Microbial Contamination of Cell phones of Health Care Workers in the Orthopaedic Department at Charlotte Maxeke Johannesburg Academic Hospital

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A research report submitted to the Faculty of Health Sciences, University of Witwatersrand, in partial fulfilment of the requirements for the degree of Masters of Medicine.

Declaration

I, Yenzi Ngema declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Orthopaedic Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

This 19th day of December 2024 in Johannesburg

Dedication

To God be the glory because it is in Him and through Him that we have our being.

“Wonderful are Your works, and my soul knows it very well.” Psalm 139:14

To my parents Thamsanqa and Ntombiyenkosi Ngema, my siblings Cebisani, Khethukuthula, Sizophila and Sizwiwe; without your love, support, constant rescuing and belief in my capabilities, I would not be who I am. I love you and hope to make you proud in both my word and deed.

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Nomenclature

CDC	Centre for Disease Control and Prevention
CFU	Colony Forming Units
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
HAI	Hospital Acquired Infections
HCW	Health Care Worker
HREC	Human Research Ethics Committee
ICU	Intensive Care Unit
NHLS	National Health Laboratory Services
NICE	National Institute for Health and Care Excellence
PJI	Peri-prosthetic Joint Infection
SHEA	Society for Healthcare and Epidemiology of America
SSI	Surgical Site Infection
TKA	Total Knee Arthroplasty
THA	Total Hip Arthroplasty
WHO	World Health Organisation

Abstract

The role that fomites play in surgical site infection (SSI) and peri-prosthetic joint infection (PJI) has been observed and researched in the past. However, the role that cell phones play in the transfer of micro-organisms from hands to surgical sites and the indiscriminate use of cell phones within the orthopaedic environment, could increase the risk of infection. This study aimed to measure the contamination of cell phones of health care workers (HCWs) in a South African tertiary hospital.

This was a prospective cross-sectional study conducted from the 6th June 2022 to 20th of June 2022. Samples were taken from the participant's cell phones under aseptic techniques and sent for microbiological testing. The participants also filled out a questionnaire on cell phone behaviour. Included in the study were nurses and doctors on the orthopaedic theatres, wards and clinics.

Sixty-two participants were included; 54 from the orthopaedic, seven from anaesthesia and one was not identified. From the samples taken 48/62 (75%) grew pathogens while 30/62 (48%) grew two or more colonies. This is slightly lower than other studies which showed contamination of up to 100%. Micro-organisms cultured included *Staphylococcus* species, *Staphylococcus epidermidis,* methicillin-sensitive *Staphylococcus aureus* and *Escherichia coli.* Cell phone hygiene behaviour was also better than most other studies in terms of frequency of cleaning the devices and hand hygiene around cell phone usage. This may be a contributing factor to the lower micro-organism contamination.

We have identified that there are indeed pathogens on cell phones transferable to patients; that may lead sepsis. Though cell phones have become vital in patient management in the hospital setting, factors such as improvement in cell phone hygiene through education and frequent cleaning of cell phones will aid in disabling the negative impact of cell phones in the orthopaedic environment.

CHAPTER 1 - INTRODUCTION/BACKGROUND

Peri-prosthetic joint infection (PJI) is described by both literature and orthopaedic surgeons as “disastrous” and “devastating” (1). The grave descriptions are as a result of the complexity and the cost of its management as well as the subtle feeling of guilt that one has imposed this iatrogenic crippling ailment on an old, but generally well individual. Although the incidence of PJI is generally low ranging from 2.0%, in Total Hip Arthroplasty (THA), to 2.4% in Total Knee Arthroplasty (TKA) (2), the cost to the patient and health care system is what makes the prevention of PJI important. In the United States, PJI is the primary reason for revision surgery in arthroplasty (3). The average cost of treating a patient with PJI after primary surgery is almost $6 000 (around R114 000) (2). The most current projected cost is estimated at $1.85 billion (R35.15 billion) ($753.4 million (R14.3 billion) for THA PJI and $1.1 billion (R 20.9 billion) for TKA PJI) (4); an increase from the 2020 projected cost of $1.62 billion (R 30.78 billion) (2). This increase is attributable to an increase in volume (4). The price to bear is not only extraordinary financially it is also costly to the patient burdened by the morbidity. Revision surgery associated with PJI has is recorded as having major adverse effects on patients. Deep surgical infection, of which PJI is a part of, has been found to result in hopelessness, isolation, severe pain, and if left untreated, death (5, 6). It has been noted that the event, i.e. PJI, was detrimental to the life of the patient in various aspects; physically, emotionally, socially and economically (6, 7). The complexity of the management of PJI, whether it is the one-stage or two-stage approach to revision, still has a risk of re-infection, immobility (more importantly in between stages in the two-stage revision), and disability even after revision surgery (5).

A close and ominous relation to PJI is Surgical Site Infection (SSI). SSI is defined as an infection that occurs within 30 days of having surgery without an implant or within a year if an implant has been inserted (6). It is one of the commonest hospital-acquired infections (HAI) accounting for up to 20% of HAI (6). In a 2009 study done in a large Brazilian Hospital (an economically similar country to our own), the incidence of SSI was found to be 3.4%

(8), a slight increase from a study done in the United States; 2% in spine surgery (9). The World Health Organisation (WHO) has noted the challenge and calamity brought on by SSIs. The WHO notes that SSIs not only “threaten the lives” of many patients but they are also responsible for the increase in drug-resistant micro-organisms, increased length of patient hospitalisation and care cost (10).

