Bacterial Contamination of Stethoscopes of Anaesthetists in the Department of Anaesthesiology.

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of

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i

Declaration

I, Fatimah B.E. Lambat declare that this research report is my own work. It is being submitted for the degree of Masters of Medicine in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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Dedication

I dedicate this piece of work to my father, Ebrahim Lambat, my mother, Khadijha Lambat for their endless support.

To my husband, Ridwaan Sirkhot for his emotional and computer support.

To my brother in law, Ozeyr Ahmed and my sister, Safiyya Lambat for the hours spent in proofreading my work.

I acknowledge and thank my supervisors, Helen Perrie, Juan Scribante and Warren Lowman who have spent a tremendous amount of time assessing my work.

Abstract

Background

South Africa has a huge burden of infectious diseases as many patients are immunocompromised and are at an increased risk for infection. An almost unnoticed piece of equipment possibly harbouring pathogens is the stethoscope. Alcohol swabs are readily available and have been shown to effectively reduce the growth of micro-organisms on stethoscopes.

Methods

Data was collected from 26 anaesthetists and their stethoscopes in the Department of Anaesthesiology at two academic hospitals in Johannesburg. Two samples were taken from each stethoscope. Group A was assigned to the stethoscope samples that were taken prior to disinfecting the stethoscope with a 70% isopropyl alcohol swab and Group B was assigned to the stethoscope samples that were taken after disinfecting of the stethoscope. Anaesthetists were then asked about their frequency of cleaning the stethoscopes.

Results

In Group A 19 (73%) stethoscopes grew micro-organisms. Micro-organisms were identified on three stethoscopes in Group A. Two stethoscopes grew coagulase-negative staphylococcus (CNS) and one stethoscope grew *Staphylococcus aureus.* In Group B, 5 (19.2%) cultured micro-organisms. The only micro-organism identified in this group was CNS. The results showed that most anaesthetists even if infrequently disinfected their stethoscopes.

Conclusion

This study demonstrated the contamination of stethoscope diaphragms in the Department of Anaesthesiology and the effectiveness of disinfecting the stethoscope with a 70% isopropyl alcohol swab. Most of the anaesthetists reported disinfecting their stethoscopes.

Table of contents

List of figures

Figure

List of tables

Section 1: Literature Review

1.1 Introduction

In this section the literature regarding a brief history of stethoscopes, patient safety initiatives, incidence and impact of nosocomial infections, transmission of nosocomial infections, guidelines on disinfectant policies and the different types of disinfectants will be reviewed. It will also include reviews on the different studies dealing with the growth of pathogens on stethoscopes and the effect of cleaning the stethoscope with different agents. The disease profile of the common micro-organisms that were found will also be delineated.

1.2 History of stethoscopes

In the early 1800s, Rene Laennac (1781 to 1826), a French physician, firmly believed in placing the ear directly over the chest to listen to the sounds of the heart and lung. This was found to be an awkward procedure especially in female patients. He subsequently experimented with a towel that he rolled like a tube and found that he could listen to the chest sounds. Later he made a wooden monoaural stethoscope with one tube and one earpiece. (1)

In 1851, the bi-aural stethoscope was developed and this was only adopted in the 1900s due to uncertainty by some doctors. At present the stethoscope is an essential instrument that is used on a daily basis for auscultation but may also be a potential vector of infection. (1)

1.3 Patient safety initiative

Patient safety is becoming a growing concern globally. The World Health Organisation (WHO) has stated; "healthcare associated infections (HCAI) are a major problem for patient safety and it must be a first priority for settings and institutions committed to making health care safer." (2)

In October 2004, a World Alliance of Patient Safety (WAPS) was formed by WHO secondary to the growing concern of the increasing number of nosocomial infections (3). WHO has established that research is the building block in dealing with patient safety. However, research in developing countries is minimal.

The African Partnerships for Patient Safety (APSS) is a framework that is part of the WAPS. It is a four step process setting the platform for the improvement of patient safety in the African regions. The development of a partnership between the European and African hospitals was the first step. The second step in the APSS revolves around gathering data and information to assess the situation around patient safety in Africa, which is currently in progress. WHO has encouraged research which will be used to ensure universal reduction in patient harm. The next two steps will focus on the implementation of guidelines and sustainability. (4)

The Global Patient Safety Challenge is a core programme developed in the WAPS and it involves campaigns in which guidelines are formulated to ensure patient safety globally. The three campaigns to date are the "Clean Care is Safer Care", "Safe Surgery Saves Lives" and "Tackling Antimicrobial Research". The aims of these campaigns are to acknowledge universally that infection control is an essential component of patient safety and to provide guidelines in each campaign. (4) Disinfecting the stethoscope will aid in better infection control.

1.4 Incidence and impact of nosocomial infections

In developed countries, nosocomial infections affect 5 to 15% of all hospitalised patients and 9 to 27% of patients admitted to ICU (2). A prevalence survey in four regions by WHO (Europe, Eastern Mediterranean, South-East Asia and Western Pacific) showed that 8.7% of patients develop nosocomial infections (5). An estimated five million nosocomial infections occurs annually in the acute care hospitals in Europe and this contributes to approximately 135 000 deaths per year. This increases the economic burden substantially with an approximate 25 million extra days stay in hospital. The expenditure was calculated to be an estimated 13 to 24 billion pounds. (2)

Developing countries have a paucity of surveillance data with regard to nosocomial infections. The most frequent surveyed infections in developing countries are surgical site infections. The risk of patients developing surgical site infections in these countries is considerably higher than those in developed countries. Examples of these are seen in Africa and demonstrate a risk of 30.9% in a paediatric hospital in Nigeria, 23% in a general surgery hospital in Tanzania and 19% in a maternity unit in Kenya. (2)

A study done in 55 ICU's in developing countries in South America that 22.5 per 1000 patients develop device associated infections (6). Brazil has reported that nosocomial infections cause approximately 45 000 deaths per year (7). This emphasises the significance of ensuring appropriate cleaning and sterilisation of equipment.

Nosocomial infections are a significant cause of morbidity and mortality in South Africa, where there is a huge burden of immunocompromised patients (8). However, surveillance data regarding nosocomial infections in South Africa is not standardised and thus minimal data can be found (9).

Paruk et al (10) conducted the "Prevalence of Infection in South African Intensive Care Units" study which reviewed antibiotic practices in public and private sector ICUs in South Africa. One of the components in this study evaluated 248 patient records. During this period it was found that 27.8% of patients had evidence of sepsis. Of these 86.1% were nosocomial infections and 13.9% were community acquired infections. (10) This study emphasizes the incidence of nosocomial infections in South Africa.

The high incidence of nosocomial infections has many consequences. There is an increased burden to the country's global costs whether it is direct (costs to the hospital) or indirect (decreased productivity of work) (11). In the United States of America (USA) it was shown that nosocomial infections increased the economic expenditure to 6.5 billion dollars in 2004 (2).This poses a great burden especially in a resource limited country such as South Africa. These infections can also cause permanent disability and can impact on the patients' quality of life. (5) Transmissions of nosocomial infections which are preventable occur in hospitals on a daily basis. The mode of transmission will be further discussed below.

1.5 Transmission of nosocomial infections

Brink et al. (9) were invited by the South African Thoracic Society (SATS) to develop guidelines for the management of nosocomial infections. In these guidelines they have detailed the following different modes of nosocomial transmission.

- Contact spread is defined as direct physical contact from one patient to another or from the health care worker to the patient. A subgroup of this includes indirect contact which involves contact with inanimate objects such as stethoscopes, blood pressure cuffs, thermometers etc.
- Droplet spread includes spread of pathogens larger than five microns. These are spread during sneezing, coughing, talking or respiratory procedures.

- Airborne spread is defined as spread of pathogens smaller than five microns which are also spread through sneezing, coughing, talking or respiratory procedures. (9)

Healthcare workers move around between patients and thus the risk of contact spread can be anticipated. Hands, clothing and stethoscopes, among others, are potential vectors carrying a host of micro-organisms that can then be transferred through contact with the patients. (12) It is for this reason that guidelines have been formulated to improve disinfection practices.

1.6 Guidelines on the management of disinfectants and equipment

Over 30 years ago Spaulding had developed a clear approach to the disinfection and sterilisation of patient care equipment. He believed that a classification system could be easily understood and would improve patient care. The Centre for Disease Control and Prevention (CDC) has subsequently elaborated on this classification. (13) Items can be classified as follows.

- **Critical items:** These instruments enter vascular or sterile tissue compartments. The critical items must be sterilised as these compartments have a high risk of infection as contamination with all micro-organisms can occur. Critical items should either be purchased as sterile or be sterilised in a steamer.
- **Semicritical items:** Semicritical items come into contact with mucous membranes or nonintact skin. It is imperative that they must be free from all types of micro-organisms. Low levels of bacterial spores are, however, allowed. Semicritical items can be disinfected minimally with a high level disinfectant. High level disinfection is defined as disinfectants that will completely eradicate all bacteria except for a small number of bacterial spores.
- **Noncritical items:** These items come into contact with intact skin which is an effective barrier to micro-organisms. They can be further subdivided as

"noncritical patient care items" and "noncritical environmental surfaces". Some of the "noncritical patient care items" include stethoscopes, thermometers, blood pressure cuffs, crutches and bedpans. Some of the environmental noncritical items include linen, bed rails, furniture and the floor. These areas are frequently touched by hands and thus can transfer micro-organisms between patients and other surfaces. Low level disinfectants can be used to clean this type of equipment. (13) Low level disinfection is defined as disinfectant that can kill most bacteria, fungi and viruses. However, it does not destroy bacterial spores (5).

