3	2003	F	12	GT00025216	No	Streptococcus pyogenes	
J	8	2003	M	14	GT00106321	No	Streptococcus species	
B	3	2003	F	15	GT08961344	Yes	HISTOLOGY	
J	3	2003	F	18	GT00089475	No	coagulase negative staphylococcus	
J	4	2003	F	45	GP00009426	No	NO BACTERIAL GROWTH	
J	4	2003	M	15	GT00097286	No	Streptococcus pyogenes	
J	7	2003	M	24	GT00123929	No	NPRF	
J	7	2003	F	17	GT08990866	No	Coagulase negative staphylococcus, Streptococcus viridans	Prevotella species
J	7	2003	F	15	GT00054156	No	Streptococcus species	

UNFILTERED RAW DATA								
Hospital	Month	Year	Gender	Age	Hospital Reference	Neurosurgery	Aerobic Organisms	Anaerobic Organisms
J	7	2003	M	12	GT00125602	No	NPRF	
J	10	2003	M	39	GT00012575	No	coagulase negative staphylococcus	
J	7	2003	M	15	GT00125340	No	NO BACTERIAL GROWTH	
J	7	2003	M	17	GT08990866	Yes	NPRF	
B	1	2003	M	33	GP08658493	No	HISTOLOGY	
J	7	2003	M	16	GT00125240	No	Haemophilus influenzae, coagulase negative staphylococcus	
J	7	2003	M	13	GT00129313	No	SPECIMEN REJECTED	
J	8	2003	M	14	GT00106321	No	Streptococcus species	
J	9	2003	M	14	GT00141667	Yes	Streptococcus species	
J	7	2003	M	15	GT00125340	No	NO BACTERIAL GROWTH	
HJ	3	2003	M	15	271188	No	NPRF	
B	5	2003	M	62	GT08983219	No	HISTOLOGY	
HJ	1	2003	M	16	010886	No	NPRF	
HJ	9	2003	M	20	241283	No	NPRF	
J	7	2003	M	8	GT00113240	No	Streptococcus species	
B	1	2003	F	3	GT08928276	No	Streptococcus pyogenes	
B	12	2003	F	10	GT09053907	No	HISTOLOGY	
B	7	2003	M	3	GT09001956	No	HISTOLOGY	
B	9	2003	F	13	GT09026403	No	HISTOLOGY	
B	9	2003	F	8	GT09020126	No	HISTOLOGY	
B	8	2003	M	17	GT09016846	No	HISTOLOGY	
B	8	2003	F	13	GT08780380	No	Streptococcus group C	Peptostreptococcus species
B	10	2003	M	26	GP08687086	No	HISTOLOGY	
B	3	2004	F	24	GT08996351	No	HISTOLOGY	
J	12	2004	M	10	GT00268996	No	Haemophillus influenzae, Stapylococcus aureus, beta lactamase negative	
J	11	2004	M	11	GT00259464	Yes	Streptococcus Group F	
J	9	2004	M	10	GT00244914	No		Peptostreptococcus species, Propionbacterium species
J	8	2004	F	14	GT00234630	No	NPRF	
J	8	2004	M	11	GT00231140	No	NPRF	
J	7	2004	M	9	GT00228635	No	Streptococcus Group F	
J	9	2004	M	19	GT00243578	No	Streptococcus Group C	
J	7	2004	F	43	GT00128608	No	Streptococcus pyogenes	
B	5	2004	F	8	GT09107687	No	HISTOLOGY	
B	10	2004	M	16	GT09172159	No	HISTOLOGY	
J	8	2004	M	17	GT00235918	No	NO BACTERIAL GROWTH	
J	8	2004	M	19	GT00243578	No	Streptococcus Group C	
B	9	2004	F	52	GP54157505	No	HISTOLOGY	
B	9	2004	M	13	GT09144632	No	Haemophilus influenzae	
J	8	2004	M	17	GT00235918	No	NO BACTERIAL GROWTH	
J	7	2004	M	24	GT00161104	No	coagulase negative staphylococcus	Peptostreptococcus anaerobius
J	5	2004	M	9	GT00216036	No	Hameophillus influenzae, Streptococcus species	
J	7	2004	M	20	GT00226693	No	Staphylococcus species	
J	5	2004	F	3	GT00206092	No	Bacteroides species	
J	7	2004	M	17	GT00235198	No	NPRF	
B	11	2004	F	16	GT09175830	No	HISTOLOGY	
B	11	2004	M	8	GT08910260	No	HISTOLOGY	
B	7	2004	M	7	GT09134118	No	HISTOLOGY	
J	6	2004	M	12	GT00219151	Yes	Haemophillus influenzae	
J	6	2004	F	0	GT00	No	NPRF	
HJ	9	2004	M	30	120174	No	NPRF	
J	5	2004	M	14	GT00214135	No	NO BACTERIAL GROWTH	
J	9	2004	F	13	GT00238098	No	NO BACTERIAL GROWTH	
J	7	2004	F	3	GT00224779	No	NPRF	
B	2	2004	M	6	GT08725154	No	HISTOLOGY	