In view of the negative impact of both SSI and PJI, numerous studies have been done from which evidence-based guidelines used for the prevention of SSI and PJI arose (11). The WHO guidelines are the most widely recognised guidelines covering 23 components of prevention (10). The Centre for Disease Control and Prevention (CDC), the Society for Healthcare and Epidemiology of America (SHEA) (12) and the National Institute for Health and Care Excellence (NICE) (13) are other important contributors to guidelines and recommendations for the prevention of SSI and PJI (11). Many of these guidelines have been practiced to varying degrees by both developed and developing countries and extrapolated accordingly. The most recent and relevant are the guidelines used for the prevention of peri-prosthetic joint infection authored by Pravizi et al. (11).

These guidelines go into great lengths to compare and contrast the various previously suggested measures used to prevent SSI and PJI. These measures range from nasal screening and decolonisation, pre-operative skin preparation; intra-operative laminar airflow, operating room traffic, antibiotic-impregnated bone cement, normothermia, and blood transfusion (11-13). The impact of cell phones as fomites has been excluded from many a guideline, but not from the operating room. It is a device used by health care workers (HCWs) without discretion in almost every theatre and ward.

Cell phones have revolutionised the world we live in. They not only allow almost unlimited accessibility to one another, they also enable the virtual world to be at the tips of our fingers. Whether it is medical applications, research studies, social media or just the World Wide Web, cell phones have allowed for information to be gained as fast as one could type. Cell phones

in medical practice have transcended personal use and have become a key tool in improving patient care. Cell phones enable HCWs to communicate with each other for senior advice and obtain expertise; they contain medical applications that assist in decision making and patient care; they provide cameras for picture taking thereby improving internal education and external referrals; and they also allow convenience with regards to accessing laboratory results (14). There have even been reports of cell phone torches being used during intubation upon the failure of the laryngoscopy light (14). Studies have shown that as many as 88% of HCWs use their cell phones in the workplace (15). For many HCWs, the role of the cell phone in the clinical setting has become critical.

The use of cell phones in the medical field is unfortunately not without its consequences. In an article by Attiri et al., various adverse consequences are noted as concerns with regard to the use of cell phones in the Operating Theatre (OT), as well as in the Intensive Care Unit (ICU) (14). Notably, the authors place great emphasis on the use of cell phones as a conduit for nosocomial infections, as well as an avenue for distraction (14). This study will investigate the former.

Studies done across the globe, including Saudi Arabia, Turkey, France and Ethiopia, have shown that cell phones are highly contaminated with micro-organisms (15-18). More importantly in these studies, both in developing and developed countries, cell phones have been demonstrated to harbour pathogenic micro-organisms that can lead to HAI such as SSI and PJI (15-17). South Africa is considered a middle-income country (19), but would likely to be closer affiliated to a developing country in this regard. Previous studies have reported that the contamination rate of cell phones of HCWs ranged between 40% and 100% (20), with the average rate being 81.4% (15, 16, 21, 22). A systematic review by Szabo et al. found that the

most common micro-organisms were Coagulase-negative *Staphylococci* and *S. aureus.* Furthermore, most of these were methicillin-resistant (20).

There are two main contributory factors to the micro-organism contamination of cell phones. The first, as stated by Brady et al., is the breeding surface of the cell phone (23). This occurs due to the heat that is produced by the devices combined with the constant handling by hands and the phones habitat; usually a handbag or a side pocket (23). The second contributory factor is the behaviour surrounding the use of personal cell phones. Most HCWs and, even non-HCWs, do not clean their phones on a regular basis. An astounding finding was that 93% of HCWs had never cleaned their cell phones (24, 25). Although the study was done in a time when cell phones were not frequently used (24), current results have not shown a significant change (25). A study in Ethiopia found that 100% of HCWs never wash their hands after using their cell phones (26). Of note, is that the cell phones of both HCWs and non-HCWs grew micro-organisms but it was the cell phones of the HCWs that grew pathogenic micro-organism and had a higher frequency of drug-resistant pathogens (17, 27).

The studies have also shown that a large proportion of HCWs use their cell phones throughout the day. Furthermore, HCWs do not sanitise their hands after the use of their cell phones (21) and use their cell phones while seeing patients (26). Considering the amount of microorganisms found on cell phones, the cross contamination from cell phone to hand, and hand to patient could be an important contributor to both PJI and SSI. A study done by Murgier et al. noted an almost 20% decrease in colony forming units after the decontamination of cell phones (16) whereas, Hassoun et al. found that 75% of previously culture positive phones became culture negative after cleaning them with alcohol swabs (24).

Problem Statement

This study would be the first step in gaining relevant data on the rate of cell phone contamination in a South African tertiary hospital as well as investigating the behaviour of HCWs at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) with regards to cell phone use. In addition, the findings will be compared to previous studies. The purpose, if found to be relevant, would be to implement simple strategies that can be used to reduce the contamination rate as has been done in some health institutions around the world. Thus, the behavioural problem of the constant use of contaminated cell phones, without antiseptic procedures, around patients both in the peri- and post-operative phases may be contributing to wound sepsis, SSIs and PJIs.

CHAPTER 2 - STUDY AIM AND OBJECTIVES

Aim

To measure the micro-organism contamination of cell phones used by HCWs in orthopaedic theatres, wards and clinics at CMJAH.

Objectives

- To measure the degree of micro-organism contamination of cell phones used by HCWs (including doctors and nursing staff) working in orthopaedic theatres, wards and clinics.
- To describe the pathogenicity and resistance profile of the micro-organisms cultured.
- To describe the behavioural patterns of HCWs around the use of their cell phones in the hospital setting.

Methods

This was a prospective cross-sectional study that was conducted from the 6th June 2022 to 20th of June 2022. Consent was obtained from the HCWs to firstly, take samples from their cell phones as well as participate in the filling out of a questionnaire focussing on the habits around the use of cell phones and the hygiene practices around them.

