

https://dspace.org/

Noise levels in the operating theatres at a central hospital

Carbonari, Alicia

2021
https://hdl.handle.net/10539/33570

Downloaded from a DSpace repository. https://dspace.org/

Noise levels in the operating theatres at a central hospital

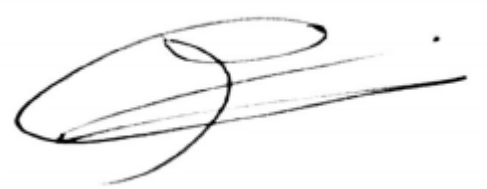
Alicia Carbonari

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

Johannesburg, 2021

Declaration

I, Alicia Carbonari 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 Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



02 August 2021

Abstract

Background

Noise in operating theatres has the potential to lead to miscommunication, noise-induced hearing loss and non-auditory health effects in operating theatre staff due to prolonged exposure and can be a stressor to operating theatre staff and patients. The aim of this study was to measure noise levels in the operating theatres at Chris Hani Baragwanath Academic Hospital (CHBAH).

Methods

A cross-sectional study design was followed. A convenience sampling method was used with a sample size of 24 theatres, 18 in elective operating theatres and six in emergency operating theatres. Noise level readings at different time points, during office hours and after hours, were obtained for each surgical discipline at CHBAH and in all emergency operating theatres using a Type 2 sound level meter, the Professional ET-958 model, with IEC61672-1 standard. The acceptable average noise levels in operating theatres in this study was ≤ 35 dB(A).

Results

The highest single peak noise level recorded was 97.1 dB(A) and the lowest single noise level was 41 dB(A). The average noise levels range from 60.9 dB(A) in interventional radiology to 68.5 dB(A) in orthopaedic surgery. No significant difference was found when comparing induction, incision and emergence ($p=0.5227$). No significant difference was found between the noise levels in the emergency and elective operating theatres. None of the noise levels at different time points were found to be compliant with the recommendations of ≤ 35 dB(A).

Conclusion

The results of the study conducted at CHBAH found that the noise levels occurring in the operating theatres are not compliant with and exceed the acceptable noise levels for operating theatres according to the South African National Standards, World Health Organization and Environmental Protection Agency.

Acknowledgements

The author would like to thank the following people fore their contribution, advice and support.

Mr Gabriel Mizan (National Institute of Occupational Health): For his advice and expertise.

Prof Juan Scribante and Ms Helen Perrie: For always being available to assist and for the invaluable guidance.

Dr Maria Fourtounas: For all the support and contributions.

Family: For all the encouragement, unconditional love and support.

Table of contents

Declaration ii

Abstract iii

Acknowledgements iv

Abbreviations x

Statement xi

Section 1: Review of the literature 1

1.1 Introduction 1

1.2 Background to noise and noise levels 1

1.3 Regulations for occupational noise levels and guidelines for noise levels in operating theatres 2

1.4 The effects of noise on patients 3

1.5 The effects of noise on operating theatre staff 5

1.6 Music in the operating theatres 6

1.7 Noise sources in the operating theatres 7

1.8 Noise levels at different times in the operating theatres 8

1.9 Noise levels in different surgical disciplines 10

1.10 The effects of behaviour modification on noise levels in operating theatres 11

1.11 Summary 12

1.12 References 13

Section 2: Author's guidelines 18

Section 3: Draft article 25

Abstract 26

Introduction 27

Methods 28

Results 31

Discussion 36

Conclusion 39

Conflict of interest 39

Acknowledgement 39

References 40

Section 4: Proposal 43

4.1 Introduction and problem statement 44

4.2 Aim and objectives 46

4.2.1 Aim 46

4.2.2 Objectives 46

4.3 Research assumptions 46

4.4 Demarcation of study field 47

4.5 Ethical considerations 47

4.6 Research methodology 48

4.6.1 Research design 48

4.6.2 Study population 48
4.6.3 Study sample 48
4.6.4 Data collection 49
4.6.5 Data analysis 51
4.7 Significance of the study 52
4.8 Validity and reliability of the study 52
4.9 Potential limitations 53
4.10 Project outline 54
4.10.1 Time frame 54
4.10.2 Budget 54
4.11 References 55
4.12 Appendices 58
Section 5: Annexures 61
5.1 Ethics waiver 61
5.2 Graduate studies approval 62
5.3 Turnitin report 63
5.4 Sample size letter 65

List of figures

Figure 1 – The 15 highest peak noise levels and surgical procedure..... 36

List of tables

Table 1 – Data points collected and operating theatres where collected..... 30

Table 2 – Operating theatre list, number of recordings and time of recording..... 32

Table 3 – Peak and minimum noise levels in the different operating theatres..... 33

Table 4 – Operating theatre noise levels at the different time points..... 34

Table 5 – Comparisons between noise levels in elective and emergency operating theatres 35

Abbreviations

dB(A)	Decibel A
NIOSH	National Institute of Occupational Safety and Health
CHBAH	Chris Hani Baragwanath Academic Hospital

Statement

The Research Report consist of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the rest of the Research Report in order to comply with the author guidelines of the Southern African Journal of Anaesthesia and Analgesia, the journal to which it is intended to be submitted.