J	11	2004	F	9	GT00208012	No	Streptococcus group F	

UNFILTERED RAW DATA								
Hospital	Month	Year	Gender	Age	Hospital Reference	Neurosurgery	Aerobic Organisms	Anaerobic Organisms
B	2	2004	F	23	GT09038493	No	HISTOLOGY	
B	12	2004	M	12	GT09192082	Yes	HISTOLOGY	
B	9	2005	M	12	GT09293475	No	Corynebacterium species	
J	8	2005	F	12	GT00337247	No	NO BACTERIAL GROWTH	
J	8	2005	F	10	GT00334021	No	NO BACTERIAL GROWTH	
J	7	2005	M	14	GT00326841	No	Streptococcus viridans	
J	7	2005	M	10	GT00301802	No	NO BACTERIAL GROWTH	
J	7	2005	M	15	GT00318117	No	coagulase negative staphylococci	
J	4	2005	M	8	GT00300502	No	NO BACTERIAL GROWTH	
J	4	2005	F	9	GT00300360	No	Haemophillus influenzae	
B	8	2005	M	12	GT09286809	Yes	Streptococcus milleri, Streptococcus viridans, Haemophillus influenzae	Photobacter species
J	9	2005	F	9	GT00337188	No	Streptococcus Group F	
B	8	2005	M	15	GT09287250	No	Streptococcus milleri	
J	10	2005	M	12	GT00138399	No	NO BACTERIAL GROWTH	
B	9	2005	M	15	GT09292518	No	NO BACTERIAL GROWTH	
B	9	2005	M	18	GT09295919	No	Klebsiella species, Streptococcus milleri	
B	10	2005	M	14	GT09307936	No	Staphylococcus aureus	
B	10	2005	M	13	GT09136246	Yes	Streptococcus viridans	
B	11	2005	M	9	GT09308983	No	Streptococcus milleri	
B	8	2005	F	29	GP54203998	No	NO BACTERIAL GROWTH	
B	8	2005	M	14	GT09281958	Yes	NO BACTERIAL GROWTH	
B	7	2005	M	15	GT09263662	Yes	HISTOLOGY	
B	7	2005	M	14	GT09266162	No	NO BACTERIAL GROWTH	
B	7	2005	F	13	GT09271118	Yes	Eikenella corrodens	
B	7	2005	M	12	GT09272486	Yes	Streptococcus milleri	
B	8	2005	M	6	GT08683711	No	NO BACTERIAL GROWTH	
B	8	2005	F	12	GT09280111	No	NO BACTERIAL GROWTH	
B	8	2005	M	15	GT09280044	No	Streptococcus milleri	
J	9	2005	M	13	GT00340696	No	Staphylococcus aureus	
B	7	2005	M	13	GT09273903	Yes	Streptococcus milleri	
B	11	2005	M	7	GT09316900	No	Streptococcus milleri	
B	8	2005	M	16	GT09285409	No		Prevotella species
J	7	2005	M	18	GT00325227	Yes	Streptococcus pyogenes	
J	7	2005	M	16	GT00324065	Yes	Streptococcus group C	
J	7	2005	M	17	GT00328963	Yes	NO BACTERIAL GROWTH	
J	12	2005	F	7	GT00362462	No	NO BACTERIAL GROWTH	
J	10	2005	F	9	GT00352367	No	NO BACTERIAL GROWTH	
B	12	2005	F	30	GT09233906	No	Escherichia coli, Staphylococcus aureus, Enterobacter faecalis	
J	9	2005	F	9	GT00342541	No	Streptococcus species	
B	7	2005	M	14	GT09273764	Yes	Streptococcus milleri	Peptostreptococcus species
J	6	2005	F	22	GT00315641	No	Streptococcus milleri	
B	11	2005	M	7	GP08776376	No	Staphylococcus aureus	
J	12	2005	F	31	GT00295842	No	NPRF	
J	11	2005	F	42	GP08659576	No	NPRF	
J	10	2005	M	9	GT00347272	No	Streptococcus species	Fusobacterium species
J	9	2005	M	23	GT00345279	No	NO BACTERIAL GROWTH	
J	8	2005	M	19	GT08990866	No	Streptococcus species	
J	7	2005	F	48	GT00328283	No	NPRF	
J	2	2005	M	8	GT00284835	No	NPRF	
J	10	2005	M	39	GT00345236	No	Staphylococcus aureus	
J	2	2005	M	13	GT00279643	No	NO BACTERIAL GROWTH	
J	5	2005	F	22	GT00312150	No	Staphylococcus aureus	
J	5	2005	M	32	GT00301382	No		Peptostreptococcus anaerobius
J	4	2005	M	48	GT00294653	No	Candida glabrata	Sacchromyces cerevisiae
J	4	2005	M	18	GT00296803	No	NO BACTERIAL GROWTH	
J	4	2005	M	16	GT00294075	No	NO BACTERIAL GROWTH	
J	2	2005	M	16	GT00280429	No		Peptostreptococcus anaerobius