Data Collection

Samples were taken from all the cell phones by a single clinician; the principal researcher (Dr Y. Ngema). During sample collection, sterile gloves were used after sanitising the hands with alcohol. The sample was collected by swabbing the participant's cell phone with a pus swab that was moistened with sterile water for injection. The cell phone was sampled on the back and the front. If the cell phone had a protective film or case, samples were taken from the protective film or case. If the phone was encased in a fold over cover, the cover was opened, and the sample was taken. Microbiology data was collected from the National Health

Laboratory Services (NHLS) at CMJAH. The NHLS Infection Control Services Laboratory processed the samples taken from the cell phones.

Six micro-organisms were to be targeted for identification once isolated due to budget constraints. These micro-organisms were chosen as they are the most frequently isolated both in orthopaedic infections and are also common micro-organisms affecting our geographic location. These included *Staphylococcus aureus* (*S. Aureus*)*, Staphylococcus epidermidis* (*S. Epidermidis*)*, Escherichia coli* (*E. coli*)*, Acinobactcer baumannii* (*A. baumanii*)*, Group B streptococcus and Pseudomonas aeruginosa* (*P. Aeruginosa*)*.* HCWs included were doctors (medical officers, registrars and consultants) and nurses working in the orthopaedic theatres, wards and clinics. They also included doctors in the Department of Anaesthesia working in orthopaedic theatres. Intern doctors were excluded secondary to resource constraints.

Ethics approval was obtained from the Human Research Ethics Committee (HREC) (Medical) of the University of Witwatersrand, and permission was obtained from CMJAH prior to the commencement of the study. Participation was voluntary and informed consent was obtained from the participants prior to their enrolment into the study. In addition, approval from NHLS for the work of analysing the swabs was obtained.

CHAPTER 3 - RESULTS

The data were captured on Microsoft Excel (version 2010) and analysed using STATA version 17. Descriptive statistics for categorical variables were reported as frequencies and percentages. Graphical representations were used to describe the distribution of microorganisms and an antibiogram was done for sensitivity and resistance of the organisms. The Chi-square test was done to assess any association between pathogen contamination and phone cleaning frequency and if ever the cell phone was cleaned.

Descriptive statistics

Table 3.1 shows the descriptive characteristics of the participants. Most of the participants were from the Orthopaedic Department (87.1%), worked in the trauma unit (45.16%) and were registrars (37.1%).

Table 3.1: Descriptive statistics of the participants

Variables	Categories	Number of HCWs	Percentage (%)
Department	Anaesthesia	7	11.29
	Orthopaedics	54	87.10
	Not Identified	1	1.61
Orthopaedic Unit	Arthroplasty	7	11.29 11.29
	Paeds Ortho	7	11.29
	Spine	7	6.45
	Sport	4	45.16
	Trauma	28	11.29
	Tumours	7	3.23
	Not identified	2	
Designation	Consultant	15	24.19 37.10
	Registrar/Medical Officer	23	17.74
	Theatre Nurse	11	19.35
	Ward nurse	12	1.61
	Not identified	1	

Personal cell phone information

Table 3.2 shows the personal cell phone information of the participants. Most of the participants responded that they use plastic protective covers (64.52%), used back covers that are closed (as opposed to perforated) (79.03%) and their cell phones are placed in the front bottom pocket (56.45%). The use of cell phones was confirmed to be quite frequent as 53.23% used their phone every hour. The main reason for using the cell phone at work was work communication (79.03%), followed by social communication. Participants who did use their cell phones while in the bathroom (59.68%) mainly used the cell phone for answering calls (32.26%) and texting (17.74%). Most participants indicated that they used their cell phones in theatre/ward/clinic (48.39%). Participants who are usually in one area (i.e. theatre) logically indicated that area as the single area where they use their cell phones

Table 3.2: Cell phone usage

Variable	Categories	Frequency	Percentage (%)
Plastic protective cover	No Yes	22 40	35.48 64.52
Type of cover with regards to coverage	Back, closed Fold over, closed Perforated, back Not identified	49 6 4 3	79.03 9.68 6.45 4.84
Storage of cell phone when not in use	Back pocket Front bottom Handbag Upper pocket Not identified	8 35 7 10 2	12.9 56.45 11.29 16.13 3.23
Frequency of cell phone use when at work	Every 10 minutes Every 3-6 hours Every hour Not identified	17 10 33 2	27.42 16.13 53.23 3.23
What the cell phone is primarily used for at work	Work communication Education reference Social communication Not identified	49 3 8 2	79.03 4.84 12.9 3.23
Bathroom use*	Answering calls Texting Social media	20 11 4	32.26 17.74 4.45

	Games Browsing Not applicable	2 2 25	3.23 3.23 40.32
Phone at work	No Yes	5 57	8.06 91.94
Areas in the hospital where cell phone is used	Theatre/ward/clinic Theatre Theatre/Ward Ward Not identified	15 11 3 16 2	48.39 17.74 4.84 25.1 3.23

Table 3.3 illustrates cell phone hygiene. Regarding cleaning phones, 70.97% indicated that they clean their cell phones and 51.61% stated they cleaned with alcohol swabs. A fair number of the participants cleaned their cell phones once per day (38.71%). There were 59.68% of the participants indicated that they used their cell phone while seeing patients and only 46.77% indicated that they wash/clean their hands after using the cell phone.

Table 3.3: Cell phone hygiene

Variable	Categories	Frequency	Percentage (%)
Do you clean your cell phone?	No Yes Not identified	16 44 2	25.81 70.97 3.23
Method of cleaning cell phone	Alcohol swab Dry cloth/tissue Hand wash (soap/alcohol) N/A	32 8 5 17	51.61 12.9 8.06 27.42
Frequency of cleaning cell phone	Once per week Once per day After every use 1-2 times a month N/A (Phone never cleaned) Seldom	9 24 2 6 16 5	14.52 38.71 3.23 9.68 25.81 8.06
Use of cell phone while seeing patients	No Yes	25 37	40.32 59.68
Washing of hands after using cell phone	Mostly No Yes	13 20 29	20.97 32.26 46.77

Microbe contamination information

Table 3.4 shows the microbe contamination information. There were 91.94% of the participants who were aware of micro-organism contamination. Above seventy percent (74.19%) acknowledged that cell phones are vehicles for the spread of nosocomial pathogens while almost half of HCWs, 44.89% were of the mind that there should not be restrictions on the use of the cell phone (see Figure 3.1).