Section 1: Review of the literature

"Unnecessary noise is the most cruel absence of care which can be inflicted either on sick or on well." Florence Nightingale, 1859 (1).

1.1 Introduction

In this literature review, a background to noise and noise levels is given. The regulations for occupational noise levels and guidelines for noise levels in operating theatres are outlined. The effect noise has on patients and operating theatre staff, music in the operating theatre and noise sources in the operating theatre are discussed. Noise levels at different times, in different surgical disciplines and the effects of behaviour modification on noise levels in operating theatres are reviewed.

1.2 Background to noise and noise levels

Sound is defined as "continuous rapid movements or vibrations that travel through air or water and can be heard when they reach a person's or animal's ear" (2). It is measured as the force per unit area produced by the sound wave and expressed in decibels, a logarithmic scale. The pitch of the sound is determined by frequency, which is the number of waves per second. The range of human hearing is between 20 and 20 000 Hz, with the decibel A (dB(A)) scale most in keeping with this frequency range (3, 4). Human perception of loudness is not equivalent to the actual sound pressure level measured in dB(A). A general rule is that an increase of 10 dB(A) is perceived as doubling the loudness of the sound to humans (4, 5).

Noise is defined as "a sound; especially when it is loud, unpleasant or disturbing" (2). Noise is subjective and differs between individuals. Sound becomes a noise when it is found to be disruptive and has a negative impact on an individual's work, communication or health (6). In physics, noise is "random, fluctuating, inharmonious waveforms that interfere with desired signals" (3).

The noise levels of objects encountered in daily life vary significantly; the rustling of leaves creates approximately 10 dB(A) of noise, normal conversation roughly 60

dB(A), a lawnmower creates 90 dB(A), while an ambulance siren is 120 dB(A). A shotgun is 130 dB(A) when fired and a jet engine during take-off is 140 dB(A) (7). Average noise levels have been found to be between 51 and 75 dB(A) in operating theatres, with peak levels between 80 and 119 dB(A) (8).

The effects of noise depend on the level of noise, type of noise, predictability, controllability, level of tolerance and task complexity involved. Continuous or periodic noises are predictable, while discontinuous or episodic noises are found to be unpredictable, which are considered more disruptive even at lower levels (9).

Communication is vital for operating theatre staff to ensure safe and efficient performance. For speech to be heard with 90% accuracy, the signal to noise ratio should be 10 – 15 dB(A) (10). Normal speech is said to be 50 dB(A), which implies that for normal communication to be heard, the background noise in the operating theatre should be a maximum of 35 dB(A). Noise in the operating theatre has the potential to lead to miscommunication and errors (11). When speech is not heard clearly, people often use visual cues to clarify the communication; however, this is hindered in the operating theatre due to the use of surgical masks, making speech harder to hear as it can be muffled by the mask (10).

A phenomenon known as masking occurs when multiple auditory signals present simultaneously to the ear, resulting in difficulty distinguishing between them. The Lombard effect occurs when the background noise is high and an individual raises their voice, talking louder, in order to be heard above the background noise (12).

1.3 Regulations for occupational noise levels and guidelines for noise levels in operating theatres

According to the American Occupational Safety and Health Administration (13), “the maximal exposure times allowed for noise exposure at 90 dB is 8 hours in a day” with a 5 dB(A) exchange rate rule, with every increase in 5 dB(A) the duration of exposure should be halved (considering that there are interruptions in the exposure to noise throughout the day). The National Institute of Occupational Safety and Health (NIOSH) (14) in America recommends a maximum exposure of

85 dB(A) for eight hours, with a 3 dB(A) exchange rate rule. Both the Occupational Safety and Health Administration and NIOSH state the maximum impulsive noise exposure, defined as a steep increase in sound level to a peak and followed by a rapid decrease in sound level, to be 140 dB(A). The NIOSH recommendation is considered the more conservative and therefore safer to hearing and is the limit quoted and used by the Department of Labour in the Environmental Regulations for Workplaces in South Africa (15) with the maximum noise exposure allowed of 85 dB(A) for eight hours with a 3 dB(A) exchange rate rule.

The World Health Organization (16) and the Environmental Protection Agency (17) of America have established guidelines for noise levels in hospitals and operating theatres. The recommendation made by the World Health Organization is that noise levels should not exceed an average of 35 dB(A) over a period of time, while that of the Environmental Protection Agency is that noise levels should not exceed an average of 45 dB(A) and should be kept as low as possible (16, 17). The South African National Standards (18), as part of the South African Bureau of Standards, has determined that average noise levels in operating theatres in South Africa should not exceed 35 dB(A).