UNFILTERED RAW DATA								
Hospital	**Month**	**Year**	**Gender**	**Age**	**Hospital Reference**	**Neurosurgery**	**Aerobic Organisms**	**Anaerobic Organisms**
J	1	2005	M	32	GT00277450	No	Staphylococcus species	
J	1	2005	M	30	GT00273338	No	Corynebacterium species	
J	4	2005	F	0	GT00707	No	INCOMPLETE INFORMATION	
B	12	2005	F	13	GT09323240	No	Streptococcus milleri, Staphylococcus aureus	
B	12	2005	F	21	GT09320305	No	MRSA	
J	3	2005	M	9	GT00290281	No	Staphylococcus aureus	Peptostreptococcus anaerobius
J	3	2005	F		GT00286552	No	NPRF	
J	2	2005	M	13	GT00282005	No	Staphylococcus aureus	
J	2	2005	M	9	GT00280113	No	NO BACTERIAL GROWTH	
J	1	2005	M	12	GT00275098	No	NO BACTERIAL GROWTH	
J	1	2005	M	13	GT00274341	No	NO BACTERIAL GROWTH	
B	6	2005	F	11	GT09257914	No	Streptococcus milleri	Acinetobacter baumanii
B	12	2005	M	10	GT09323020	Yes	Streptococcus milleri	Peptostreptococcus species
J	12	2005	F	37	GT00363992	No	NPRF	
B	12	2005	M	13	GT09328157	No	NO BACTERIAL GROWTH	
B	12	2005	F	8	GT09328296	No	Staphylococcus aureus, Streptococcus pneumoniae	
B	7	2005	M	16	GT09273228	No	Streptococcus milleri	
J	4	2005	M	39	GT00293563	No	Streptococcus viridans	
J	2	2005	F	37	GT00240840	No	NPRF	
J	2	2005	M	28	GT00280611	No	NPRF	
J	1	2005	M	34	GT00276209	No	NPRF	
J	1	2005	M	12	GT00275175	No	NPRF	
J	1	2005	M	8	GT00272180	No	NO BACTERIAL GROWTH	
B	8	2005	M	14	GT09277028	No	Haemophillus species, Streptococcus pneumonie	
B	6	2005	M	17	GT09260003	Yes	Streptococcus milleri, Streptococcus viridans	Prevotella species
B	6	2005	M	10	GT09262108	Yes	Streptococcus milleri	
J	2	2005	M	17	GT00153011	No	Staphylococcus aureus	
B	6	2005	M	12	GT09260397	Yes	Coagulase negative staphylococcus	Peptostreptococcus species
B	1	2005	F	13	GT54284363	Yes	NPRF	
B	6	2005	M	10	GT09262108	Yes	Streptococcus milleri	
B	8	2005	M	13	GT09255063	Yes		Peptostreptococcus species,Prevotella species
HJ	3	2005	M	28	010186	No	NPRF	
HJ	6	2005	M	18		No	NPRF	
J	12	2005	M	11	GT00360829	No	Haemophillus parainfluenzae	
J	5	2005	M	17	GT00399640	No	Streptococcus group C	
B	2	2005	M	8	GT09214991	No	Staphylococcus aureus	
B	2	2005	M	10	GT09180627	No	Streptococcus pneumoniae	
B	4	2005	M	15	GT09237430	No	NO BACTERIAL GROWTH	
B	6	2005	F	10	GT09259309	No	Streptococcus milleri	
B	3	2005	F	8	GT09222799	No	Haemophilus influenzae, Streptococcus milleri	
B	6	2005	F	31	GP08753659	No	Staphylococcus aureus	
B	2	2005	F	46	GT09209286	No	Klebsiella ozaenae	
B	6	2005	M	15	GT09251701	No	NO BACTERIAL GROWTH	
B	5	2005	M	14	GT09251635	No	Streptococcus pneumoniae, Haemophilus influenzae	
B	6	2005	M	4	GT09257919	No	Streptococcus pneumonie	
B	3	2005	M	4	GT09219375	No	Haemophillus influenzae, Moraxella catarrhalis	
HJ	8	2005	M	15	121190	No	NPRF	
B	8	2005	F	24	GT08732936	No	Pseudomonas aeruginosa, Staphylococcus aureus	
B	5	2005	M	24	GT09250952	No	Haemophilus influenzae, Proteus mirabilis	
B	5	2005	M	24	GP08751432	No	Streptococcus milleri, coagulase negative staphylococci	Peptostreptococcus species

UNFILTERED RAW DATA								
Hospital	Month	Year	Gender	Age	Hospital Reference	Neurosurgery	Aerobic Organisms	Anaerobic Organisms
B	5	2005	F	5	GT09240510	No	Haemophilus influenzae	
B	9	2006	M	7	GT54246749	No	Streptococcus viridans	Peptostreptococcus species