Table 3.4: Microbe contamination information

Variable	Categories	Frequency	Percentage (%)
Micro-organisms on your cell phone awareness	No Yes	5 57	8.06 91.94
Cell phones are a vehicle for the spread of nosocomial pathogens	Strongly agree Agree Neutral Disagree Strongly disagree Not identified	22 24 6 2 5 3	35.48 38.71 9.68 3.23 4.06 4.84
There should be restricted use of cell phones in the clinical setting	Strongly agree Agree Neutral Disagree Strongly disagree Not identified	8 11 10 16 14 3	12.9 17.74 16.13 25.81 22.58 4.84

Figure 3.1 shows that the participants agree that cell phones can pose a hazard by being vectors for micro-organisms, the same participants also show that they are against the banning of cell phone usage in the hospital; likely as a result of the pivotal role they place in clinical work.

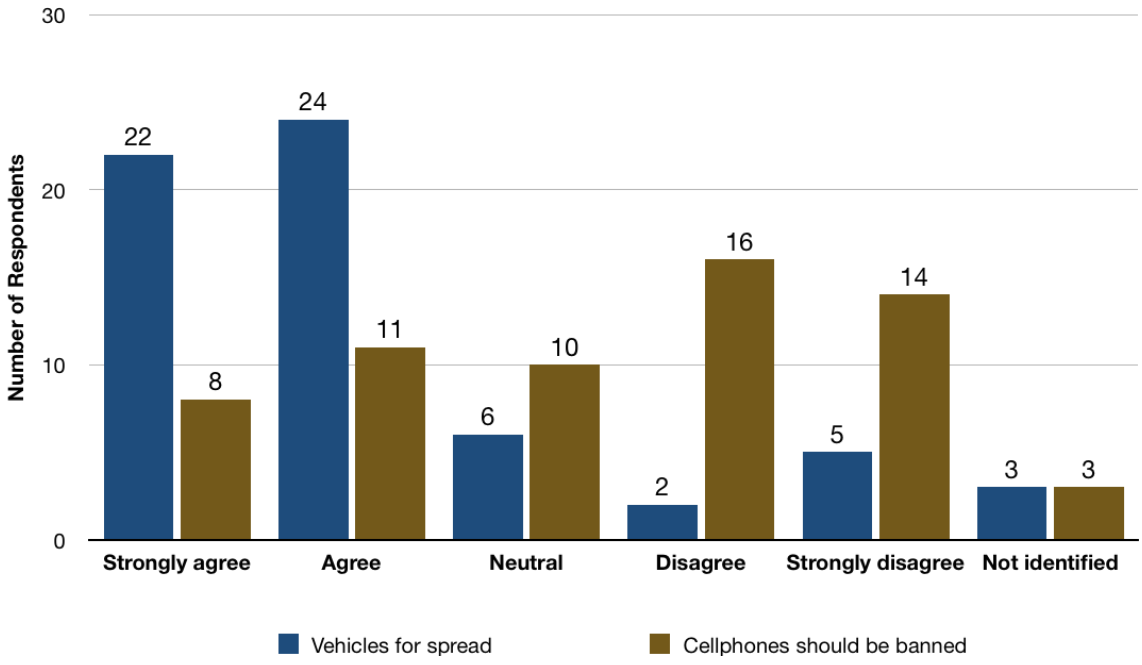

Figure 3.1: Distribution of responses of two groups regarding their ideas about cell phones as vectors and whether there should be areas where they should be banned in the hospital. Awareness of cell phones as conduits for spread of pathogens (**Blue bars**) and those that believe cell phone usage should be banned at work (**Bronze bars**).

Cell phone Sampling Results

Figure 3.2 shows the pathogen contamination patterns. Of the total samples tested, there were 37/62 (59.68%) single colonies, 7/62 (11.29%) had 2 colonies and around 4/62 (6.45%) had more than 2 colonies. Approximately 15/62 (24.19%) of the samples had no pathogen growth.

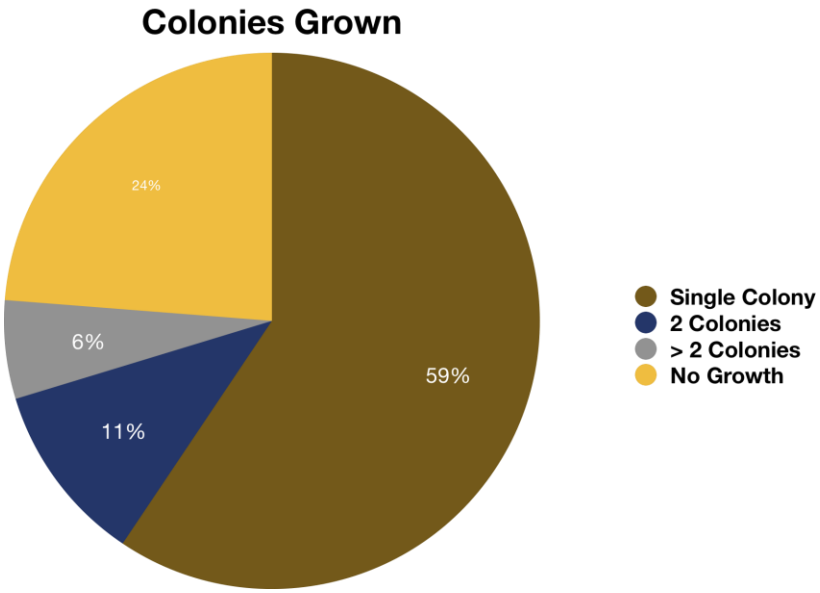

Figure 3.2: The different micro-organisms that were isolated and identified.