Brink et al. (9) have stated in their guidelines that standard precautions such as hands washing, decontamination of linen as well as disinfecting patient care items should be carried out appropriately. These precautions coupled with the appropriate use of antibiotics can be an effective way of reducing the high incidence of nosocomial infections. (9)

1.7 Disinfectants

The South African Society of Anaesthesiologists drafted guidelines for infection control in anaesthesiology in South Africa. There are no specific guidelines for disinfecting stethoscopes. However, in these guidelines they outline the classification of disinfection. Disinfection can be categorised as high level disinfection, intermediate level disinfection and low level disinfection which will be explained below. (14)

1.7.1 High level disinfectants

High level disinfectants destroy all micro-organisms including bacterial spores. High level disinfectants include products containing glutaraldehyde and peracetic acid. (14, 15)

Glutaraldehyde

Glutaraldehyde has been used for more than 30 years for sterilisation and as a high level disinfectant. It is a potent bactericidal agent and is non-corrosive to metals, plastics and rubbers. The concentrations range from 2.4% to 3.4%. (15)

It is used as a cold sterilant, a biocide in oil and gas pipelines, in balming solutions and in the preparation of grafts and bioprosthesis. In the healthcare industry it is an effective disinfectant against equipment that cannot be heat sterilised e.g. dialysis instruments, surgical instruments, suction bottles, bronchoscopes, endoscopes, and ear, nose and throat instruments. Examples of glutaraldehyde solutions include Cidex ®, Cidex Plus ® and Cidex OPA ®. (16, 17)

Cidex ® is a 2.4% alkaline glutaraldehyde solution and destroys all micro-organisms including bacterial spores in 45 minutes at 25˚C. It is effective for sterilisation of a variety of medical equipment. (17)

Cidex Plus ® is a 3.4% glutaraldehyde solution and is a high level disinfectant at 25˚C. Instruments should be soaked for 20 minutes. (17)

Cidex OPA® contains 0.55% of ortho-phthaldehyde. It destroys micro-organisms in 12 minutes at 20˚C. The advantage of this over the others is that it does not require any mixing or activation. (17)

Peracetic acid

Peracetic acid belongs to the peryoxygen compounds. It is only used in the USA for the automated STERIS SYSTEM 1. The STERIS SYSTEM 1 is a liquid sterilising system that is approved by the FDA for sterilisation of medical devices. It is effective against all micro-organisms including bacterial spores at concentrations of 0.2%. (15)

1.7.2 Intermediate level disinfectants

Intermediate level disinfectants destroy mycobacteria, vegetative bacteria, most viruses and fungi. However, they will not destroy bacterial spores. Some examples of these include alcohols such as 70% isopropyl alcohol, iodophor and phenolic compounds, concentrated quaternary ammonium compounds, e.g. hospital cleaners and disinfectants with a tuberculocidal claim. Alcohols are the most commonly used intermediate level disinfectants and will be further elaborated on below. (14)

Alcohols

Alcohols used for disinfection refers to two water-soluble chemical compounds; ethyl alcohol and isopropyl alcohol. Any substance containing alcohol as the main ingredient has not been approved by the Food and Drug Administration (FDA) for high level disinfectants. They are, nevertheless, effective as intermediate level disinfectants. They are effective bactericidal compounds especially against vegetative forms of bacteria such as *Tuberculosis.* Bacterial spores are, however, not destroyed by alcohol. (13)

Early studies in the 1930s examined the effectiveness of ethyl alcohol against various micro-organisms. The exposure period to the alcohol was between 10 seconds and one hour. *P. aeruginosa* was killed in 10 seconds by 30% to 100% ethanol concentrations whereas *E.coli, Serratia marcenes* and *Salmonella typhosa* were destroyed in 40% to 100% concentrations of alcohol. The gram-positive micro-organisms were more resistant and required concentrations of 60% to 95% alcohol to be killed in 10 seconds. Isopropyl alcohol was more efficacious than ethyl alcohol against *E.coli* and *S. aureus* as seen in another study cited by the CDC. (13)

Ethyl alcohol (60% to 80%) is a potent virucidal agent. It can inactivate all lipophilic (e.g. herpes and influenza virus) and hydrophilic viruses (e.g. adenovirus, enterovirus, rhinovirus and rotavirus). Ethyl alcohol is also effective in inactivating the human immunodeficiency virus (HIV). Isopropyl alcohol is effective against

lipid viruses but not fully active against nonlipid viruses. It has been demonstrated to inactivate hepatitis B virus (HBV) and the herpes virus in studies cited by the CDC. (13)

These alcohols are not recommended for sterilisation of high level items, however, they can be effective in disinfecting non-critical instruments and environmental surfaces where a tuberculocidal agent is required. (14)

1.7.3 Low level disinfectants

Low level disinfectants destroy vegetative bacteria, lipid or medium-sized viruses and fungal spores. These include diluted quaternary ammonium compounds, e.g. hospital cleaners and disinfectants which does not require a tuberculocidal agent. (14)

1.8 Evidence and types of pathogenic micro-organisms cultured on stethoscopes and effect of cleaning

Several studies have shown that stethoscopes are potential vectors of infection (7, 18-21). Some of the micro-organisms have shown resistance to commonly used antibiotics (7, 21, 22). This will be further discussed below.

In 1972, Gerken et al. (21), sampled 100 stethoscopes from various departments in a London teaching hospital. The objectives to the study were to identify organism growth on the various stethoscopes and to test the resistance to various antibiotics. Table 1.1 shows the results of the study.

Table 1.1 Coagulase-positive staphylococcus infection on stethoscopes related to sites and owners (21).

	Total sampled	Coagulase-positive staphylococci (%)
Open general wards	36	17
Wards divided into cubicles	29	31
Ultra-clean unit	12	0
Operating theatres	4	25
Doctors and medical students	19	26

It can be seen from Table 1.1 that the growth of coagulase-positive organisms ranged from 0 to 26%. The ultra-clean unit had not been defined in the study but was the only unit showing no micro-organism growth. Defining this unit might have given an idea of the cleaning techniques that result in no organism growth. All the other stethoscopes produced pathogenic micro-organism growth. (21)

Sensitivity of the micro-organisms to various antibiotics was tested. Of the coagulase-positive staphylococci 24% were sensitive to all antibiotics, 33% were resistant to penicillin only and 43% were resistant to two or more antibiotics. (21) This was one of the many studies that found both micro-organism growth on stethoscopes and resistance of these micro-organisms to various antibiotics.

Mangi et al. (23) published an article in 1972 which reviewed stethoscopes sampled from the Yale-New Haven Hospital. In this study the researchers collected 60 stethoscopes and divided them into two groups; 50 stethoscopes to determine organism growth and another 10 stethoscopes in which they determined organism growth after cleaning with a 70% isopropyl alcohol swab. Samples were taken from stethoscopes of residents, interns, ICU nurses, wards nurses and bedside stethoscopes of the faculty actively engaged in patient care. Table 1.2 shows a summary of the distribution of growth on the different groups of stethoscopes.

Table 1.2 Distributions of micro-organism growth between the different groups (23).

	Interns	Residents	Faculty	ICU nurses	Ward nurses	Total	Stethoscopes cleaned
Total number of stethoscopes	10	10	10	10	10	50	10
Stethoscopes with bacterial growth	10	10	10	9	10	49	3
Stethoscopes with potential pathogenic bacteria	2	5	1	3	2	13	0

It is shown in Table 1.2 that 49 out of the 50 stethoscopes that were not cleaned grew bacteria and 13 of these grew potential pathogenic bacteria. In the ICU, 9 out of the 10 stethoscopes grew bacteria and three stethoscopes grew potential pathogens. This is concerning especially in an environment with critically ill patients. The stethoscopes that had been swabbed with 70% isopropyl alcohol swabs showed a decrease in growth of micro-organisms with no pathogenic bacterial growth. (23)

Micro-organisms that were grown included gram-positive and gram-negative bacteria, molds and yeasts. A total of 15 pathogenic micro-organisms were grown on these stethoscopes which included a count of six *S. aureus,* two *E. coli* and a count of one isolate each for *Erwinia, Serratia, Klebsiella, Proteus vulgaris (Proteus mirabilis), Enterobacter A, Enterobacter B* and *P. aeruginosa.* These pathogenic micro-organisms indicates asymptomatic carrier states which can lead to possible infections of immunocompromised patients. (23)

In Israel, the paediatric division of the Assaf Harofeh Medical Centre swabbed 43 stethoscopes belonging to senior physicians, residents, interns and medical students. The doctors worked in general paediatric wards, the paediatric ICU, the

neonatal ICU and the paediatric emergency wards. Micro-organisms were grown on 85.7% of stethoscopes. (19) Table 1.3 shows the distribution of micro-organism growth between the different health professionals' stethoscopes.

Table 1.3 Results of bacterial cultures in different sectors of health professionals (19)

	Number of samples	Positive cultures (n) (%)	Main pathogens (n)
Medical students	8	5 (62%)	CNS (2) Bacillus spp. (2) *Micrococcus* (2)
Interns	7	6 (85%)	CNS (7) Bacillus spp. (4) *Micrococcus* (3) *E. coli (*2) MRSA (1)
Residents	15	14 (93%)	CNS (7) Bacillus spp. (4) *Micrococcus* (9) *P. aeruginosa* (1) *E. coli* (2) *A. baumanii* (1)
Seniors	13	12 (92%)	CNS (5) Bacillus spp. (6) *Micrococcus* (8) *P. aeruginosa* (1)

Table 1.4 separates these stethoscopes between the different wards in which these doctors worked.