B	7	2006	M	7	GT09418294	No	Streptococcus milleri	
B	9	2006	F	8	GT09443628	No	Streptococcus group F	
B	11	2006	M	8	GT25378030	Yes	Streptococcus group C, Staphylococcus aureus	Prevotella species
B	9	2006	F	13	GT09440553	No	Streptococcus milleri (anginosus)	
B	8	2006	M	13	GT09436737	No	Streptococcus milleri (anginosus)	Prevotella species
B	8	2006	M	17	GT09437713	No	Streptococcus milleri	
B	8	2006	M	8	GT09436213	No	Streptococcus milleri	
B	9	2006	M	10	GT09442662	No	NO BACTERIAL GROWTH	
J	5	2006	F	3	GT00395518	No	NPRF	
B	8	2006	F	19	GT09433392	Yes	NO BACTERIAL GROWTH	
B	8	2006	M	16	GT09432955	No	coagulase negative staphylococcus, Streptococcus viridans	
B	8	2006	M	21	GP25412996	No	NO BACTERIAL GROWTH	
B	7	2006	M	12	GT09420090	No	NO BACTERIAL GROWTH	
B	7	2006	M	12	GT09423660	No	Streptococcus milleri	
B	6	2006	M	12	GT54346960	Yes	Streptococcus milleri, Eikenella corrodens	
B	10	2006	F	11	GT09465082	No	NPRF	
B	7	2006	F	10	GT09421852	No	Staphylococcus aureus	
B	7	2006	M	9	GT09421257	No	Streptococcus pneumoniae	
B	7	2006	M	18	GT09428490	No	Streptococcus milleri	
B	1	2006	M	14	GT09331056	Yes	Streptococcus species, Haemophillus influenzae	Prevotella species
B	6	2006	M	14	GT9410530	No	Enterobacter cloacae	
B	12	2006	M	10	GT09477335	No	Streptococcus group C	Peptostreptococcus species
B	11	2006	M	27	GT09467884	No	NO BACTERIAL GROWTH	
B	11	2006	F	44	GP08642734	No	NPRF	
B	11	2006	M	19	GT09469691	Yes	Citrobacter koserii, Klebsiella oxytoca, Staphylococcus aureus	
B	11	2006	M	9	GT09463490	No	Haemophillus influenzae	
B	11	2006	M	6	GT09463881	No	Staphylococcus aureus, Streptococcus viridans, Eikenella corrodens	
J	6	2006	F	19	GT00407066	No	Corynebacterium species	
B	10	2006	M	25	GT09450744	No	Streptococcus milleri	
B	7	2006	M	17	GT09420841	No	Streptococcus milleri, Escherichia coli	
B	6	2006	F	11	GT00263410	Yes	Streptococcus milleri	Prevotella species, Peptostreptococcus species
B	1	2006	F	54	GT09327387	No	Haemophillus influenzae	
B	1	2006	F	26	GT09333130	No	Streptococcus pyogenes	
B	1	2006	F	16	GT09335254	No	Streptococcus milleri	
B	1	2006	F	15	GT09336425	No	NO BACTERIAL GROWTH	
B	2	2006	F	23	GT09344703	No	Staphylococcus aureus	
B	6	2006	M	15	GT25680372	Yes	Streptococcus milleri, coagulase negative staphylococcus	
B	8	2006	F	20	GP08811240	Yes	Streptococcus milleri, coagulase negative staphylococcus, Klebsiella species	
B	8	2006	M	11	GT09436667	Yes	Streptococcus group C	Prevotella species
B	11	2006	M	8	GT25378030	Yes	NPRF	
B	10	2006	M	13	GT09453243	No	NPRF	
J	1	2006	F	1	GT00370305	No	NO BACTERIAL GROWTH	
B	4	2006	M	16	GT0932287	Yes	NO BACTERIAL GROWTH	
B	4	2006	M	43	GP08660768	No	NO BACTERIAL GROWTH	
B	4	2006	F	39	GP08792920	No	NO BACTERIAL GROWTH	
B	3	2006	F	74	GT00032207	No	Streptococcus milleri	
B	3	2006	M	14	GT09378327	Yes	Streptococcus milleri, MRSA	

UNFILTERED RAW DATA								
Hospital	Month	Year	Gender	Age	Hospital Reference	Neurosurgery	Aerobic Organisms	Anaerobic Organisms
B	2	2006	M	16	GT09364209	No	NO BACTERIAL GROWTH	
B	2	2006	M	30	GP08786445	No	Streptococcus milleri	
B	2	2006	M	10	GT09345756	Yes	Haemophillus influenzae, Staphylococcus aureus	
J	9	2006	M	16	GT00427174	No	coagulase negative staphylococci	