1.4 The effects of noise on patients

Noise in operating theatres can cause patient discomfort, with 52% of patients reporting operating theatres being noisy and this noise inducing stress in as many as 16% of patients (1). It is assumed that the effects of noise depend on the type of surgery, the type of anaesthetic and the duration of exposure to the noise levels (19).

A randomised control trial at the University of Sugkyunkwan in South Korea aimed to determine if music or blocking the noise would decrease the bispectral index score of patients undergoing total knee replacements under combined spinal-epidural anaesthesia with propofol sedation (20). Fifty-nine American Society of Anesthesiologists Class I and II patients who were undergoing total knee replacements were recruited and divided into three groups. The first group was the noise group, where the patient was subjected to the ambient operating theatre

sound. The second group was the music group, where the patient could choose the music listened to through a headset and the third group was the silent group, where the patient's ears were closed with cotton wool and a headset. After the spinal-epidural anaesthetic was completed, the bispectral index score monitor was placed to obtain a baseline reading. The propofol sedation was then commenced. The results of the study showed that bispectral index scores were similar in the noise and music groups with a reduction seen in the silent group (20).

The protective reflex of the stapedius muscle contracting when a loud noise is heard is decreased or abolished by many anaesthetic agents. This is a risk and can affect patient hearing as there is the transmission of the sound energy to the inner ear. Elderly patients and those exposed to long noisy procedures are particularly susceptible to damage (1).

Another potential complication of higher noise levels in operating theatres is surgical site infections. This occurs when incisions are contaminated by skin commensals, potentially due to non-compliance with aseptic principles due to distractions such as noise. A study consisting of 64 patients with no known risk factors for surgical site infections was conducted at the Milton Keynes General Hospital in the United Kingdom (5). The patients were followed up for 30 days post-operatively. The noise levels were measured during the surgical procedures in order to determine a possible link. The results showed that in the five patients who developed surgical site infection, the noise levels were up to 10 dB(A) above the starting baseline of 47.6 dB(A), specifically at the 50-minute mark of the surgery which corresponded with the closure of the wound. Music and unrelated conversations contributed to the noise levels, possibly distracting the surgeon. The fact that the junior surgeon or assistant is often left to close the wound is also considered, as studies have shown that distraction due to noise and music is inversely proportional to experience, with the more experienced senior surgeon less affected than the junior surgeon (5).

1.5 The effects of noise on operating theatre staff

Noise-induced hearing loss is a sensorineural condition that cannot be treated medically. It often develops slowly and is only noticed once hearing has been significantly impaired (21). The characteristics of noise that can result in hearing loss include sound pressure (dB), frequency (Hz), duration of exposure and pattern of exposure (1). Personnel-related factors that may predispose staff to hearing loss include age, comorbidities, medications, substance abuse and cumulative exposure (22). The anaesthetist is particularly vulnerable to the effect of operating theatre noise on hearing loss due to prolonged exposure (1). A study showed that anaesthetists younger than 55 years of age, when compared to the general population, had significant deficits in their hearing, with 66% showing abnormalities in audiograms (23).

It is hypothesised that noise causes its non-auditory health effects by disrupting communication as well as causing annoyance. Noise is a stressor and can have an additive effect on other stressors, which are often found in the operating theatre environment (24). Stress is associated with many health complications, such as hypertension and other cardiovascular disease (25), fatigue, cognitive dysfunction, headaches, anxiety and irritability in staff members (4); as well as increased cortisol levels which can contribute to insulin resistance, stress ulcers and can further worsen cardiovascular disease (25). This is all dependent on the characteristics of the noise and its associations. Noise has been shown to compromise social cue interpretation, reducing helpfulness and increasing aggression (24).

Complex mental tasks, performed by all operating theatre staff, are at risk of being disrupted with up to 84% of anaesthetists reporting that noise affected their ability to perform mental tasks efficiently and short-term memory tests were negatively affected (1). Approximately 54% of all operating theatre personnel working in Greek public hospitals reported that noise disturbed them in the operating theatre (19).

The operating theatre is an environment that has many different forms of information occurring simultaneously, this often requires personnel, especially anaesthetists, to multitask while monitoring patients. At the Vanderbilt University in Nashville, a study assessed the ability of 33 anaesthesiology registrars to perform a visual task (testing attention) and determine a change in the tone of the pulse oximeter (26). The results of this study showed that the visual task with increasing difficulty significantly affected the participants' ability to detect changes in the pulse oximeter tone and their reaction time, with the presence of background noise compounding these effects (26).

A randomised crossover volunteer study performed at the Rouen University Hospital in France, objectively assessed the effect a noisy environment has on the anaesthetists' clinical reasoning ability using a script concordance test designed as a series of vignettes (27). The results revealed that the more junior residents in their first and second years performed less well in the noisy environment. This was not seen in the more senior residents, showing the possibility of adaptation to noise. However, the concentration in all residents was shown to be 50% lower in the noisy environment, evaluated using a visual analogue scale (27).