Table 1.4 Results of different bacterial cultures in different wards (19)

	Number of samples	Positive cultures (%)	Main Pathogens
Paediatric general ward	24	21 (88%)	CNS (8) Bacillus spp. (7) *Micrococcus* (14) *P. aeruginosa* (1) *E. coli* (1)
Paediatric ICU	6	5 (83%)	CNS (2) Bacillus spp.(2) *Micrococcus* (4) *E. coli* (1) *P. aeruginosa* (1)
Neonatal ICU	7	6 (86%)	CNS (2) Bacillus spp. (1) *Micrococcus* (4) *A. Baumanii* (1)
Paediatric emergency care ward	6	5 (83%)	CNS (4) Bacillus spp. (3) MRSA (1)

All the stethoscopes showed micro-organism growth. The growth of gram-negative micro-organisms is perturbing especially in the setting of ICU. It was found that at the time of the study there was an outbreak of *A. baumanii* in the neonatal ICU with two cases of *A. baumanii* bacteraemia. (19) One can appreciate the evidence that stethoscopes are potential vectors of organism growth and can be a source of infection especially in susceptible patients.

In India a study conducted in a tertiary level hospital in Tamilnadu over a one year period from 2002 to 2003 included 40 stethoscopes and 60 pagers. These belonged to doctors from various disciplines namely; medicine, surgery, obstetrics and gynaecology and child health. From the 40 stethoscopes 11 (27.5%) grew micro-organisms and 15 (25%) of the 60 pagers grew micro-organisms. The gram-positive bacteria that grew included *Enterococcus faecalis (E.faecalis.), Enterococcus faecium (E. faecium),* other enterococci and *S. aureus.* The gram-negative bacteria that grew included Enterobacter spp*., K. pneumonia, E. coli and A. baumanii.* It can be seen that any equipment being handled in the hospital can grow potentially lethal micro-organisms emphasising the importance of compliance to sterilising and cleaning methods. (20)

A prospective, double blinded study at a tertiary hospital with a bed strength of 1800 in India was done over a period of one year. Samples were taken from 100 stethoscopes used by medical personnel from the paediatric wards, paediatric ICU, medicine wards and gynaecology and obstetrics wards. The researchers swabbed these stethoscopes pre-cleaning (Group A). Group A was then cleaned with a 66% isopropyl alcohol swab and then reswabbed for culture (Group B). A third sample of culture swabs were taken after five days with instructions to the medical personnel to use their stethoscopes as they usually would (Group C). Group C was then cleaned with a 66% isopropyl alcohol swab and swabbed for culture (Group D). (18)

Group A showed 90% of stethoscopes grew micro-organisms and this decreased to 28% after cleaning in Group B. Group C demonstrated organism growth on 95% of the stethoscopes and growth in Group D decreased to 28% of the stethoscopes. (18)

The difference between the departments was statistically insignificant (p>0.05). In the paediatric unit 25 stethoscopes from the ward and 15 stethoscopes from the ICU were assessed. Twenty four (96%) stethoscopes harboured micro-organisms from the paediatric ward and 100% of the stethoscopes from the paediatric ICU grew micro-organisms. From the medicine wards 40 stethoscopes were assessed and of these 33 grew micro-organisms. The gynaecology and obstetrics ward cultured micro-organisms on 18 of the 20 stethoscopes that were swabbed. (18)

Micro-organism growth on stethoscopes is shown to be prevalent across different departments. Cleaning stethoscopes with 66% isopropyl alcohol swabs are shown to be effective in reducing micro-organisms. It is a practical, feasible and inexpensive method of cleaning. (18)

In Conjunto Hospitalar de Sorocobar, a tertiary care hospital in Brazil, a study was carried out which included 300 stethoscopes. These stethoscopes were taken from medical residents, medical students, nurses and nursing students. Other sectors of the hospital were also included but were not described by the researchers. In this study it was found that 87% of these stethoscopes were contaminated. Furthermore, 96% of the contaminated stethoscopes showed more than one isolate of micro-organisms. A mixture of pathogenic and non-pathogenic micro-organisms were cultured. These included; coagulase-negative staphylococcus, *S. aureus*, *Sarcina*, Bacillus spp., Acinetobacter spp*., Pseudomonas putida*, *Klebsiella pneumonia*, Streptococcus spp*.* and yeasts. (7)

The second part of the study was to determine the sensitivity of selected micro-organisms to commonly used antibiotics. *S. aureus* showed a sensitivity rate of 6.5%, 5.6% and 100% to ampicillin, penicillin and vancomycin respectively. *Streptococcus spp.* showed a sensitivity of 0%, 1% and 7% to ampicillin, penicillin and vancomycin respectively. The author concluded that the increased use of these drugs secondary to the increase in nosocomial infections causes a simultaneous rise in the resistance to the antibiotics which is of concern. These resistant micro-organisms are being transmitted through contact spread. (7)

In 2009, Whittington et al (22) investigated the practices of stethoscope cleaning in a London ICU. The ICU's protocol was to clean the bedside stethoscope at the beginning of each shift. The researchers aimed to answer the following questions:

- what the current cleaning practices of the stethoscopes were?
- what the level of bacterial contamination was?
- what the impact of the current user decontamination practice was?

Included in the study were 24 ICU nurses (with bedside stethoscopes), 10 doctors, nine physiotherapists, two medical students and one nurse. The other 22 healthcare professionals had personal stethoscopes. (22)

Collection of specimens took place on two separate days, three months apart. First a questionnaire was handed out to the nurses and other healthcare professionals on both the study days to assess the current cleaning practices. Swabs were then taken from the bedside and personal stethoscope diaphragms and ear pieces. The healthcare professionals were then asked to clean the stethoscopes according to their current practice and these stethoscopes were then swabbed for culture. (22)

Two questionnaires from the 24 ICU nurses were not accounted for in the study. Of the 22 reported questionnaires which were answered by the nurses, 20 claimed to have cleaned the stethoscopes after every use and two said that they cleaned the stethoscopes daily.

The cleaning practices of the doctors were diverse with three claiming to clean it after every use; one cleaning it weekly; three cleaning their stethoscopes monthly; one cleaned the stethoscope twice a year and two said that they had never cleaned their stethoscopes. Both the medical students cleaned their stethoscopes monthly while all nine physiotherapists cleaned their stethoscopes after every use. The nurse with the personal stethoscope cleaned it after every use. (22)

Isopropyl alcohol swabs were the preferred method of cleaning by 29 out of the 46 health care professionals. Eight said that they applied alcohol gel that was

designed for hand washing and one used soap and water for cleaning. The other seven healthcare professionals used the detergent wipes that were used for cleaning equipment such as trolleys. It would have been useful to compare organism growth between the different cleaning times and methods, however this study did not assess this. The cleaning method of one healthcare professional was not accounted for in the study. (22)

Cultures found that 70% of ICU bedside stethoscope diaphragms and ear pieces were colonised and 97% of personal stethoscope diaphragms and ear pieces were colonised. Of the ICU bedside stethoscopes diaphragms and ear pieces, 21% grew pathogenic micro-organism whereas 19% of the personal stethoscope diaphragms and ear pieces grew pathogenic micro-organisms. The pathogenic bacteria that they had found pre-cleaning consisted of MRSA, *Acinetobacter iwoffi (A. iwoffi)*, *A. baumanii*, *S. aureus*, *Enterobacter cloacae*, *Stenotrophomonas maltophilia* and *Pseudomonas luteola*. (22)

Eighteen (75%) bedside and seven (31.8%) personal stethoscope diaphragms and ear pieces had no micro-organism growth post cleaning. From the bedside and personal stethoscope diaphragms, 33% had no micro-organism growth after cleaning and only four percent grew pathogenic micro-organisms after cleaning. The remainder of the stethoscopes grew skin flora. Ten (21.7%) ear pieces had no micro-organism growth and three (6.5%) ear pieces grew pathogenic micro-organisms. (22)

The researchers had also tested for resistance of the micro-organisms to certain antibiotics. Pathogenic bacteria grown on both the ICU bedside and personal stethoscopes were multidrug resistant. MRSA was found on seven stethoscope diaphragms and three earpieces of the bedside and personal stethoscopes. These were sensitive to vancomycin and teicoplanin only. *S. aureus* was found on 22 personal stethoscope diaphragms and two earpieces and showed sensitivity to methicillins but resistance to penicillins. The *A. baumanii* found on the personal stethoscopes were multidrug resistant and only sensitive to the polymyxins. The 24 isolates of *A.* baumanii found on the ICU bedside stethoscopes were panresistant and only sensitive to colistin. (22)

A single, double blinded study was conducted by Schroeder et al. (24) in a community-based hospital and a satellite family health centre in Pittsburgh. Samples were taken from 92 stethoscopes. In this study they simultaneously washed their hands and stethoscope diaphragms in a 62.5% ethyl alcohol based foam. Two samples were taken; a pre-wash sample and a post-wash sample. (24)

Both the pre-wash and post-wash samples showed a skewed distribution to the right. This implies that there was organism growth on most of the stethoscopes during both stages. Although data was skewed, the researchers had calculated a mean of both the pre-wash and post-wash samples. The pre-wash showed a mean of 28.4 (CI: 20.2-36.6) and the post-wash sample showed a mean of 3.2 of contaminated stethoscopes (CI: 1.8-4.6; P<0.01). (24)

Two hundred and six isolates were found on the stethoscopes pre-washing and these consisted of; 100 CNS, 51 *Bacilli,* 24 *Microccocci,* 17 non-fermenting gram-negative bacteria, 3 MRSA*,* 2 of each coagulase-positive staphylococci, *Lactobacilli,* and *Pseudomonas.* One isolate each of *Acinetobacter*, *Enterobacter*, *Klebsiella* and *Streptococcus* was found. The bacteria that grew on the post-wash sample was not specified in the study. The authors concluded that cleaning the stethoscope while simultaneously washing hands with an alcohol-based foam reduces organism growth significantly. (24)

A study was done in Nigeria between January 2010 and April 2011 at the Ebonyi State University Teaching hospital. The aim of the study was to assess if disinfection of stethoscopes with a 70% isopropyl alcohol swab was effective. This study was a follow up to a pilot study that was done between August 2007 and May 2008. The pilot study found a micro-organism contamination rate of 78.5%. (25)

The researchers first arranged workshops to train 202 medical personnel about disinfection of stethoscopes. The trained medical personnel carried out these disinfection practices and were assessed by an interviewer. The researcher requested 89 stethoscopes for micro-organism sampling. All 89 health workers disinfected their stethoscopes after every patient. A micro-organism contamination rate of 20.2% was reported. A reduction of 58.3% of micro-organisms was seen post-disinfection. (25)

In a tertiary care hospital in the Department of Microbiology in India, 50 stethoscope diaphragms and bells were sampled for micro-organism growth pre-disinfection. The researchers then randomly selected 20 stethoscopes for disinfection with a 70% isopropyl alcohol swab. These stethoscopes were sampled for micro-organism growth. (26)

Fifty two isolates of micro-organisms were identified on the 50 stethoscopes pre-disinfection. These included; *CNS* (77%), *Acinetobacter* (5%), *S.aureus* (5%), *Bacillus* (4%), *Aspergillus fumigatus* (4%), *Pseudomonas stutzeri* (2%) and *Citrobacter kasseri* (2%). (26) The identification of these pathogenic micro-organisms in a tertiary care institute is concerning.