Figure 3.3 shows the distribution of the pathogens isolated. Of the isolates identified, *S. epidermidis* predominated (36.36%), followed by *Staphylococcus haemolyticus* (*S. haemolyticus*) and *S. aureus* (both at 3.64%) and *E. coli* (1.82%). There was a large sample that was not identified (50.91%) though there were colonies grown; this was secondary to budget constraints.

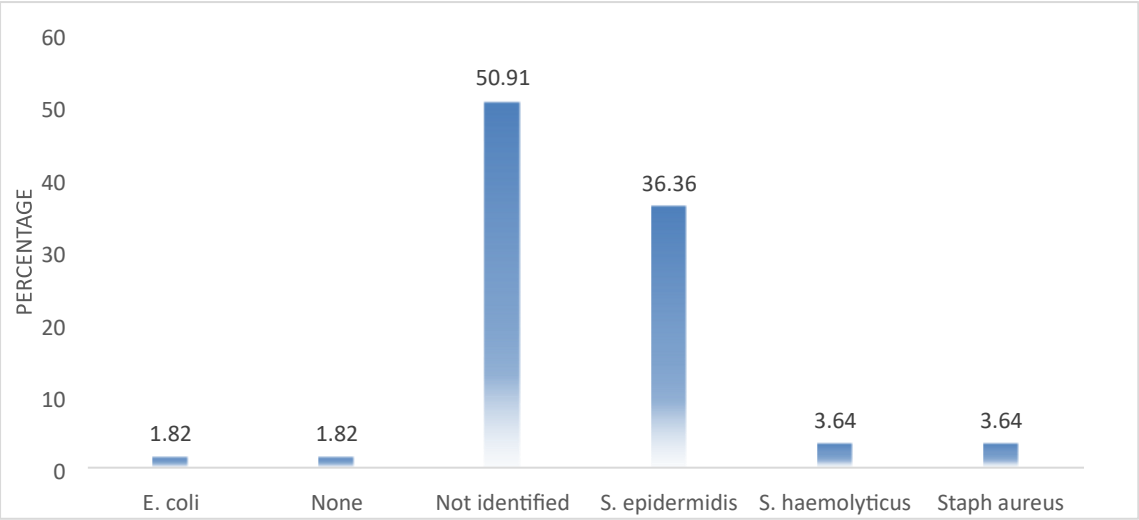

Figure 3.3: Distribution of the pathogens isolated.

Table 3.5 shows that all the micro-organisms identified were sensitive to antibiotics that are readily available in the hospital. *Staphylococcus epidermidis*, the most commonly isolated micro-organism, is responsive to most antibiotic treatment used in the hospital which is encouraging. Though *S. haemolyticus* was only sensitive to Vancomycin, and usually administered intravenously, it is still good to note that it is a drug that is readily available in the hospital.

Table 3.5: Antibiogram patterns - Sensitivity

	S. epidermis	*S. haemolyticus*	*S. aureus*	*Staphylococcus. capitis (S. capitis)*	**Total**
	N = 20	N = 2	N = 2	N = 1	
Cloxacillin	8	-----	2	1	10
Penicillin	1	-----	-----	-----	1
Ampicillin	-----	-----	-----	-----	1
Clindamycin	11	-----	2	-----	13
Erythromycin	5	-----	2	-----	7

Vancomycin	10	1	1	-----	1
Other	7	-----	2	-----	10

Table 3.6 below depicts the resistance of the micro-organisms. Generally it shows that though the micro-organisms have resistance to some antibiotic drugs, they do not have resistance to all the drugs available in the hospital. For example, with *S. epidermidis*; the 20 isolated specimens had resistance to Penicillin (14), Cloxacillin (11) and Erythromycin (13). This implies that in general, because this is an overall depiction; there should be another option within the drugs that are readily available. This Table shows that in isolation, if these microorganisms (looking at the columns); were to cause infection through cross-contamination, they will likely be treatable in a clinical setting. With regards to *S. aureus,* the results showed that resistance was not only low but none of the isolates were methicillin-resistant *S. aureus* (MRSA). Similarly E. coli isolated (N = 1) did not show multi-drug resistance.

Table 3.6: Antibiogram patterns - Resistance

	S. epidermidis	*S. haemolyticus*	*S. aureus*	*S. capitas*	**Total**
	N = 20	N = 2	N = 2	N = 1	
Cloxacillin	11	1	-----	-----	12
Penicillin	14	1	1	1	17
Ampicillin	6	1	1	1	9
Clindamycin	6	-----	-----	-----	6
Erythromycin	13	1	-----	-----	14
Azithromycin	5	1	-----	-----	6
Other	5	-----	-----	-----	5

CHAPTER 4 - DISCUSSION

Cell phone usage in the workplace has become an integral part in streamlining and making the workday functional in both the health and corporate world. Cell phones continue to make communication between colleagues, the access of online resources as well as access to patient information easier for HCWs and Table 3.2 is a depiction of various places and times cell phones are used by the participants. Though the use of cell phones in the operating theatre continues to be a cause for concern, Table 3.2 shows that almost half (46.8%) of the participants confirmed usage of their cell phones while in theatre and 54.8% admitted to using their cell phones in the ward. In essence, HCWs will use cell phones wherever they are stationed without discretion according to this study as well studies performed outside of the settings of ICUs (28). Most HCWs (91.4%) were aware of the potential of cell phones to harbour micro-organisms, as demonstrated in Figure 3.1, yet strongly disagreed to there being restrictions on their usage in the workplace. Previous studies done in Saudi Arabia have noted more co-operation for the restrictions of cell phones use, though this is likely a result of the increased importance of cell phone usage in our current setting (29). This means there is a need to create decontamination protocols and promote hand and cell phone hygiene so that the disadvantages and potential hazards of cell phones can be reduced or eliminated, and the advantages of cell phones can continue being utilised to their optimum.