1.6 Music in the operating theatres

Music is a contributing factor to noise and noise pollution. A study performed in the United Kingdom showed that 72% of operating theatre staff report music being played (28). It has been found that the choice of music, as well as how it is played, are important factors as to the effect it has on staff and patients (1). Music is often played too loudly in operating theatres, increasing the volume of the alarms to compensate, resulting in more noise (7). Twenty to 26% of operating theatre staff members find that music is distracting and impairs effective communication, especially during emergencies or complications (10).

A study conducted in Glasgow at the Western Infirmary aimed to determine the effect of music and noise on psychomotor performance of anaesthetists (29). Twelve anaesthetists were selected to perform two computerised psychomotor tests, performing each test while wearing headsets with adjustable volumes. Each

subject listened to Pachelbel's Canon in D, self-chosen music, white noise or had silence while performing the tests. The results of this study showed that there was no significant difference in outcomes and that in a laboratory setting, music did not impact the anaesthetists' psychomotor performance (29).

An observational study in operating theatres at the Imperial College in London was designed to assess the effect of music on communication in operating theatres (30). Video recordings were made of 20 operations, with a total of 5 303 request and response observations made. Sixty-nine of these requests were repeated requests; 63 of these occurred in the operations with music playing showing that with music playing there is a more than five-fold increase in having to repeat the request. The effect of these repeat requests is an increase in the total operating time from 4 – 68 seconds per request. This also results in added frustration between staff members (30).

1.7 Noise sources in the operating theatres

Operating theatres are designed to be efficient and convenient to clean and maintain sterility of the operating field. The air conditioning unit contributes to the baseline noise of the operating theatre, with baseline noise levels averaging 50 dB(A) (31). The surgical equipment and trolleys are made of stainless steel, resulting in loud peaks of noise when instruments are dropped or fall on to the surface. Modern surgical equipment is a source of noise in operating theatres, with electric or air-powered drills, hammers and saws contributing significantly to noise level. The walls, floors and ceilings are made of easily washable materials in smaller areas prolonging the reverberation time of sound in the room (25). Forced-air warming units can create up to 84 dB(A) of noise encountered in operating theatres (1, 32). Anaesthetic machines and the associated alarms are considered a major source of noise in the operating theatre and are considered to be the most disruptive, according to operating theatre staff (1).

At the Indiana University Medical Centre, America, a survey was conducted on baseline operating theatre noise and then individual surgical equipment noise levels were measured (22). The baseline noise was found to be 53 dB(A) and the

equipment used had an additive effect, with all the equipment resulting in higher noise level at their maximum power setting. This showed that decreasing the power setting or number of revolutions per minute would result in less noise production. The study also showed that the smaller chisels and smaller drill bits were less noisy (22). In Johns Hopkins Hospital, in Baltimore, America, the average noise levels in 38 of the operating theatres ranged from 53 – 70.5 dB(A), with a peak noise level of 112.8 dB(A) (31).

A study conducted by Keller et al (33) at the University Hospital of Bern, Switzerland, recorded noise levels during 109 surgical procedures and determined the average noise level to be 59.5 dB(A). In Greece, nine public hospitals had noise levels measured in the operating theatres and found the mean noise levels to be from 57.4 – 78.2 dB(A) (19). The Cork University Hospital in Ireland found the mean noise level over 43 surgical procedures to be 63 dB(A), with the peak noise level of 92.8 dB(A) (12). At Hautepierre Hospital in France, the average noise levels measured during 26 surgical procedures was 52.1 dB(A) (9).

Wang et al (11) at Peking University Third Hospital in China showed the average noise levels across the operating theatres to be 61.8 – 66.7 dB(A) with the mean noise level of 64.2 dB(A). In the Chongqing Jiulongpo District Hospital of Traditional Chinese Medicine in China, the average noise level for orthopaedics, gynaecology and general surgery was 62.3 dB(A) (34).

In Egypt, the noise levels at the Kars Al Ainy Hospital were measured during surgical procedures performed under regional anaesthesia. The study found the mean noise levels to be 73 dB(A), with background noise levels of 49.9 dB(A) and a peak level of 97.2 dB(A) in the orthopaedic operating theatre and a minimum level of 51.6 dB(A) in the ophthalmology operating theatre (35).

1.8 Noise levels at different times in the operating theatres

A study performed in New Brunswick, New Jersey, America, looked at 23 cardiac procedures with the aim to determine noise levels at specific times during the procedure (25). The noise levels were measured for two minutes, with the

maximum value included. The time periods were room setup, induction, skin incision, 60 minutes post-incision, off bypass, emergence and then transport of the patient. The results of this study showed that noise levels are notably higher during induction and emergence when compared to baseline and skin incision (25).