From the 20 stethoscopes that were disinfected only 3 (15%) stethoscopes grew micro-organisms. The identity of the micro-organisms on these stethoscopes was not specified in the study. (26) This demonstrates the effectiveness of a 70% isopropyl alcohol swab.

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1.9 Description of gram-positive and gram-negative micro-organisms

1.9.1 Gram-positive micro-organisms

S. aureus and MRSA

S. aureus is a gram-positive cocci and causes a host of community acquired and nosocomial infections (27). In the USA, it was shown from the reviews of the National Nosocomial Infections surveillance data that MRSA was increasing by approximately 3% each year from the years 1992 to 2003 (28). A prevalence study done in one of the tertiary hospitals in Gaborone showed that the incidence of *S. aureus* and MRSA were 25.3% and 11.2% respectively (29).

S. aureus is found in the nasal passages and skin of individuals. Nasal passages of 52 patients were swabbed in KwaZulu Natal. They had found that 25% of the patients carried *S. aureus*. Of these 85% had MRSA growing in their nasal passages. (30)

S. aureus causes a host of infections which can be suppurative (pus-forming) or toxic. These can manifest as a variety of diseases, namely; superficial lesions such as a furuncle, boil etc. and more serious infections such as pneumonia, meningitis, osteomyelitis, toxic shock syndrome and endocarditis. It is a major cause of nosocomial infections. (27)

MRSA has developed after the repeated use of penicillins. It is a strain of *S. aureus* that is resistant to methicillins and has cross resistance with many other antibiotics. (27)

It occurs among the immunocompromised patients and patients who have undergone invasive medical procedures. It may be frequently transferred from one patient to the other through contact spread. (27)

MRSA can cause severe illnesses such as pneumonia, septicaemia and surgical site infections. This causes significant morbidity and mortality in hospitilised patients. (27)

1.9.2 Gram- negative micro-organisms

Enterobactericiae

Enterobactericiae is a large family consisting of up to 100 species of anaerobic gram-negative bacilli. The following Enterobactericiae will be discussed:
- *K. pneumoniae*
- *E. coli*
- *Enterobacter*

K. pneumoniae

K. pneumoniae is a gram-negative bacteria that belongs to the Enterobactericiae spp*.* It is mentioned separately due to the spectrum and severity of diseases that it causes. It is the second most common gram-negative pathogen. It causes significant .Wen-Chien Ko et al (31) found that 32% of pneumonias were caused by *K*.pneumonia in South Africa (31)Patients who are at most risk for these infections include; ill patients on ventilators, patients with intravenous lines or those that are on a long course of antibiotics. (32)

They normally colonise the intestines and are found in stool. They do not cause disease in healthy patients, however in immunocompromised patients they can cause severe disease. *K. pneumoniae* may cause severe illnesses such as pneumonia, urinary tract infections, meningitis, thrombophlebitis, endotoxin shock syndrome, septicaemia, lung abscesses and a variety of other diseases as cited by Montgomery. (33)

E. coli

E. coli is a gram-negative organism belonging to the genus called Escherichia. It is the only species in this genus (34). It is one of the most common bloodstream infections and accounts for 15 to 40% of isolates (35). Risk factors for *E. coli* infections include extremes of age, immunocompromised patients and eating certain types of food such as unpasteurised milk, undercooked meat and soft cheeses made from raw milk (36).

E. coli is a commensal of the human intestines. However it can cause a variety of infections in the healthy and immunocompromised host. These infections include gastrointestinal infections, urinary tract infections, biliary tract infections, lower respiratory tract infections and septicaemia. (34)

Enterobacter

These are gram-negative micro-organisms which are part of the Enterobactericiae spp. The normal habitat of *Enterobacter* is in faeces and the respiratory tract of humans. Although they are thought to be closely related to Klebsiella spp., the principle infections that they cause are hospital acquired infections. These infections include lower respiratory tract infections and urinary tract infections (34).

1.9.3 Other gram-negative bacteria

A. baumanii

A. baumanii is an aerobic gram-negative bacilli (37). It is a rapidly evolving organism and is a major cause of morbidity and mortality. The mortality rate in ICU patients is between 26%-68%. It is a contaminant on medical equipment and outbreaks can occur. (38) Moreover, *A. baumanii* resistance has increased considerably over the years (39). Some of the risk factors include prolonged length of hospital stay, exposure to an intensive care unit (ICU), mechanical ventilation, exposure to antimicrobial agents, recent surgery and invasive procedures.

It causes severe disease and patients can develop severe septicaemia, septic shock and disseminated intravascular coagulopathy. This micro-organism is also implicated in soft tissue injuries (40).

P. aeruginosa

P. aeruginosa is a gram-negative rod (41). According to the CDC, the overall incidence is 0.4% in USA and it accounts for the fourth most common nosocomial infection (27). The main risk factor for *P. aeruginosa* is an immunocompromised patient (41).

P. aeruginosa is an opportunistic organism and is one of the most common nosocomial infection causing a multitude of diseases including; septicaemia, meningitis, brain abscess, otitis media, respiratory tract infections, endocarditis, gastrointestinal infections, osteomyelitis and urinary tract infections. It is also implicated in burn wound sepsis. These can be associated with high mortality rates. (41)

1.10 Conclusion

This literature review demonstrates the growth of micro-organisms on stethoscopes showing that stethoscopes are potential vectors of infections. The finding of gram-positive, gram-negative and resistant bacteria is also a concern as they are responsible for severe diseases. The availability of disinfectants and cleaning agents allows lower levels of contamination.

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The following are sample references:

1. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process: volume assessment by 3-dimensional reconstruction by high-resolutional CT scanning. Otolaryngol Head Neck Surg. 2005 Mar;132(3):429-34.
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Section 3: Draft Article

Title: Bacterial Contamination of Stethoscopes of Anaesthetists
in the Department of Anaesthesiology.

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(MSC); Scribante, J[1] (M Cur); Lowman, W[2,3,4] (MMed, FC Path (SA) Micro).

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Keywords: Anaesthetics
Contamination
Disinfection
Micro-organisms
Stethoscopes

Abstract

Background

South Africa has a huge burden of infectious diseases as many patients are immunocompromised and are at an increased risk for infection. An almost unnoticed piece of equipment possibly harbouring pathogens is the stethoscope. Alcohol swabs are readily available and have been shown to effectively reduce the growth of micro-organisms on stethoscopes.

Methods

Data was collected from 26 anaesthetists and their stethoscopes in the Department of Anaesthesiology at two academic hospitals in Johannesburg. Two samples were taken from each stethoscope. Group A was assigned to the stethoscope samples that were taken prior to disinfecting the stethoscope with a 70% isopropyl alcohol swab and Group B was assigned to the stethoscope samples that were taken after disinfecting of the stethoscope. Anaesthetists were then asked about their frequency of cleaning the stethoscopes.

Results

In Group A 19 (73%) stethoscopes grew micro-organisms. Micro-organisms were identified on three stethoscopes in Group A. Two stethoscopes grew coagulase-negative staphylococcus (CNS) and one stethoscope grew *Staphylococcus aureus.* In Group B, 5 (19.2%) cultured micro-organisms. The only micro-organism identified in this group was CNS. The results showed that most anaesthetists even if infrequently disinfected their stethoscopes.

Conclusion

This study demonstrated the contamination of stethoscope diaphragms in the Department of Anaesthesiology and the effectiveness of disinfecting the stethoscope with a 70% isopropyl alcohol swab. Most of the anaesthetists reported disinfecting their stethoscopes.

Acknowledgments

Introduction

South Africa has a huge burden of infectious diseases. This is due to the fact that many patients are immune compromised and they are at an increased risk for infection. This category of patients include; people living with human immunodeficiency virus (HIV), other infectious diseases, injuries and non-communicable diseases.[1] It has been shown that one in seven patients are at an increased risk of acquiring nosocomial infections.[2]

Nosocomial infections are preventable infections that occur in health care settings. These infections result in increased morbidity and mortality and increase the length of hospital stay which culminates in increased costs.[3] Patients who develop nosocomial infections also usually require more expensive second line drugs to treat those infections which are often associated with more resistant pathogens.[4] The age-old adage of "prevention is better than cure", no matter how over-used, still applies.