In the hospital setting, five colony forming Units per square centimetre (CFU/cm^2) is considered the upper limit acceptable for contamination of surfaces (30). This study (see Figure 3.2) demonstrated that the vast majority of cell phones had single or two CFU/cm^2 (82.25%) which is still acceptable in a hospital environment but if not acceptable, may have added to the bio-burden in the hospital setting. Micro-organism contamination of cell phones in CMJAH was 76.4% as shown in Figure 3.3; lower than most studies done before which ranged between 89.7% and 98% contamination (15,16,21,22), and within the rates noted by Morva et al. (40 – 100% contamination) (20), and significantly lower than some studies done

in fellow developing countries; 94% in Ethiopia (35), 92% in India (33). The lower rates of contamination may be attributable to the global change in behaviour, i.e. that the world had become more conscious of fomites and the need to decontaminate cell phones because of the COVID-19 pandemic and thereafter. Of the cell phones where micro-organisms were isolated; 50.91% were not identified due to the limitation of financial resources. Figure 3.3 demonstrates the micro-organisms that were identified (*n* = 26). Twenty of these; (76.9%) were *S. Epidermidis*, a pathogen previously regarded as a commensal and now ranked first as an agent of nosocomial infections as well as bacteraemia associated with indwelling devices (31). Most notable *S. Epidermidis* infections preferentially affect patients that are critically ill, those with prolonged hospital stay and the immunocompromised patient (32).

The rest of the micro-organisms identified are also considered to be pathogenic. These included *S. aureus; S. haemolyticus, S. capitis and E. coli*; in descending prevalence. There was no record of multi-drug resistance with *S. aureus*, unlike studies done by Ulger noting 52% methicillin-resistant *S. aureus* contamination (16) (see Table 3.6).This is an important finding in our setting; as drug resistant micro-organisms are noted to be tremendously difficult to manage, especially around PJI's. Table 3.6 shows micro-organisms frequently resistant to the penicillin, specifically cloxacillin; but none were noted to be multidrug-resistant and requiring drugs such as an oxazoldinone (Linezolid) for escalation of management.

The high number of micro-organisms that were isolated but not identified means that we may have missed micro-organisms similar to other studies from around the world, which include *Klebsiella pneumoniae*, Coagulase-negative *staphylococcus and Bacillus* species (28). These, alongside those already identified should increase concern for nosocomial sepsis because of cell phone contamination, as well as increased levels of virulence. Most studies yielded growth of Coagulase-negative *staphylococcus* (CONS) ranging from 11% (17) to 68% (15,28) – Ulger and Karabay while systemic review done by Morvai et al. reported CONS to be one of the two most identified bacteria in 30 studies (20).

The frequent isolation of *S. epidermidis* is a concern, though it is expected because this is the most frequently identified micro-organism in both PJI as well as nosocomial infections in patient with indwelling medical devices. The fact that it is found on the surfaces of cell phones at a high rate may correlate with the cell phone being a vector between the HCWs cell phone and their hand, then to the patient and their surgical wound. Not only that, but the indiscreet proximity of the cell phone when the anaesthetist assists with either taking of pictures or bringing the phone closer for the surgeon whilst operating, is something that should not be but has been easily overlooked.

This study could not directly correlate micro-organisms found on cell phones with pathogens isolated from wounds in the same setting, but noting the degree of pathogenic contamination of micro-organisms in the South African setting, as well as findings from Elkhoy et al. noting the same micro-organisms isolated from the user's hands and cell phone (34), one can speculate that hazard of cell phones being problematic, through hand cross-contamination. An Ethiopian study also reported that 73% of participants who did not practise hand hygiene before touching patients had bacterial isolates from their phones (31). This raises concern similar to that of Jeske et al. who found that previously decontaminated hands of HCWs were then recolonised after handling their cell phone (35). Meadow et al. were also able to report a fraction of micro-organisms found on cell phones of HCW subsequently being found on the participant's hand (36).

This study, as per Table 3.3, demonstrated the poor hygiene involved in using cell phones while seeing patients (59.7%) and subsequent lack of decontamination after cell phone usage; 20.9% mostly washed their hands and 32.26% never cleaned their hands after usage and before touching the patient. The results are not similar to Tiwarli et al.'s depiction of dental professionals who reported using the cell phones in between patients without wearing gloves or imploring decontaminating procedures (37). A similar study done by Misgana et al. had

similar results; almost half of the HCWs used their phones while seeing patients and did not implore any form of hand hygiene in between seeing the patient and using their phone (26).

Though there are studies, which illustrate the effectiveness of frequent cleaning and decontamination of cell phones (16,38), the vast majority of health institutes do not have a protocol or even guidelines around cell phone hygiene. Shakir et al. found that cell phones in their study had a contamination rate of 53% prior to and 44% after decontamination (38). Similar results were found by Jalalmanesh et al. (39). Murgier et al., found the rates of contamination to be 94% pre-decontamination and 75% post decontamination in the Orthopaedic theatre setting (16). Shakir et al. also found that after a week post decontamination, cell phone contamination peaked at 75%, after dropping to 8% immediately after decontamination (38). This implies that regular cleaning is mandatory to prevent recolonisation. Most (74.29%) healthcare workers in our setting admit to cleaning their phones, with only 38.71% cleaning their phones every day and about 14% cleaning their phones every week, one quarter (25.81%) reporting to never cleaning their phones (see Table 3.4). This is quite an improvement in comparison to previous studies where the rate of participants cleaning their phones ranged between 8% and 29% (16, 40,41). In addition, to note was the use of alcohol swabs to clean cell phones; which have been found to be effective in eradicating cell phone bacteria (42).