In Greece, a total of 43 surgeries performed in nine public hospitals attempted to ascertain which stage during the procedure was associated with the most noise (19). The surgery was divided into three periods; pre-surgical, surgical and post-surgical. A sound meter was observed with peak noise levels of 75 dB(A) or higher noted with the source of the noise. The results showed that the pre-surgical time was the noisiest and the surgical time the quietest period. Sources of noise peaks observed during the operations, in order of loudness, were as follows: connection or disconnection of gas supply, displacement of equipment, tools and objects falling, metal trays, talking or laughing, doors opening or closing, suction, machine alarms and diathermy (19).

At the University of Hautepierre in France, 26 paediatric general surgery cases had noise levels recorded, dividing each into three specific times, P1 to P3. P1 was the entry of patient and preparation until prior to incision, P2 was from incision until the dressing application and P3 was from completion of dressing until exit from the operating theatre. Average noise levels were found to be around 52.1 dB(A). P1 and P3 were louder than P2, with levels of 56.5 dB(A) and 55.5 dB(A), respectively, compared to 53.1 dB(A) (9).

At the Zeynep Kamil Hospital in Istanbul, Turkey, a study was conducted which determined the noise levels for weekdays and weekends at different times of the day and night (36). This study measured noise levels in the operating theatres, clinics and outpatients on a Tuesday, Friday and Saturday over one-hour periods; 09:00 – 10:00, 13:00 – 14:00, 17:00 – 18:00, 21:00 – 22:00 and 03:00 – 04:00. The results showed that on average the noise levels in the operating theatres were lowest on Saturday at 65.3 dB(A) and highest on Tuesday at 75.7 dB(A). The noisiest period of time on Tuesday and Friday were found to be 13:00 – 14:00, with noise levels of 81.3 dB(A) and 72.9 dB(A), respectively, and 17:00 – 18:00 on

Saturday with noise levels of 66.9 dB(A). The outpatient department was found to have average noise levels higher than both the clinics and operating theatres, with Saturday 09:00 – 10:00 being the highest at 78.5 dB(A). The clinics had the lowest average noise levels, with the highest noise level found on Friday 09:00 – 10:00 at 70.2 dB(A). The quietest time for all three days was 03:00 – 04:00, with the operating theatres' noise levels at 52.3 dB(A), the clinics at 53,5 dB(A) and the outpatients at 55.6 dB(A) (36).

1.9 Noise levels in different surgical disciplines

In maxillofacial operating theatres at The Royal Blackburn Hospital in the United Kingdom, noise levels were measured during 50 different surgeries. The average noise level was found to be 58 dB(A) ranging from 54 – 61 dB(A), with peaks reaching a maximum of 117.4 dB(A) when power tools were in use (37).

At the University of Damascus in Syria, the noise levels that dentists were exposed to were determined during oral surgery and ranged from 62.1 – 72.7 dB(A) (38). This study also found a difference in noise levels produced by equipment, with new turbine drills producing noise levels of 70.9 dB(A) and used turbine drills producing noise levels of 80 dB(A) (38).

Studies have found orthopaedic surgeries to have the highest noise levels due to the tools used (39-41). A study conducted by the Department of Anaesthesia at Cork University in Ireland looked at the noise levels in 43 orthopaedic surgeries to determine the average noise levels and the peak levels above 65 dB(A) and determined the sources of these peaks (12). Average noise levels were found to be 63 dB(A), with a maximum peak level of 92.8 dB(A). In 22.2% of cases, noise levels were higher than 65 dB(A), with levels over 80 dB(A) in only 1% of cases. Peaks above 65 dB(A) were assessed; conversations between staff members were the noise source in 29.5% of cases, 19.9% were due to metal instruments and 19.1% due to orthopaedic tools. Regarding the conversations, 54.4% were patient-related or with the patient and 45.6% were not (12).

At the Tufts University in Boston, America, the noise levels experienced in the obstetric operating theatres were determined (42). A total of 10 scenarios were recorded, measuring the noise levels in the centre of the operating theatre with the addition of various noise sources being suction, pulse oximeter, paper crinkling and people talking. The initial noise measurement was the operating theatre baseline at 54.3 dB(A). With the addition of three suction machines, the noise level was 58.5 dB(A). The three suction machines and the pulse oximeter combined had a noise level of 59.8 dB(A). The suctions machines with the pulse oximeter and glove paper crinkling had noise levels of 81.3 dB(A). The suctions, pulse oximeter and with two people talking measured noise levels of 73 dB(A) and with the addition of glove paper crinkling measured 81.6 dB(A). The suction, pulse oximeter and the throwing away of sharps resulted in a noise level of 77.7 dB(A). The authors concluded that a large amount of noise is avoidable or modifiable with behaviour modification (42).

In the academic hospitals associated with the Hamadan University in Iran, the noise levels in operating theatres were determined and compared to the recommended standards (43). The findings were that all operating theatre noise levels were above the recommended noise levels, with orthopaedic surgery being the noisiest. The main sources of noise in this study were falling objects at 93 dB(A) followed by alarms and hammering at 78 dB(A) and 77 dB(A), respectively (43).