Health care professionals can significantly decrease the spread of infection by appropriate hand washing, adopting sterile techniques during procedures, using adequate protective clothing as well as sterilising and cleaning of equipment used for patients.[5] An almost unnoticed piece of equipment possibly harbouring pathogens is the stethoscope.

Alcohol swabs have been shown to effectively reduce the growth of micro-organisms on stethoscopes.[6] These are readily available to healthcare professionals and is a simple measure to decontaminate stethoscopes. It is also a feasible and practical method to ensure that the instrument of help does not transform into an instrument of harm.

A study was therefore undertaken to describe micro-organism growth on stethoscopes of anaesthetists before and after decontamination with a 70% isopropyl alcohol swab and to describe the frequencies of stethoscope cleaning by anaesthetists in two central hospitals, Chris Hani Baragwanath Academic Hospital (CHBAH) and Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

Methodology

Study design

A prospective, contextual, comparative descriptive study was used. Approval from the Human Research Ethics Committee (Medical) (M130307) and appropriate institutions was obtained. This study was conducted in compliance with the Declaration of Helsinki (2013). A sample size of at least 26 stethoscopes for each group was determined to have a significance of 5% and statistical power of 90% with the proportion of contaminated stethoscopes being estimated to be 0.9 pre-cleaning and 0.45 post-cleaning.

Data was collected at the departmental academic meetings at the two study hospitals. As anaesthetists arrived at the meeting, they were invited to take part and an information letter was given to those who consented. Each stethoscope was then given a study number. Participants were asked about their frequency of disinfection of stethoscopes. Participants were assured of confidentiality but anonymity could not be

guaranteed as the results could be linked to the participants. Results would be given to participants if they had requested it and if pathogenic micro-organisms had grown on the stethoscope diaphragm.

Stethoscopes from anaesthetists were swabbed before and after disinfection. All 26 participants were then asked about their frequency of disinfecting their stethoscopes. Exclusion criteria included medical interns that rotate in anaesthesiology for two months, if there was a breach of the aseptic technique in the collection and transportation of samples and if a post cleaning sample could not be obtained e.g. anaesthetist called away for an emergency.

Swabs were taken from the stethoscope diaphragms in a standardised manner. Sterile gloves were donned before each stethoscope was swabbed and disinfected. The stethoscopes were swabbed with a moistened sterile swab that had been dipped in sterile 10 ml ¼ Ringers lactate. The swab was taken using a continuous rolling technique from point A to point B following the arrows as shown in Figure 1 until the surface of the stethoscope diaphragm was covered. The tip of the swab was cut with a sterile blade and deposited in the remaining 10ml ¼ Ringers lactate solution. The old gloves were disposed of and new gloves were donned before disinfecting the stethoscope diaphragm with a 70% isopropyl alcohol swab following the same sequence as for swabbing. Specific care was taken to clean the rim. The stethoscope diaphragm was allowed to dry for two minutes before it was again swabbed using the same technique. The tip of the swab was cut by the researcher with a sterile blade and deposited in a second container of 10 ml ¼ Ringers lactate solution. Group A referred to those stethoscopes that were sampled before disinfection. Group B referred to those stethoscopes that were sampled after disinfection.
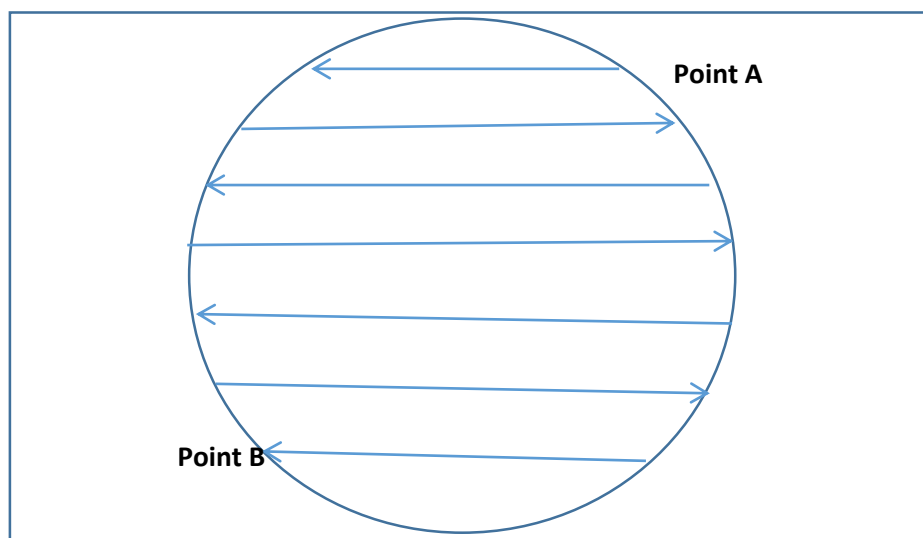
Figure 1: The technique of swabbing the stethoscope diaphragm.

The samples were labelled using the National Health Laboratory Service's standardised form for identifying specimens. Samples were stored at room temperature and transported to the Infection Control Laboratory Services, Department of Clinical Microbiology and Infectious Diseases of the School of Pathology, University of the Witwatersrand as soon as possible for culture and identification. . Laboratory personnel pipetted 1ml of the Ringers lactate solution and placed this onto two aerobic count petrifilms. These were left for one minute to allow for the gel to dry. The petrifilms were then incubated aerobically at 35°C for 48 hours and colonies were quantified from the petrifilms. The Ringers lactate solution was also used to inoculate

standard blood agar plates which was the culture medium for micro-organism growth. The agar plates were then incubated aerobically for 48 hours. Identification of microorganisms was done on agar plates.

A culture was considered positive if there was any growth on the petrifilms. Petrifilms that grew no micro-organisms were considered clean samples and disposed of according to laboratory protocol. All samples were identified and quantified by microbiology laboratory personnel according to standard microbiological practices.

The results were interpreted as colony forming units (CFUs) per one millilitre of a ¼ Ringer's lactate solution. Only aerobic micro-organisms were identified due to financial constraints. CFUs were defined as quantitative counts were classified according to three levels of contamination. Low-level contamination was defined as a count of 1 to 99 micro-organisms per sample seen, intermediate-level of contamination as a count of 100 to 300 micro-organisms per sample seen and high-level contamination as a count of more than 300 micro-organisms per sample.

Data was analysed using Statistica version $12.5^{®}$ software. Non-parametric data were analysed using descriptive statistics (counts and percentages for categorical variables and means and standard deviations for continuous variables). A two-sided McNemar test was done to compare the proportions of stethoscopes that grew micro-organisms between the two groups. A Wilcoxon matched pairs test was done to test the significance of the CFUs on the individual stethoscope between the two groups. A p-value 0f <0.05 was considered to be statistically significant.

Results

In Group A, a total of 26 samples were collected prior to disinfection. In this group 19 (73%) stethoscope diaphragms isolated micro-organisms. All 19 samples demonstrated low-level contamination. Micro-organisms were identified on three stethoscope diaphragms in Group A using conventional culture. Two stethoscope diaphragms grew coagulase negative staphylococci (CNS) and one stethoscope diaphragm grew *Staphylococcus aureus.* The stethoscope diaphragms that grew CNS had a total of 67 and 78 CFUs and the stethoscope diaphragm that grew *Staphylococcus aureus* had a total of 48 CFUs. The low level contamination did not permit identification of isolates due to lack of growth using conventional culture.

From the 26 stethoscopes that were sampled after disinfection in Group B, 5 (19.2%) cultured micro-organisms. CFU growth on the three stethoscope diaphragms mentioned above in Group A decreased after disinfectant to 0, 36 and 0 respectively. Only the stethoscope diaphragm that grew 36 micro-organisms still grew CNS after disinfectant. There were no other micro-organisms identified in Group B.

Participants were asked how often they disinfected their stethoscopes with the 70% isopropyl alcohol swab. Table I shows the frequency of disinfection by participants and percentage micro-organism growth in each category.

Table I: Frequency of disinfection and percentage micro-organism growth.

	Frequency of disinfection (no.)	Micro-organism growth (%)
After every patient	1	100%
Daily	5	60%
Weekly	8	87.5%
Monthly	10	60%
3 monthly	1	100%
Never	1	100%

The comparison of micro-organism growth before disinfectant (Group A) and after disinfectant (Group B) revealed that the 70% isopropyl alcohol swab reduced the micro-organism growth by 75%. In Group A, 19 (73%) stethoscopes grew micro-organisms and in Group B only 5 (19.2%) stethoscopes grew micro-organisms.

A McNemars test and a Wilcoxon match pairs test were used to compare the micro-organism growth in the two groups. It was postulated that there would be a significant decrease in micro-organism growth after disinfectant. The McNemars test is a test of no agreement and evaluated the overall reduction in the number of micro-organisms on the stethoscopes between the two groups. A p-value of 0.87 did not show a statistical difference in the overall reduction of micro-organisms between the two groups. The Wilcoxin match pairs test is a measurement of agreement and evaluated the difference of the CFUs between individual stethoscopes. A p-value of 0.0003 showed a statistically significant reduction in CFUs on the individual stethoscopes in Group B.

Discussion

Patient safety is a growing concern globally. The World Health Organisation (WHO) has stated; "healthcare associated infections are a major problem for patient safety and it must be a first priority for settings and institutions committed to making health care safer." [7] In October 2004, a World Alliance of Patient Safety (WAPS) was formed by WHO secondary to the growing concern of the increasing number of nosocomial infections.[8] The Global Patient Safety Challenge is a core programme developed in the WAPS and it involves campaigns in which guidelines are formulated to ensure patient safety globally. The three campaigns to date are the "Clean Care is Safer Care", "Safe Surgery Saves Lives" and "Tackling Antimicrobial Research". The aims of these campaigns are to acknowledge universally that infection control is an essential component of patient safety and to provide guidelines in each campaign.[9] Stethoscopes are essential pieces of equipment which are used on a daily basis. Disinfecting the stethoscope is one intervention which aims to improve infection control.