To note there was no statistically significant difference in micro-organism contamination of cell phones that were regularly cleaned and those that were not ($p = 0.637$). Similar findings were noted in a study Koscova et al. (43), though the confounders can be many i.e. method of cleaning, thoroughness of disinfection or accuracy of information.

The pivotal role of cell phones and dire consequence of nosocomial infections, including surgical site sepsis and peri-prosthetic infections presents a conundrum when it comes to how cell phones should be handled in Orthopaedic theatres and around orthopaedic patients.

Contamination of cell phones at CMJAH showed not only a high bacterial contamination rate, but also showed contamination with pathogens. These findings, coupled with the cell phone hygiene behaviour tending towards use without discretion and infrequent decontamination, leaves the in-patient vulnerable to inoculation and subsequent morbidity. The overwhelming recommendation in previous studies around cell phone contamination and hygiene is the need for strict adherence to hand hygiene. Cell phones are here to stay, it is imperative that through education, decontamination procedures and hand hygiene, we endeavour for nosocomial infections to be on their way out.

Limitations

- Resource constraints limiting the number of micro-organisms that could be identified after isolation.
- Maintaining anonymity with regards to questionnaires and cell phone sampling while ensuring there is no repetition of participants.
- Intern doctors, who make up a large proportion of the working staff, could not be included in the study due to budget constraints.

Recommendations

i. Mandate the daily cleaning of cell phones - either through decontamination procedures on entry of theatre or the ward

ii. Promote hand hygiene (cleaning or alcohol clean) before and after handling of patients.

iii. Avoid use of cell phones between clinical procedures

iv. Avoid cell phone use when seeing patients. If necessary use alcohol to decontaminate your hands if you do touch your cell phone.

v. Frequent education around the potential of cell phones being hazardous and vectors for the spread of micro-organisms.

vi. Further studies to be done to assess the microorganism contamination cellphones of orthopaedic patients

CHAPTER 5 - CONCLUSION

The micro-organism contamination rate of cell phones of health care workers at Charlotte Maxeke Academic Hospital was generally lower than contamination rates from previous studies elsewhere. Moreover, the CFU/cm^2 contamination rate was within the acceptable limits for surfaces in the hospital environment. Education around cell phone hygiene is pivotal in attempting to decrease cell phone contamination and subsequently preventing surgical site sepsis and peri-prosthetic joint infection.

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APPENDICES

Appendix A: Data Collection form

Appendix B: Ethics clearance certificate

Appendix C: Patient Information sheet and Informed Consent form

Appendix A: Data Collection form

CMJAH Cell phone Microbial Contamination Study

Age:_____years Gender: ☐M ☐F

Department:

☐Orthopaedics ☐Anaesthetics ☐General Surgery ☐Other

_____

Orthopaedic Unit:

☐Spine ☐Trauma ☐Arthroplasty ☐Paeds ☐Sports/Foot & Ankle

Designation:

☐Consultant ☐Fellow ☐Registrar ☐MO ☐Intern ☐Medical Rep

☐Scrub Nurse ☐Floor Nurse ☐Anaesthetic Nurse ☐Ward Sister

☐Ward Nurse

Questions

Do you own a personal cell phone? **☐Yes** **☐No**

1. If yes, does it have a plastic protective cover ☐Yes ☐No
2. Does it have ☐a back cover protection ☐a fold over cover

a. Is the cover ☐closed or ☐perforated

Type of phone: ☐Keypad/QWERTY ☐ Touch screen

☐ Both

Where is your phone usually placed when not in use?

☐Upper pocket ☐Front bottom pocket ☐Back pocket ☐ Phone pouch ☐

Handbag/Bag ☐Belt pouch

Do you use your cell phone at work? ☐Yes ☐No

1. How often do you use your cell phone at work?

☐At least every 10 mins ☐At least every hour ☐At least every 3 hour

☐Only every 6 hours ☐Pretty much never

What do you MOSTLY use your cell phone at work for? (Tick 1)

☐Work communication ☐Social communication ☐Social media

☐ Education reference/Medical Information ☐Track results ☐Other _____

_____

Do you use your cell phone in the bathroom? ☐Yes ☐No

1. If yes, what activities do you use your phone for when using the bathroom?

☐Answering calls ☐Texting ☐Social media ☐Games ☐Browsing ☐Not applicable

Do you clean your phone? ☐Yes ☐No

1. If yes, what do you clean your phone with?

☐Alcohol swab ☐Dry cloth ☐Chlorhexidine hand wash ☐Soap and water

☐wet tissue

☐Household surface cleaner ☐Other _____

2. How often do your clean your cell phone?

☐After every use ☐≥once per day ☐ at least once per week ☐ at least once every 2 weeks ☐at least every month much ☐very seldom ☐pretty never

Do you use your phone while seeing patients? ☐Yes ☐No

1. Do you wash your hands or use alcohol/chlorhexidine spray after using your phone before touching patients? ☐Yes ☐No ☐Mostly

Which are the areas in the hospital that you have used your mobile phone?

☐ Theatre ☐Ward ☐Clinic

Are you aware that there may be micro-organisms on your cell phone?