1.10 The effects of behaviour modification on noise levels in operating theatres

In order to determine if noise levels could be reduced with behaviour modification, a quality improvement project was implemented over four months in two community hospitals associated with the Post University in Waterbury, Connecticut, America (44). The first two months involved obtaining initial noise levels in the operating theatres and then analysing the data that was collected. In the third month, changes were implemented, which involved lectures as well as a formal letter which contained details regarding noise and specific strategies to be

used to decrease the noise levels encountered in the operating theatre, especially during induction and emergence of anaesthesia. Along with this, posters stating “Quiet Please” were placed on all the operating theatre doors as a reminder. A sound meter was placed on the anaesthetic machine, large enough to be visible to all the staff members in the operating theatre so that they could be aware of the noise levels created. During the fourth month, noise levels in the operating theatres were reassessed, showing that after implementing these changes there was a statistically significant reduction in noise levels during induction and emergence, as well as a reduction in the number of episodes of noise levels greater than 70 dB(A) (44).

Ukegjini et al (45) confirmed that visual feedback on noise levels intra-operatively resulted in a reduction in the average noise levels. This was done with a prospective single-centred study conducted in two phases at the Kantonsspital St. Gallen in Switzerland. Phase one determined the average noise level of 54.6dB(A). A sound level meter which provided visual feedback to the staff was used in phase two. There was a reduction in the average noise level to 50.8 dB(A), confirming that behaviour modification can reduce noise levels in operating theatres (45).

1.11 Summary

All the studies found in this literature review showed that the operating theatre noise levels were in excess of the recommendations made, showing that this is a global problem. It has been found that noise is particularly detrimental to anaesthetists due to the prolonged exposure and the association with loudest noise levels occurring during induction and emergence of anaesthesia. Noise has been shown to have detrimental effects on staff and patients and that with behaviour modification, it may be possible to improve this.

1.12 References

1. Katz J, Levy J. Noise in the operating room. Anesthesiology. 2014;121(4):894-8. DOI: 10.1097/ALN.0000000000000319.
2. Hornby A. Oxford advanced learners dictionary. 6th ed. Oxford, United Kingdom: Oxford University Press; 2000. p. 1408.
3. Kam P, Kam A, Thompson J. Noise pollution in the anaesthetic and intensive care environment. Anaesthesia. 1994;49(1):982-6. DOI: 10.1111/j.1365-2044.1994.tb04319.x.
4. Oliveira C, Arenas G. Occupational exposure to noise pollution in anesthesiology. Rev Bras Anestesiol. 2012;62(2):253-61. DOI: 10.1016/S0034-7094(12)70123-X.
5. Dholakia S, Jeans J, Khalid U, D'Souza C, Nemeth K. The association of noise and surgical-site infection in day-case hernia repairs. Surgery. 2015;157(6):1153-6. DOI: 10.1016/j.surg.2014.12.026.
6. Hodge B, Thompson J. Noise pollution in the operating theatre. Lancet. 1990;335(8694):891-4. DOI: 10.1016/0140-6736(90)90486-O.
7. Shambo L, Umadhay T, Pedoto A. Music in the operating room: Is it a safety hazard? AANA J. 2015;83(1):43-8. PMID: 25842633.
8. Hasfeldt D, Laerkner E, Birkelund R. Noise in the operating room: What do we know? A review of the literature. J Perianesth Nurs 2010;25(6):380-6. DOI: 10.1016/j.jopan.2010.10.001.
9. Alshammari D, Sica M, Osailan S, Tuan V, Talon I, Schneider A, et al. Noise in a university operating theatre during the course of pediatric surgical procedures. Current Pediatric Research. 2017;21(4):572-6.
10. Way T, Long A, Weihing J, Ritchie R, Jones R, Bush M, et al. Effects of noise on auditory processing in the operating room. J Am Coll Surg. 2013;216(5):933-8. DOI: 10.1016/j.jamcollsurg.2012.12.048.
11. Wang X, Zeng L, Li G, Xu M, Wei B, Li G, et al. A cross-sectional study in a tertiary care hospital in China: Noise or silence in the operating room. BMJ Open. 2017;7(e016316):1-6. DOI: 10.1136/bmjopen-2017-016316.
12. Fitzgerald G, O'Donnell B. Anaesthetists noise exposure in orthopaedic operating theatres. Ir Med J. 2012;105(7):239-41. PMID: 23008884.