There are many studies that have shown potential pathogenic micro-organisms on stethoscopes.[10, 11-14] A 70% isopropyl alcohol swab is readily available and has been shown to effectively reduce micro-organism growth.[6, 10 13-17] The literature shows that stethoscopes are potential vectors of infection and micro-organism

contamination on stethoscopes range from 25% to 100%. Micro-organism growth that was reported included bacteria, moulds and yeasts.[6, 10, 11] Many of these micro-organisms were found to be resistant.[11,13,15]

Whittington et al [15] found that seven out of 22 stethoscope diaphragms cultured MRSA and all 24 identified isolates of *A.baumannii* were extremely drug resistant and only susceptible to colistin.[15] Zuliani Maluf et al [11], in a tertiary care hospital in Brazil, found that *S. aureus* and *Streptococcus* species showed a reduced susceptibility to commonly used antibiotics.[11] This shows micro-organisms that are isolated from stethoscopes are potentially multidrug resistant pathogens. Antimicrobial susceptibility testing was not performed in our study.

In our study, 19 (73%) stethoscopes had a positive micro-organism count prior to disinfection. This is similar to the results of Whittington et al [15] who reported micro-organism growth from 70% of the ICU bedside stethoscopes in a London hospital. The results are also comparative to a recent study conducted in a tertiary care hospital in Nigeria which showed micro-organism growth on 78.5% of stethoscopes.[6] Parmar et al [10] and Gupta et al [16] reported micro-organism growth from 90% and 100% of the stethoscopes respectively in tertiary care institutes in India.[10, 16] Only aerobic micro-organisms were investigated in our study due to financial constraints and thus the micro-organism contamination rate could be higher.

The micro-organisms that were reported by Gupta et al [16] in India included CNS, *Acinetobacter* species, *S. aureus, Bacillus* species, *Aspergillus fumigatus, Pseudomonas stutzeri and Citrobacter koseri*.[16] Two micro-organisms were isolated in our study namely CNS and *S.aureus.* This is not a true reflection of the micro-organisms growing on the stethoscopes as samples were grown on petrifilm plates to ensure accurate quantification and due to the low yield of CFUs, it was difficult to identify the micro-organisms. Nevertheless, the growth of *S.aureus* and CNS is of concern since they are potentially pathogenic micro-organisms.

Many studies suggest that alcohols are effective disinfectants in reducing the micro-organism growth on the diaphragms of stethoscopes.[6, 10, 15-17] In our study, 21 (81.6%) out of the 26 stethoscopes in Group B did not grow micro-organisms. Micro-organism contamination was reduced by 75% after disinfection. Chigozie et al [6] in Nigeria showed a reduction in micro-organism growth of 58.3% after disinfectant with a 70% isopropyl alcohol swab. [6] Our results are similar to a study done in India which reported a reduction of 62% in micro-organism growth after disinfecting with a 66% isopropyl alcohol swab.[3] The substantial reduction of micro-organism growth on stethoscope diaphragms shows that an isopropyl alcohol swab is an effective disinfectant. It is a rapid, readily accessible and an effective method of disinfecting stethoscope diaphragms.

The results revealed that those disinfecting their stethoscope diaphragms daily grew the same percentage yield of micro-organisms as those disinfecting their stethoscope diaphragms monthly. However the stethoscope diaphragms that were being disinfected weekly had a higher contamination rate than those that were being disinfected monthly. These results must be interpreted with caution because this was a small sample size. Participants may have also given a socially acceptable answer to the questions regarding regularity of disinfecting due to fear of being judged. It is important to note that one stethoscope diaphragm that was cleaned daily by a participant grew 67 CFUs and CNS was identified. Two stethoscopes that were cleaned monthly grew 78 and 48 CFUs respectively. The latter grew *S. aureus* which is a significant pathogen. Whittington et al [15] investigated the cleaning practices of healthcare professionals in a London ICU. Their results were also diverse showing that amongst the doctors, three cleaned it after every use; one cleaned it weekly; three cleaned their stethoscopes monthly; one cleaned the stethoscope twice a year and two said that they had never cleaned their stethoscopes. Twenty two nurses and nine physiotherapists were

also asked about their cleaning practices in the same study. From these twenty nurses and all physiotherapists cleaned their stethoscopes after every use. This emphasizes the poor practice of doctors in cleaning their stethoscopes as compared to the other healthcare professionals. They did not compare the cleaning practices to the micro-organism growth. [15]

It is clear from this study that stethoscopes are vectors for micro-organism transmission. Growth of micro-organisms namely *Staphylococcus aureus* and CNS in the setting of critically ill and immunocompromised patients is of major concern. This is of significance as anaesthetists deal with these patients on a daily basis.

The results of this study may not be generalised as it was done contextually in CHBAH and CMJAH. The study sample size was small and only aerobic bacteria were tested for. It is therefore suggested that a larger, multisite study testing for all pathogenic micro-organisms be conducted.

We have shown that a 70% isopropyl alcohol swab is effective in reducing the number of micro-organisms by 75%. The demonstrated difference in CFUs and level of contamination was statistically significant. Alcohol swabs are readily accessible and are a cost effective method of cleaning the stethoscope. Chigozie et al [6] in their follow up study in Nigeria trained healthcare professionals to disinfect their stethoscopes with a 70% isopropyl alcohol swab. They subsequently observed the adherence to the cleaning method and found that all healthcare professionals disinfected their stethoscopes after being trained.[6] In anaesthesiology, there is no ward round to remind the anaesthetist of the importance of cleaning a stethoscope and this practice may be neglected. The frequency of disinfection could improve with education and training. We, as healthcare professionals should acknowledge that infection control is a fundamental element of patient safety. Improving disinfection practices of stethoscopes could be a positive step toward the WAPS campaigns to improve infection control and therefore patient safety.

Conflicts of interest

We declare that we have no financial or personal relationship(s) which may have inappropriately influenced us in writing this paper.

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Section 4: Appendices

Post Graduate Approval

<div align="right">

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</div>

Dr FBE Lambat
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South Africa

Dear Dr Lambat

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *Bacterial contamination of stethoscopes of anaesthestics in the Department of Anaesthesia* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approvesd.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Ethics Approval

R14/49 Dr Fatimah Bibi E Lambat

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130307

NAME:
(Principal Investigator)

Dr Fatimah Bibi E Lambat

DEPARTMENT:

Department of Anaesthesiology
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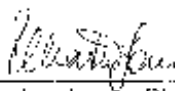
PROJECT TITLE:

Bacterial Contamination of Stethoscopes of
Anaesthetists in the Department of Anaesthesia

DATE CONSIDERED:

05/04/2013

DECISION:

Approved unconditionally

CONDITIONS:

SUPERVISOR:

Dr Helen Perrie

APPROVED BY:

Professor P Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL:

16/01/2015

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor,
Senate House, University.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned
research and I/we undertake to ensure compliance with these conditions. Should any departure be
contemplated, from the research protocol as approved, I/we undertake to resubmit the
application to the Committee. **I agree to submit a yearly progress report.**

Principal Investigator Signature   Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Section 5: Annexure

Proposal

5.1 Background

South Africa has a huge burden of infectious diseases. This is due to the fact that many patients are immunocompromised and they are at an increased risk for infection. This category of patients include; people living with human immunodeficiency virus (HIV), other infectious diseases, injuries and non-communicable diseases. (1) It has been shown that one in seven patients are at an increased risk of acquiring nosocomial infections (2).

Nosocomial infections are preventable infections that occur in health care settings. These infections cause an increased morbidity and mortality amongst patients and increase the length of hospital stay which results in a concurrent spike to the costs to society (3). Patients suffering from nosocomial infections also require more expensive second line drugs as a result of resistant pathogens that are responsible for nosocomial infections (4). The age-old adage of "prevention is better than cure", no matter how over-used, still applies.

Health care professionals can significantly decrease the spread of infection by appropriate hand washing, adopting sterile techniques during procedures, using adequate protective clothing as well as sterilising and cleaning of equipment used for patients (5). An almost unnoticed piece of equipment possibly harbouring pathogens is the stethoscope.

A study conducted in London in 1972, showed that 100% of stethoscopes grew coagulase-positive staphylococci. Of these, 76% were resistant to commonly used antibiotics. (6) It is not only the growth that poses an issue, but also the type of organism and the development of resistance to antibiotics.

In 2009, a study conducted in an intensive care (ICU) in the United Kingdom (UK) found that 8% of personal stethoscopes and 14% of ICU bedside stethoscopes

were colonised with pathogenic micro-organisms. These pathogens included micro-organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas aeruginosa (P. aeruginosa).* (7) In ICU nosocomial infections pose a significant hazard in critically ill patients.

A literature search did not identify any articles in South Africa regarding pathogenic growth on stethoscopes.

Alcohol swabs containing 66% ethyl alcohol have been shown to effectively reduce the growth of micro-organisms on stethoscopes (8). These are readily available disinfectants that medical practitioners can use to decrease the growth of micro-organisms on stethoscopes. It is also a feasible and practical method to ensure that the instrument of "help" does not transform into an instrument of "harm".

5.2 Problem statement

Anaesthetists come into contact with patients who present with a variety of infectious diseases. There is a potential risk of transmitting these infections from one patient to another. While other variables such as hand washing and equipment sterilisation are being stressed, the cleaning of stethoscopes may receive less attention.

During ward rounds, stethoscopes are regularly cleaned with alcohol swabs. However, in anaesthesiology, there is no ward round to remind the anaesthetist of the importance of cleaning a stethoscope and this practice may be neglected.