J	11	2006	M	5	GT00441951	No	Staphylococcus aureus	
B	3	2006	M	14	GT09378327	Yes	MRSA	
J	5	2006	M	17	GT00399640	No	Streptococcus Group C	
J	6	2006	M	30	GT00407562	No	Streptococcus species, Klebsiella species	
B	4	2006	M	15	GT09395638	Yes	NO BACTERIAL GROWTH	
J	3	2006	F	3	GT00340474	No	coagulase negative staphylococci	
J	3	2006	M	13	GT00381531	No	NO BACTERIAL GROWTH	
J	6	2006	M	17	GT00403292	No	NO BACTERIAL GROWTH	
J	6	2006	M	10	GT00403025	Yes	Streptococcus milleri	
J	6	2006	M	18	GT00406043	No	coagulase negative staphylococci, Streptococcus group C	
J	7	2006	M	18	GT00411633	No	coagulase negative staphylococcus	
HJ	9	2006	M	41	150666	No	NPRF	
HJ	5	2006	F	30	250275	No	NPRF	
HJ	3	2006	F	15	230491	No	NPRF	
C	2	2006	M	13	030692	No	coagulase negative staphylococcus	
C	10	2006	F	6	310500	No	NO BACTERIAL GROWTH	
J	8	2006	M	4	GT00422022	No	NO BACTERIAL GROWTH	
B	6	2006	M	20	GT09410519	No	Streptococcus milleri	
B	7	2006	M	21	GP25412996	No	NO BACTERIAL GROWTH	
B	7	2006	M	17	GP08805735	No	Klebsiella species	
J	1	2006	M	18	GT00369293	No	Straphylococcus species, Enterococcus durans	
J	2	2006	F	46	GT00373558	No	Yeast-like organisms	
J	3	2006	F	20	GT00386563	No	Haemophilus influenzae	
J	6	2006	M	17	GT00403292	No	Streptococcus species, Lactobacillus species	
J	6	2006	M	30	GT00407562	No	Haemophillus influenzae	
B	6	2006	M	8	GT08750760	No	Staphylococcus aureus	
B	6	2006	M	7	GT09412724	No	NO BACTERIAL GROWTH	
B	6	2006	F	19	GT09411501	No	Staphylococcus aureus	
B	4	2006	F	15	GT08907215	No	Haemophillus influenzae	
B	6	2006	M	14	GT09410530	No	Enterobacteracea cloacae	
B	4	2006	F	23	GT09395317	No	NO BACTERIAL GROWTH	
B	6	2006	F	10	GT09607133	Yes	NO BACTERIAL GROWTH	
B	6	2006	M	15	GT09408339	Yes	Streptococcus milleri	
J	1	2006	M	68	GT00367659	No	NPRF	
J	1	2006	F			No	INCOMPETE INFORMATION	
B	6	2006	F	28	GT09407869	No		Prevotella species, Peptostreptococcus species
B	5	2006	M	12	GT09407142	No	Staphylococcus aureus	
B	5	2006	M	15	GT09405292	No	Streptococcus milleri, Eikenella corrodens	
B	5	2006	M	12	GT25566364	No	Haemophillus influenzae, Staphylococcus aureus	Prevotella species
B	5	2006	M	16	GT09401597	No	Streptococcus milleri	
B	5	2006	F	10	GT09399932	No	Staphylococcus aureus, Streptococcus milleri	
B	5	2006	F	3	GT09397543	No	NO BACTERIAL GROWTH	
B	7	2006	M	12	GT09420090	No	NO BACTERIAL GROWTH	
B	6	2006	M	14	GT08706651	No	Haemophillus parainfluenza, coagulase negative staphylococci	Prevotella species
B	8	2008	M	10	GT09431814	No	NO BACTERIAL GROWTH	

APPENDIX: II

ANTIBIOTIC SUSCEPTIBILITY AND RESISTANCE RECORDS							
Hospital	**Month**	**Year**	**Hospital Reference**	**Susceptibility**	**Resistance**	**Penicillin Resistance**	**Number of isolates**
J	7	2002	2793646	Penicillin, Ampicillin, Erythromycin		No	1
J	10	2002	GT00003915	Co-amoxiclav, Rifampicin, Vancomycin, Fucidic acid	Penicillin, Ampicillin, Erythromycin, Cloxacillin	Yes	2
J	10	2002	GT00003915	Cotrimoxazole, Rifampicin, Vancomycin, Fucidic acid	Penicillin, Ampicillin, Erythromycin, Cloxacillin	Yes	2
J	4	2002	2775626	Cloxacillin, erythromycin, clindamycin, cotrimoxazole	Penicillin, Ampicillin	Yes	1
J	3	2002	2761871	Co-amoxiclav, cefzolin, cephalexin, gentamicin, cotrimxazole	Penicillin, Ampicillin	Yes	2