13. U.S. Department of Labor. Occupational noise exposure. Available from: http://www.osha.gov/dts/osta/otm/noise/standards.html [Date accessed 11 Nov. 2017].
14. National Institute for Occupational Safety and Health. Criteria for a recommended standard: Occupational noise exposure, 1998. Available from: http://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf [Date accessed 11 Nov. 2017].
15. Department of Labour. Occupational Health and Safety Act: Noise-induced Hearing Loss Regulations, 85. Sect. 43 (2003) Available from: http://www.labourguide.co.za/health-and-safety/848-health-and-safety-downloads [Date accessed 11 Nov. 2017].
16. World Health Organization. Guidelines for community noise, 1999. Available from: http://www.who.int/docstore/peh/noise/guidelines2.html [Date accessed 7 Nov. 2017].
17. U.S Environmental Protection Agency. EPA identifies noise levels affecting health and welfare, 1974. Available from: http://archive.epa.gov/epa/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare.html [Date accessed 7 Nov. 2017].
18. South African National Standards. The measurement and rating of environmental noise with respect to annoyance and to speech communication. Guidelines: 10103:2008. Pretoria, South Africa: Standards South Africa; 2008 Available from: http:///C:/Users/Alicia/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/SANS10103%20(1).pdf [Date accessed 30 April 2019].
19. Tsiou C, Efthymiatos G, Katostaras T. Noise in the operating rooms of Greek Hospitals. J Acoust Soc Am. 2008;123(2):757-65. DOI: 10.1121/1.2821972.
20. Kang J, Lee J, Kim D, Kim J, Kim C, Hahm T, et al. Blocking noise but not music lowers bispectral index scores during sedation in noisy operating rooms. J Clin Anesth. 2008;20(1):12-6. DOI: 10.1016/j.jclinane.2007.06.005.

21. Chen L, Brueck S, Nirmrier M. Evaluation of potential noise exposures in hospital operating rooms. AORN J. 2012;96(4):412-8. DOI: 10.1016/j.aorn.2012.06.001.
22. Fritsch M, Chacko C, Patterson E. Operating room sound level hazards for patients and physicians. Otol Neurotol. 2010;31(5):715-21. DOI: 10.1097/MOA.0b013e3181d8d717.
23. Wallace M, Ashman M, Matjasko J. Hearing acuity of anesthesiologist and alarm detection. Anesthesiology. 1994;81(1):13-28. DOI: 10.1097/00000542-199407000-00005.
24. Stansfeld S, Matheson M. Noise pollution: Non-auditory effects on health. Br Med Bull. 2003;68(1):243- 57. DOI: 10.1093/bmb/ldg033.
25. Ginsberg S, Pantin E, Kraidin J, Solina A, Panjwani S, Yang G. Noise levels in modern operating rooms during surgery. J Cardiothorac Vasc Anesth. 2013;27(3):528-30. DOI: 10.1053/j.jvca.2012.09.001.
26. Stevenson R, Schlesinger J, Wallace M. Effects of divided attention and operating room noise on perception of pulse oximeter pitch changes. Anesthesiology. 2013;118(2):376-81. DOI: 10.1097/ALN.0b013e31827d417b.
27. Enser M, Moriceau J, Abily J, Damm C, Occhiali E, Besnier E, et al. Background noise lowers the performance of anaesthesiology residents' clinical reasoning when measured by script concordance. Eur J Anaesthesiol. 2017;34(7):464-70. DOI: 10.1097/EJA.0000000000000624.
28. Hawksworth C, Asbury A, Millar K. Music in theatre: Not so harmonious. Anaesthesia. 1997;52(1):79-83. DOI: doi.org/10.1111/j.1365-2044.1997.t01-1-012-az012.x.
29. Hawksworth C, Sivalingam P, Asbury A. The effect of music on anaethetists' psychomotor performance. Anaesthesia. 1997;53(2):195-7. DOI: 10.1046/j.1365-2044.1998.00274.x.
30. Weldon S, Korkiakangas T, Bezemer J, Kneebone R. Music and communication in the operating theatre. J Adv Nurs. 2015;71(12):2763-74. DOI: 10.1111/jan.12744.