The micro-organism growth on anaesthetists stethoscope and the frequency of disinfecting stethoscopes in the Department of Anaesthesiology at the University of the Witwatersrand (Wits) is not known.

5.3 Aims and Objectives

5.3.1 Aims

The first aim of the study is to describe micro-organism growth on stethoscopes of anaesthetists in two central hospitals, Chris Hani Baragwanath Academic Hospital (CHBAH) and Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) before and after decontamination with a 70% isopropyl alcohol swab. The second aim of the study is to describe the frequencies of disinfecting stethoscopes among the anaesthetists in the Department of Anaesthesiology at Wits.

5.3.2 Objectives

The primary objectives are to:

- describe the identity and quantity of the micro-organisms cultured on the diaphragms of stethoscopes prior to cleaning with a 70% isopropyl alcohol swab
- describe the identity and quantity of micro-organisms cultured on the diaphragm of stethoscopes after cleaning with a 70% isopropyl alcohol swab
- describe the frequency of disinfecting stethoscopes among anaesthetists in the Department of Anaesthesiology at Wits.
  .

The secondary objective is to:

- compare the quantity of micro-organisms on stethoscope diaphragms before and after cleaning with a 70% isopropyl alcohol swab.

5.4 Research assumptions

The following definitions are used in this study.

Anaesthetists: in this study this will refer to a group of medical practitioners that are practising anaesthesiology. These include medical officers, registrars and specialist consultants.

Stethoscopes: in this study if a stethoscope belongs to the ward it will be specified as bedside stethoscopes. Personal stethoscopes that belong to the health care worker will be referred to as stethoscopes. All stethoscopes that were included in this study were personal stethoscopes.

Disinfection: this describes the process of destroying many or all micro-organisms except bacterial spores on inanimate objects (9). In this study disinfection will refer to cleaning with a 70% isopropyl alcohol swab.

Colony forming units (CFU's): CFU's are defined as quantitative counts which can be classified into three levels of contamination. Low-level contamination is a count of 1 to 99 micro-organisms per sample seen, intermediate-level of contamination is a count of 100 to 300 micro-organisms per sample seen and high-level contamination is a count of more than 300 micro-organisms per sample seen.

Contamination: in this study contamination refers to any micro-organism growth on the stethoscopes.

Group A: Group A refers to the samples that will be collected before disinfection.

Group B: Group B refers to the samples that will be collected after disinfection.

5.5 Demarcation of study field

This study will be carried out in the Wits Department of Anaesthesiology at two central hospitals in Gauteng. CHBAH is situated in Soweto, Johannesburg, and consists of 2888 hospital beds. CMJAH is an academic hospital situated in central Johannesburg and it has 1018 hospital beds (10).

5.6 Ethical considerations

Applications will be submitted to the Human Research Ethics Committee (Medical) and Postgraduate Office, Faculty of Health Sciences, University of the Witwatersrand for approval of the study.

An information letter (Appendix 1) will be given to anaesthetists and written consent will be obtained (Appendix 2).

Participants will be assured confidentiality as only myself and my supervisors will have knowledge of the results. Participants will be informed that anonymity is not guaranteed. A list of names and stethoscope numbers will be kept. If an infectious micro-organism grows on a participant's stethoscope, they will be informed. Participants will also be allowed to enquire about the growth on their individual stethoscopes. Data will be kept for six years following the completion of this study.

This study will be conducted in compliance with the Declaration of Helsinki (2013) (11) and the South African Good Clinical Practice Guidelines (12).

5.7 Research methodology

5.7.1 Study design

This study will be a prospective, contextual, comparative descriptive study.

A prospective study is defined as a study in which data is first collected and the outcomes are then measured (13). In this study swabs from stethoscopes will be collected and measured for micro-organisms pre-disinfection and post-disinfection.

Context is described as a "small-scale world" which, amongst others can be clinics, hospital wards or critical care units (14). This study is contextual as it will be conducted in the Department of Anaesthesiology in the two central hospitals of Johannesburg.

A comparative, descriptive study is used to describe and examine the variables in two or more groups (15). This study will describe and compare the micro-organism growth on stethoscopes of anaesthetists at CHBAH and CMJAH, pre-disinfection and post-disinfection.

5.7.2 Study population

The study population will be the anaesthetists and the stethoscopes of these anaesthetists in the Department of Anaesthesiology at CHBAH and CMJAH.

5.7.3 Study Sample

The study sample will include sample size, sampling method and the inclusion and exclusion criteria.

Sample size

In consultation with a biostatistician it was determined that the proportion of contaminated stethoscopes is estimated to be 0.9 pre-cleaning and 0.45 post-cleaning. Therefore, the proportion of discordant stethoscope pairs is 0.54 with an anticipated odds ratio of nine. A sample size of at least 26 pairs of stethoscopes is required to perform a two-sided McNemar test, with a significance of 5% and a power of 90%.

Sampling method

A convenient sampling method will be used.

Convenience sampling is defined by Polit (15) as choosing the most readily available persons to participate in the study (15). In this study all anaesthetists in the accessible population who are readily available will be included until the sample size is reached.

Inclusion criterium:

- anaesthetists and stethoscopes that are used by these anaesthetists who consent to take part in the study.

Exclusion criteria:

- medical interns that rotate in anaesthesiology for two months.
- if there is a breach of the aseptic technique in the collection and transportation of samples by the researcher.
- when a post cleaning sample cannot be obtained e.g. anaesthetist called away for an emergency.

5.7.4 Data Collection

Sample collection

Data will be collected by the researcher at the departmental academic meetings. As anaesthetists arrive at the meeting the researcher will invite them to take part and an information letter will be given to those agreeing and written consent will be obtained. Each stethoscope will be given a study number.

Swabs will be taken from the stethoscope diaphragms in a standardised manner.

- The researcher will don sterile gloves before each stethoscope is swabbed and cleaned.
- The stethoscopes will be swabbed with a moistened sterile swab by the researcher. This swab will be dipped in a sterile 10 ml ¼ Ringers lactate solution.
- The swab will be taken using a continuous rolling technique from point A to point B following the arrows as shown in Figure 1 until the surface of the stethoscope diaphragm is covered.
- The tip of the swab will be cut by the researcher with a sterile blade and deposited back in the remaining ¼ Ringers lactate solution.
- The researcher will dispose of the old gloves and don new gloves. The stethoscope will be cleaned with a 70% isopropyl alcohol swab by the researcher following the same sequence as described in Figure 1 and also taking specific care to clean the rim. The stethoscope diaphragm will be allowed to dry for two minutes.
- The cleaned stethoscope will be then be swabbed by the researcher using the same technique as described above.
- The tip of the swab will be cut by the researcher with a sterile blade and deposited back in second bottle of the ¼ Ringers lactate solution.
- Group A will refer to those stethoscopes that were sampled before cleaning. Group B will refer to those stethoscopes that were sampled after cleaning.
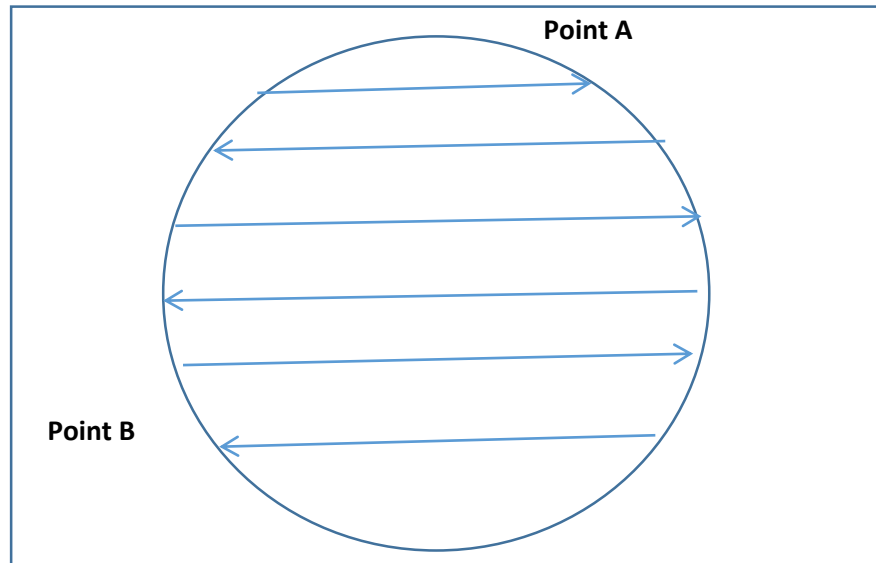
Figure 1: The technique of swabbing the stethoscope diaphragm.

Sample labelling

The samples will be labelled using the National Health Laboratory Service's standardised form for identifying specimens. The forms will then be labelled as follows:

Patient surname: Research

Patient name: Dr FBE Lambat

Patient hospital number: SthA (Study number e.g. 01) and SthB (Study number e.g. 01). Sth will refer to the stethoscope diaphragm from which the swab was taken. A and B will refer to either Group A or Group B.

One unique peel-off bar code will be attached to the samples and another will be kept by the researcher on the data capture sheet next to the study number for retrieving results.

Each participant will then be asked about their frequency of disinfecting stethoscopes and this will be documented.

Sample storage and transportation

Samples will be stored at room temperature. This will be transported by the researcher to the Infection Control Laboratory Services, Department of Clinical Microbiology and Infectious Diseases of the School of Pathology, University of the Witwatersrand as soon as possible for culture and identification.

Sample processing

The sample will reach the laboratory and laboratory personnel will pipette 1ml of the Ringers lactate solution and place this onto two aerobic count petrifilms. These will be left for one minute to allow for the gel to dry. The petrifilms will then be incubated aerobically at 35°C for 48 hours and colonies will be quantified from these petrifilms. They will then be placed on agar plates by the microbiologist which will also be incubated for 48 hours. This will be the culture medium for the micro-organism growth. Colonies will be identified from the agar plates according to standard microbiological procedures.