☐Yes ☐No

Please indicate on the scale below which one of these answers is most correct:

1. Mobile phones are a vehicle for the spread of nosocomial pathogens

☐Strongly disagree ☐ Disagree ☐Neutral ☐Agree ☐Strongly agree

2. There should be restricted use of Mobile Phones in the clinical setting

☐Strongly disagree ☐ Disagree ☐Neutral ☐Agree ☐Strongly agree

Appendix B: Ethics clearance certificate

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R14/49 Dr Yenziwe Linda Ngema

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M190510

NAME: (Principal Investigator)	Dr Yenziwe Linda Ngema
DEPARTMENT:	Orthopaedic Surgery Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	Microbial Contamination of Cell phones of Health Care Workers working in the Orthopaedic Department at Charlotte Maxeke Johannesburg Academic Hospital
DATE CONSIDERED:	31/05/2019
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Doctors J. Pietrzak, N. Sakhauli, L. Mokete and N. Samodien
APPROVED BY:	Doctor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	29/10/2019

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 Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. 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.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **May** and will therefore be due in the month of **May** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date: 31 Aug 2019

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Patient Information sheet and Informed Consent Form

STUDY INFORMATION DOCUMENT

Study title: Microbial Contamination of Cell phones of Health Care Workers in the Orthopaedic Department at Charlotte Maxeke Johannesburg Academic Hospital

Greeting

Hello, my name is Dr Ngema/Dr Ndou/Dr Pietrzak. This is a request for you to participate in a research study that intends to determine how you use your personal mobile phone device at work and whether it is colonized with any bacteria.

Introduction:

The study entails you answering a brief questionnaire. This should take no longer than 5 minutes to complete. Thereafter, we will commence with the swabbing of your personal mobile phone device. This, too, should take no longer than a minute. You can request your result in 2 weeks

Invitation to Participate: We are asking you to take part in a research study

What is involved in the study? This could include but would not necessarily be limited to such features as:

1. This is a Cross-sectional Prospective study that will involve you filling out a questionnaire and the swabbing of the back and front of your phone to assess whether there is bacterial contamination.
2. The study will run in June 2022 for 2 weeks.
3. The cellphones will be swabbed under aseptic techniques and analyses by NHLS
4. The cellphone swabbing and questionnaire filling out should take no longer than 5 to 10 minutes and will be done wherever the participant will be; either the orthopaedic wards, theatres or clinics.
5. The questionnaire to be filled out will be a hard copy which will then be collected upon completion.
6. The questions involve cellphone usage, cellphone hygiene and attitude around that. The questionnaire should take around 5 minutes to fill.

Risks of being involved in the study: There are no anticipated risks associated with study participation.

Benefits of being in the study:

This study will allow us to understand the use of your personal mobile phone devices in the hospital and especially in theatre. It will also establish if these devices are colonized with bacteria that may serve a source of infection. The participant will be given pertinent information on the study while involved in the project; after the results are available, the participant should be offered a free results summary, on request.

Participation is voluntary:

Participation in the study is voluntary. You can withdraw your consent to participate in the study at any time and without stating any particular reason. This will not have any consequences for

your further treatment. If you wish to participate, sign the declaration of consent on the final page. If you agree to participate at this time, you may later on withdraw your consent without your treatment being affected in any way. If you later on wish to withdraw your consent or have questions concerning the study, you may contact Please call me at any time to discuss any concerns that you may have.

Reimbursements for "out of pocket" expenses: there is to be no payment or cost associated with participation is this study.

Confidentiality: Normally personal information will be treated in the strictest confidence and will only be available to me and Supervisors. The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law
2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit
3. the South African Health Products Regulatory Authority (SAHPRA) might conceivably require access to personal data, if conducting an investigation into a drug trial

Participants should be assured that no individual will be identified by name in any report or publication arising out of this study. All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

Anonymity can usually only be guaranteed in questionnaires, whether in hard copy or online.

Contact details of researcher/s:

○ Dr Y.L. Ngema: Email: yenzdapres@yahoo.com. Phone: 073 680 1653 ○ Dr W. Ndou: Email: wofhatwandou@gmail.com Phone: 072 991 2240 ○ Dr J. Pietrzak: Email:

jurek.pietrzak@wits.ac.za Phone: 083 456 8090 ○ Prof M.T. Ramokgopa: Email: mmampapatla@gmail.com Phone: 082 564 6169 **Outputs**

All the participants are entitled to receive information about the outcome or results of the study. I, as the principal investigator, will contact the participant with his/her individual results if permission is granted at the onset of participation.

There will also be feedback sessions to the participants and the rest of the department with the results and strategies and protocols to improve our contamination rates as a department. This will be in the form of a group feedback session with the doctors, nurses and other orthopaedic staff. There is usually MMED feedback meetings within the orthopaedic department but as this is usually amongst doctors, there will be further feedback sessions for participants who are not doctors.

Contact details of HREC administrator and chair – for reporting of complaints / problems. The following text is recommended:

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor C.B. Penny, who may be contacted via any one member of the secretariat. The telephone numbers for the Committee secretariat are 011 717 2700/1234/2656/1252 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za, Rhulani.Mukansi@wits.ac.za, Mapula.Ramaila@wits.ac.za and Iain.Burns@wits.ac.za.

Thank you for reading this Study Information Sheet. Date: March 2023

WITS UNIVERSITY

PARTICIPANT CONSENT SHEET

Project Title: Microbial Contamination of Cell phones of Health Care Workers in the Orthopaedic Department at Charlotte Maxeke Johannesburg Academic Hospital

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

- Dr Y.L. Ngema, Principal Investigator, telephone no. 073 680 1653, or by e-mail at yenzdapres@yahoo.com ,
- Dr W. Ndou, Supervisor, on telephone no. 072 991 2240, or by e-mail at wofhatwandou@gmail.com
- Dr J. Pietrzak, Supervisor, on telephone no. 083 456 8090, or by e-mail at jurek.pietrzak@wits.ac.za
- Dr M.T. Ramokgopa, Supervisor, on telephone no. 082 564 6169, or by e-mail at mmampapatla@gmail.com

Professor C.B. Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, who may be contacted via any one member of the secretariat. The telephone numbers for the Committee secretariat are 011 717 2700/1234/2656/1252 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za, Rhulani.Mukansi@wits.ac.za, Mapula.Ramaila@wits.ac.za and Iain.Burns@wits.ac.za.

Name of Participant: _____

Date: _____

Place: _____

Signature or mark _____

Witnessed by:

Name of Witness: _____

Signature: _____

Date: _____