J	10	2002	GT00012416		Penicillin, Ampicillin	Yes	3
J	4	2003	GT00097286	Penicillin, Ampicillin, Erythromycin		No	1
J	8	2003	GT00106321	Penicillin, Ampicillin, Erythromycin, Tetracycline		No	1
J	7	2003	GT00125240	Ampicillin		No	2
J	7	2003	GT00113240	Penicillin, Ampicillin, Erythromycin	Tetracycline	No	1
J	7	2003	GT00054156			No	1
J	7	2003	GT08990866	Ceftriaxone, Cefotaxime, Erythromycin, Vancomycin	Penicillin, Ampicillin, Tetracycline	Yes	3
J	3	2003	GT00025216	Penicillin, Ampicillin, Erythromycin, Vancomycin		No	1
J	8	2003	GT00106321	Penicillin, Ampicillin, Erythromycin, Tetracycline		No	1
J	11	2004	GT00208012	Penicillin, Ampicillin, Erythromycin		No	1
J	7	2004	GT00228635	Penicillin, Ampicillin, Erythromycin		No	1
J	9	2004	GT00243578	Peniclillin, Ampicillin, Cefuroxime, Cefotaxime		No	1
J	7	2004	GT00128608	Penicillin, Ampicillin, Erythromycin		No	1
J	8	2004	GT00243578	Penicillin, Ampicillin, Ceftriaxone, Cefotaxime		No	1
J	6	2004	GT00219151	Ampicillin		No	1
J	9	2004	GT00244914	Penicillin, Ampicillin, Erythromycin		No	2
J	5	2004	GT00216036	Ampicillin		No	2
J	7	2004	GT00161104	Cloxacillin, Erythromycin, Cefotaxime, Rifampicin, Vancomycin, Fucidicacid	Penicillin, Ampicillin	Yes	2
B	9	2004	GT09144632	Ampicillin, Cotrimoxazole, Cefuroxime, Tetracycline		No	1
B	5	2005	GT09240510	Co-amoxiclav, Cefotaxime, Ceftriaxone		No	1
J	6	2005	GT00315641	Penicillin, Ampicillin, Erythromycin, Clindamycin		Yes	1
J	10	2005	GT00345236	Cloxacillin, Erythromycin, Clindamycin, Cotrimoxazole	Peniclillin, Ampicillin	Yes	1
J	3	2005	GT00290281	Cloxacillin, Erythromycin, Clindamycin, Cotrimoxazole	Penicillin, Ampicillin	Yes	2
B	6	2005	GT09262108	Penicillin, Ampicillin, Erythromycin		No	1
B	2	2005	GT09180627	Penicillin, Ampicillin, Erythromycin, Cotrimoxazole, Chloramphenicol, Clindamycin, Tetracycline		No	1
J	7	2005	GT00326841	Vancomycin, Linezolid	Penicillin, Ampicillin, Erythromycin, Clindamycin	Yes	1
B	7	2005	GT09273764	Penicillin		No	2
B	7	2005	GT09272486	Penicillin		No	1
J	4	2005	GT00293563	Cefotaxime, Ceftriaxone		No	1
B	7	2005	GT09273903	Penicillin		No	1
B	3	2005	GT09222799	Penicillin, Ampicillin, Erythromycin, Cefuroxime		No	2
B	7	2005	GT09273228	Penicillin		No	1
B	6	2005	GT09260003	Penicillin		No	3
B	5	2005	GP08751432	Penicillin, Ampicillin, Erythromycin, Clindamycin, Cefotaxime, Ceftriaxone		No	3

ANTIBIOTIC SUSCEPTIBILITY AND RESISTANCE RECORDS							
Hospital	**Month**	**Year**	**Hospital Reference**	**Susceptibility**	**Resistance**	**Penicillin Resistance**	**Number of isolates**
B	8	2005	GT09277028	Penicillin, Ampicillin		No	2
B	5	2005	GT09250952	Ampicillin, Cotrimoxazole		No	2
B	8	2005	GT08732936	Cloxacillin, Cotrimxazole, Ceftazidime, Amikacin, Cefepime		Yes	2
B	3	2005	GT09219375	Ampicillin, Cotrimoxazole		No	2
B	5	2005	GT09251635	Penicillin, Ampicillin, Erythromycin, Cotrimoxazole, Co-amoxiclav		No	2
J	12	2005	GT00360829	Ampicillin, Tetracycline, Cefuroxime	Cotrimoxazole	No	1
J	5	2005	GT00399640	Penicillin, Ampicillin, Erythromycin		No	1
J	2	2005	GT00282005	Cloxacillin, Cotrimoxazole	Penicillin, Ampicillin, Erythromycin	Yes	1
B	2	2005	GT09209286	Ampicillin, Co-amoxiclav, Olfoxacin, Ciprofloxacin, Gentamicin, Amikacin, Cefzolin, Cephalexin		No	1