A positive culture will be considered if there is any growth on the culture medium. Once growth is observed, micro-organisms will be identified by an experienced microbiologist. Quantification of micro-organisms will then take place using growth per 100 ml Ringers Lactate solution. Any micro-organism count that exceeds 300 colony forming units would be considered as high-level contamination due to the difficulty of counting. In the event that no organism growth occurs on the agar plate after 48 hours, it will be considered as a clean sample and disposed of according to laboratory protocol. All samples will be observed and counted by expert microbiology laboratory personnel using good laboratory practices.

5.7.5 Data capturing

The following data will be captured on a Microsoft Excel spreadsheet (Appendix 3):

- microbial contamination from Group A
- the quantification of the various micro-organism types from Group A
- microbial contamination from Group B
- the quantification of the micro-organism types from Group B
- the frequency of disinfection of stethoscope diaphragms by participants.

5.7.6 Data Analysis

Data will be entered in the Microsoft Excel 2010 spread sheet (Appendix 3). In consultation with a biostatistician, the analytical tools that will be used will consist of descriptive statistics of summary measures (counts and percentages for binary variables and means, medians and standard deviations for continuous variables). A two-sided McNemar test will be done to compare the proportions of stethoscopes that grew micro-organisms between the two groups. A Wilcoxon matched pairs test will be done to test the significance of the CFUs on the stethoscopes between the two groups.

5.8 Significance of the study

Nosocomial infections are rising in both developed and developing countries (16). They are major preventable causes of morbidity and mortality (2). Patient safety is therefore a concern. Subsequently the World Alliance Patient Safety (WAPS) has been developed by the World Health Organisation (WHO). "Clean care is safer care" is one of the campaigns that was developed by WAPS in the journey to better patient safety. (16)

Stethoscopes are essential pieces of equipment that are used on a daily basis. The possibility of stethoscopes being potential vectors for infection may be overlooked. It has been shown in many studies that stethoscopes are potential vectors of infection (6, 8, 17-20).

If it can be shown that a 70% isopropyl alcohol swab is effective in reducing organism growth, it may motivate anaesthetists and many other medical practitioners to clean their stethoscopes. An alcohol swab is a readily available and inexpensive cleaning agent that can be used with minimal time consumption. It is therefore imperative that stethoscopes should be investigated as a possible source of nosocomial infections and emphasis should be placed on the adequate cleaning of this instrument.

5.9 Validity and Reliability

Validity of the study assesses accurateness of a study. It is important in evaluating methods to measure variables. (15)

Reliability refers to the consistency of information obtained. This is also important in interpreting statistics. (15)

The validity and reliability of this study will be maintained by the following.

- Samples will be collected in a standardised manner by the researcher.
- Samples will be stored and transported in a standardised manner by the researcher.
- Samples will be analysed at the Infection Control Services laboratory at the Department of Clinical Microbiology and Infectious Disease of the Witwatersrand School of Pathology where Good Laboratory Practices are adhered to.
- Sample size was determined with assistance of a biostatistician.
- All data entry points in the Microsoft excel spreadsheet will be checked.
- Analysis will be done with the assistance of a biostatistician.

5.10 Potential limitations

The following limitations are anticipated.

The study is done contextually in CHBAH and CMJAH and the results from the study cannot be generalised to other departments or hospitals. However, this study addresses a potential problem at the two hospitals.

The study sample size was small due to financial constraints.

5.12 Project outline

5.12.1 Time frame

	Jan 2013	Feb	March	Sep 2014	Oct	Nov	Dec	Jan 2015	Feb	March
Chapters 1,2,3	▨	▨								
Proposal	▨	▨								
Ethics submission			▨							
Post graduate submission			▨							
Data Collection					▨	▨				
Data analysis							▨	▨		
Chapter 4, Chapter 5									▨	
Formalities										▨
Discuss with supervisors										▨
Edit final draft										▨
Submit										▨

5.12.2 Financial budget

Item	Price per item (Rands(R))	Amount of item	Total (Rands(R))
Ringer's Lactate solution	R 0.00	100	R 0.00
Cultures	R 66.40	100 cultures	R6640.00
Gram-negative organism identification	R 157.80	25 micro-organisms	R3945.00
Gram-negative organism identification	R 33.30	25 micro-organisms	R 832.50
Gram-positive organism identification	R 33.30	25 micro-organisms	R 832.50
Gloves	R 57.00 for box of 50 pairs	Two boxes	R 104.00
Isopropyl alcohol swabs	R 30.00 for a box of 200	One box	R 30.00
Blades	R 125.00 for a box of 100	One box	R 125.00
Printing of proposal, Data collection and Literature review	R 0.60	1750 pages	R 1050.00
Total	R 503.40	2425	R 13 559.00

A quote was received from the Department of Infection Control Services. (Appendix 4)

An application for the financial costs of this study will be submitted to the South African Society of Anaesthesiologists Jan Pretorius fund. The costs of paper and printing will be incurred by the Department of Anaesthesiology and the researcher.

Appendix 1: Information Letter to Anaesthetists.

Study Title: Bacterial Contamination of Stethoscopes of Anaesthetists in the Department of Anaesthesiology

Dear colleague

Hello, my name is Dr Fatimah Bibi Ebrahim Lambat. I am a registrar in the Department of Anaesthesiology. I would like to invite you to participate in my study.

My study involves the swabbing of anaesthetists stethoscopes in the Department of Anaesthesiology for micro-organism growth. This should take no longer than 10 minutes. During this time your stethoscope will be swabbed twice. The first swab will be taken immediately. Your stethoscope will then be cleaned with an isopropyl alcohol swab and once dry another swab will be taken. I will send this to the microbiology lab where the identification and quantification of micro-organisms will take place. I will then compare the micro-organism growth in the two stages in order to assess if the cleaning method had made a difference.

This is voluntary and no penalty or discrimination will be incurred if you do not participate. Your stethoscope will be given a unique number (e.g. A1 before cleaning and B1 after cleaning).

Every effort will be made to ensure confidentiality. No personal details will be asked of you and only myself and my supervisors will have access to the raw data. Anonymity cannot be guaranteed but I will not know your unique study number as an assistant will allocate this number to you. There is no direct benefit to you, however as stethoscopes are shown to increase nosocomial infections, the results could assist you in decreasing this problem.

Should you have any queries you may contact me at 073 553 2002. You may also contact Prof Cleaton-Jones, the chair of the Research ethics Committee at Witwatersrand University for any complaints at 011 717 1234.

Thanking you
Dr FBE Lambat

Appendix 2

Consent form for participants

I, _____, have read and understood the information letter given by the researcher and consent to participate in this study. I was given a chance to ask questions and all the questions were answered.

Date:
_____

Participants Signature:
_____

Appendix 3: Microsoft Excel Spreadsheet

Group A	CFU/cm^3	Id	Group B	CFU	Id	frequency of disinfecting
1			1			
2			2			
3			3			
4			4			
5			5			
6			6			
7			7			
8			8			
9			9			
10			10			
11			11			
12			12			
13			13			
14			14			
15			15			
16			16			
17			17			
18			18			
19			19			
20			20			
21			21			
22			22			
23			23			
24			24			
25			25			
26			26			

Appendix 4: Quote from infection Control Service

National Health Laboratory Service

University of the Witwatersrand, Johannesburg

INFECTION CONTROL SERVICES

Department of Clinical Microbiology and Infectious Diseases

Division of Hospital Epidemiology and Infection Control

Medical School Room 3T11, Level 3, Wits Medical School, 7 York Rd Parktown, Johannesburg 2193, Republic of South Africa.

PO Box 2115, Houghton 2041, South Africa Tel: (011) 489 8510 / 8578 / 8579. Fax: (011) 489 8530

PR5200296

TO: Dr FBE Lambat

Department of Anaesthesiology, University of Witwatersrand

FROM: Rob Stewart (rob.stewart@nhls.ac.za)

NHLS Infection Control Services lab

SUBJECT: Quote for Research Project

DATE: 22 February 2012

Dear Dr Lambat

We are able to do the testing for your project which entails swabbing of 50 stethoscopes pre and post cleaning with 70% alcohol.

The price for this testing is as follows:

100 Ringer's Solution (100 x 0)	No charge
100 Cultures (100 x R66.40)	R6640.00
25 Organism identifications gram negative MS (25 x R157.80)	R3945.00
25 Organism identifications gram negative (25 x R33.30)	R832.50
25 Organism identifications gram positive (Staph or Strept) (25 x 33.30)	R832.50

TOTAL   **R12250.00**

Notes:

1. The NHLS has deregistered from VAT.
2. We will request a final invoice from the NHLS on the completion of the work.
3. You will only be billed for work carried out. Whenever possible the most cost-effective ID system will be used.
4. Please discuss optimal times for delivery of cultures with lab personnel.

Please contact me if I can be of further assistance.

Regards
Rob Stewart

Technical:

1. 100ul planted onto BA and MCC
2. Counts: >300, 100-300, <100 cfu/ml
3. Identifications to genus level (DNase, Strept sugars, Short sugars & oxidase whenever possible. Microscan Rapid ID panel, API when necessary).

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15.   D. F. polit, C. T. Beck. Nursing Research. 9th ed. Philadelphia: Lippincott Williams and Wilkins; 2012.

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18.   Breathnach AS, Jenkons DR, Pedlar SJ. Stethoscopes as possible vectors of infections. British Journal of Medicine. 1992;305:1573-74.

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20.   Youngster I, Berkovitch M, Heyman E, Lazarovitch Z, Goldman M. The stethoscope as a vector of infectious diseases in the paediatric division. Acta Paediatrica. 2008;97(9):1253-5.