B	6	2005	GT09262108	Penicillin, Ampicillin, Erythromycin		No	1
B	12	2005	GT09323240	Penicillin, Cloxacillin		No	2
B	2	2005	GT09214991	Cloxacillin, Clindamycin, Cotrimoxazole, Erythromycin		No	1
B	8	2005	GT09280044	Penicillin		No	1
B	8	2005	GT09286809	Penicillin, Ampicillin		No	4
B	8	2005	GT09287250	Penicillin		No	1
B	9	2005	GT09295919	Co-amoxiclav, Cefuroxime, Gentamicin, Penicillin	Ampicillin, Amoxycillin	Yes	2
B	10	2005	GT09307936	Cloxacillin, Erythromycin, Clindamycin	Penicillin, Ampicillin	Yes	1
B	11	2005	GT09308983	Penicillin, Ampicillin, Erythromycin, Cefotaxime, Ceftriaxone		No	1
B	11	2005	GT09316900	Penicillin		No	1
B	11	2005	GP08776376	Cloxacillin, Erythromycin, Clindamycin	Penicillin, Ampicillin	Yes	1
B	12	2005	GT09320305	Vancomycin	Cloxacillin, Penicillin, Ampicillin, Ertythromycin, Clindamycin, Cotrimoxazole, Rifampicin, Gentamicin	Yes	1
J	5	2005	GT00312150	Cloxacillin, Erythromycin, Clindamycin, Cotrimoxazole	Peniclillin, Ampicillin	Yes	1
B	12	2005	GT09323020	Penicillin		No	2
B	12	2005	GT09328296	Penicillin, Cloxacillin		No	2
J	9	2005	GT00337188	Penicillin, Ampicillin	Tetracycline	No	1
J	9	2005	GT00340696	Cloxacillin, Erythromycin, Clindamycin, Cotrimoxazole	Penicillin, Ampicillin	Yes	1
J	4	2005	GT00300360	Cefuroxime	Ampicillin, Cotrimoxazole, Chloramphenicol	Yes	1
J	7	2005	GT00324065	Penicillin, Ampicillin		No	1
J	7	2005	GT00325227	Penicillin, Ampicillin, Erythromycin		No	1
B	6	2005	GT09257914	Penicillin, Imipenem, Meropenem		No	2
B	6	2005	GT09259309	Penicillin, Ampicillin, Erythromycin		No	1
B	6	2005	GT09257919	Penicillin		No	1
B	6	2005	GP08753659	Cloxacillin	Penicillin, Ampicillin	Yes	1
J	2	2005	GT00153011	Cloxacillin, Erythromycin, Cotrimoxazole	Penicillin, Ampicillin, Ofloxacin, Ci[rofloxacin	Yes	1
B	12	2005	GT09233906	Piperacillin, Ceftraxone, Gentamicin, Penicillin, Cloxacillin		No	3
J	3	2006	GT00386563	Ampicillin	Cotrimoxazole	No	1
J	5	2006	GT00399640	Penicillin, Ampicillin, Erythromycin		No	1
J	1	2006	GT00369293	Linezolid, Vancomycin	Cloxacillin, Ampicillin, Erythromycin, Clindamycin, Cotrimoxazole	Yes	2
B	6	2006	GT54346960	Penicillin, Ampicillin, Erythromycin		No	2
B	6	2006	GT00263410	Penicillin		No	3
B	8	2006	GT09436667	Penicillin, Ampicillin, Erythromycin		No	1
B	8	2006	GP08811240	Penicillin, Ceftriaxone, Cefotaxime, Ertapenem, Meropenem, Gentamicin,	Ampicillin, Amoxiil, Cefazol, Cephalex,	Yes	3

ANTIBIOTIC SUSCEPTIBILITY AND RESISTANCE RECORDS							
Hospital	**Month**	**Year**	**Hospital Reference**	**Susceptibility**	**Resistance**	**Penicillin Resistance**	**Number of isolates**
				Imipenem	Piperacillin-Tazobactam, Cefotaxime, Ceftriaxone, Ceftazidime, Coamoxiclav, Cotrimoxazole, Amikacin, Tobramycin		
B	6	2006	GT25680372	Penicillin, Ampicillin, Erythromycin		No	2
B	2	2006	GT09344703	Cloxacillin		Yes	1
B	1	2006	GT09335254	Penicillin		No	1
B	1	2006	GT09333130	Penicillin		No	1
B	1	2006	GT09327387	Ampicillin		No	1
B	1	2006	GT09331056	Penicillin, Ampicillin		No	3
J	6	2006	GT00407562	Ampicillin, Cefuroxime	Cotrimoxazole	No	1
B	8	2006	GT09436737	Cefotaxime, Ceftiaxone		No	2
B	7	2006	GT09420841	Penicillin, Ampicillin, Clindamycin; Cefotaxime, Ceftriaxone		No	2
B	7	2006	GT09421257		Penicillin	Yes	1
B	7	2006	GT09421852	Cloxacillin, Erythromycin, Clindamycin, Cotrimoxazole	Penicillin, Ampicillin	Yes	1
B	7	2006	GT09423660	Penicillin, Ampicillin, Cefotaxime, Ceftriaxone		No	1
B	7	2006	GT09428490	Penicillin, Ampicillin, Cefotaxime, Ceftriaxone		No	1
B	8	2006	GT09432955	Cefotaxime, Ceftiaxone		No	2
B	7	2006	GT09418294	Cefotaxime, Ceftiaxone		No	1
C	2	2006	030692	Cloxacillin, Erythromycin, Clindamycin, Cotrimoxazole, Gentamicin	Penicillin, Ampicillin	Yes	1
B	8	2006	GT09437713	Cefotaxime, Ceftiaxone		Yes	1
B	6	2006	GT09411501	Cloxacillin, Cotrimoxazole	Penicillin, Ampicillin	Yes	1
B	9	2006	GT09440553	Penicillin, Ampicillin, Erythromycin		No	1
B	9	2006	GT54246749	Cefotaxime, Ceftiaxone		No	2
B	9	2006	GT09443628	Penicillin, Ampicillin, Cefotaxime, Ceftiaxone		No	1
B	10	2006	GT09450744	Penicillin, Ampicillin		No	1
B	11	2006	GT09463490	Ampicillin, Cotrimoxazole, Cefuroxime		No	1
B	11	2006	GT09469691	Cotrimoxazole, Cloxacillin, Erythromycin, Clindamycin, Cefotaxime, Ceftriaxone, Ciprofloxacin, Co-amoxiclav, Gentamicin	Amoxycillin, Penicillin, Ampicillin	Yes	3
B	12	2006	GT09477335	Penicillin, Ampicillin, Erythromycin		No	2
B	6	2006	GT9410530	Ciprofloxacin, Cefepime, Amikacin, Ertapenem, Gentamicin	Ampicillin, Amoxycillin, Cefazolin, Cefuroxime, Cephalexin, Ceftraxone, Cefotaxime, Piperacillin-Tazobactam	Yes	1
B	8	2006	GT09436213	Cefotaxime, Ceftiaxone		No	1
B	5	2006	GT09401597	Cefotaxime, Ceftriaxone		No	1
B	3	2006	GT09378327	Vancomycin	Cloxacillin, Penicillin, Ampicillin, Erythomycin, Clindamycin, Cotrimoxazole	Yes	1
J	6	2006	GT00407562	Penicillin, Ampicillin, Erythromycin, Cloxacillin		No	2
B	11	2006	GT25378030	Penicillin, Ampicillin, Erythromycin, Cloxacillin, Clindamycin	Penicillin, Ampicillin	Yes	2
J	11	2006	GT00441951	Erythromycin, Cotrimoxazole, Cloxacillin, Chloramphenicol, Clindamycin	Penicillin, Ampicillin	Yes	1
B	2	2006	GT09345756	Ampicillin, Cloxacillin		No	2
B	2	2006	GP08786445	Penicillin		No	1
B	3	2006	GT09378327	Penicillin, Vancomycin, Fucidic acid		No	2
B	3	2006	GT00032207	Penicillin		No	1
B	7	2006	GP08805735	Cefuroxime, Co-amoxiclav, Gentamicin, Cotrimoxazole	Ampicillin, Amoxycillin	Yes	1

ANTIBIOTIC SUSCEPTIBILITY AND RESISTANCE RECORDS							
Hospital	**Month**	**Year**	**Hospital Reference**	**Susceptibility**	**Resistance**	**Penicillin Resistance**	**Number of isolates**
B	5	2006	GT09399932	Penicillin, Ampicillin, Erythromycin, Cloxacillin, Clindamycin	Penicillin, Ampicillin	Yes	2
B	6	2006	GT08750760	Penicillin		No	1
B	5	2006	GT25566364	Cloxacillin, Clindamycin, Cotrimoxazole, Ampicillin	Penicillin, Ampicillin	Yes	3
B	5	2006	GT09405292	Penicillin, Ampicillin		No	2
B	5	2006	GT09407142	Cloxacillin		No	1
B	6	2006	GT09408339	Penicillin, Ampicillin, Cefotaxime, Ceftriaxone		No	1
B	6	2006	GT09410519	Penicillin, Ampicillin, Erythromycin		No	1
B	6	2006	GT09410530	Etrapenem, Ciprofloxacin, Gentamicin, Amikacin	Co-amoxiclav, Cefazolin, Cefalexin, Ampicillin, Amoxycillin, Cefuroxime, Ceftriaxone, Pip-Taz	Yes	1
B	6	2006	GT08706651	Ampicillin, Vancomycin, Cefuroxime	Cloxacillin	No	3
J	6	2006	GT00403025	Penicillin, Ampicillin, Erythromycin, Clindamycin		No	1
B	4	2006	GT08907215	Co-amoxiclav, Tetracycline, Cefotaxime, Cetriaxone	Ampicillin, Cotrimoxazole	Yes	1