31. Kracht J, Busch-Vishniac I, West J. Noise in the operating rooms of Johns Hopkins Hospital. J Acoust Soc Am. 2007;121(5):2673-9. DOI: 10.1121/1.2714921.
32. Shapiro R, Berland T. Noise in the operating room. N Engl J Med. 1972;287(24):1236-8. DOI: 10.1056/NEJM197212142872407.
33. Keller S, Tschan F, Beldi G, Kurmann A, Candinas D, Semmer N. Noise peaks influence communication in the operating room. Ergonomics. 2016;59(12):1541-52. DOI: 10.1080/00140139.2016.1159736.
34. Liu W, Xie H. Noise levels and noise sources in the operating theatres. 24th International congress on sound and vibration; 23-27 July 2017; London. p. 4353-60.
35. Mohammed H, Badawy S, Hussien A, Gorgy A. Assessment of noise pollution and its effect on patients undergoing surgeries under regional anesthesia, is it time to incorporate noise monitoring to anesthesia monitors: An observational cohort study. Ain-Shams Journal of Anesthesiology. 2020;12(20):1-9. DOI: 10.1186/s42077-020-00070-1.
36. Yarar O, Temizsoy E, Gunay O. Noise pollution level in a pediatric hospital. Int J Environ Sci Technol. 2018;16(2):5107-12. DOI: 10.1007/s13762-018-1831-7.
37. Tay B, Prabhu I, Cousin C, Cousin G. Occupational exposure to noise in maxillofacial operating theatres: An initial prospective study. Br J Oral Maxillofac Surg. 2016;54(1):94-6. DOI: 10.1016/j.bjoms.2015.09.021.
38. Qsaibati L, Ibraim O. Noise levels of dental equipment used in the dental college of Damascus University. Dent Res J. 2014;11(6):624-30. PMID: 25540655.
39. Ullah R, Bailie N, Crowther S, Cullen J. Noise exposure in orthopaedic practice: Potential health risk. J Laryngol Otol. 2004;118(6):413-6. DOI: 10.1258/002221504323219509.
40. Mullett H, Synnott K, Quinlan W. Occupational noise levels in orthopaedic surgery. Irish J Med Sci. 1999;162(2):106. DOI: 10.1007/BF02946475.
41. Love H. Noise exposure in the orthopaedic operating theatre: A significant health hazard. ANZ J Surg. 2003;73(10):836-8. DOI: 10.1046/j.1445-2197.2003.02276.x.

42. Ceruzzi J, Camann W. Noise in the obstetric operating room. Int J Obstet Anesth. 2016;29:87-8. DOI: 10.1016/j.ijoa.2016.10.008.
43. Giv M, Sani K, Alizadeh M, Valinejadi A, Majdabadi A. Evaluation of noise pollution level in operating rooms of hospitals: A study in Iran. Interv Med Appl Sci. 2017;9(2):61-6. DOI: 10.1556/1646.9.2017.15.
44. Hogan L, Harvey R. Creating a culture of safety by reducing noise levels in the OR. AORN J. 2015;102(4):1-7. DOI: 10.1016/j.aorn.2015.08.005.
45. Ukegjini K, Kastiunig T, Widmann B, Warschkow R. Impact of intraoperative noise measurement on the surgeon stress and patient outcomes. A prospective, controlled, single-center clinical trial with 664 patients. Surgery. 2020;167(5):843-51. DOI: 10.1016/j.surg.2019.12.010.

Section 2: Author's guidelines

Southern African Journal of Anaesthesia and Analgesia (SAJAA)

How to submit your paper online:

1. Registered authors must login to submit a paper
    1. REGISTER HERE if you do not have a username and password
    2. LOGIN HERE if you have already registered with SAJAA
2. Select Author
3. Click on CLICK HERE TO FOLLOW THE FIVE STEPS TO SUBMIT YOUR MANUSCRIPT
4. Follow the five steps to submit your paper
5. To view a video on how to submit a paper online CLICK HERE
6. To download instructions to authors CLICK HERE

Review policy and timelines

1. Immediate notification if submitted successfully
2. Notification within 3 weeks if not accepted for further review
3. Notification within 3 months if accepted for publication, if revisions are required or if rejected by both reviewers.
4. Publication within 6 months after submission.

Aims, scope and review policy

The *SA Journal of Anaesthesia and Analgesia* aims to publish original research and review articles of relevance and interest to the anaesthetist in academia, public sector and private practice. Papers are peer reviewed to ensure that the contents are understandable, valid, important, interesting and enjoyed. All manuscripts must be submitted online.

SAJAA is accredited by the Department of Education for the measurement of research output of public higher institutions of South Africa (SAPSE accredited). All articles in SAJAA will be peer reviewed.

Article sections and length

The following contributions are accepted (word counts exclude abstracts, tables and references):

- **Original Research** (2 800 – 3 200 words / 4-5 pages)
- **Clinical Reviews** (2 400 words / 3-4 pages)
- **Drug Reviews** (2 400 words / 3-4 pages)
- **Case Studies** (1 800 words / 3 pages)
- **Scientific Letters** (2 400 words / 3-4 pages)
- **Letters to the Editor** (400-800 words]

Please see the journal's section policies section policies for further details.

FULL AUTHOR GUIDELINES

Title page

All articles must have a title page with the following information and in this particular order: Title of the article; surname, initials, qualifications and affiliation of each author; The name, postal address, e-mail address and telephonic contact details of the corresponding author and at least 5 keywords.

Abstract

All articles should include an abstract. The structured abstract for an Original Research article should be between 200 and 230 words and should consist of four paragraphs labeled Background, Methods, Results, and Conclusions. It should briefly describe the problem or issue being addressed in the study, how the study was performed, the major results, and what the authors conclude from these results. The abstracts for other types of articles should be no longer than 230 words and need not follow the structured abstract format.

Keywords

All articles should include keywords. Up to five words or short phrases should be used. Use terms from the Medical Subject Headings (MeSH) of Index Medicus when available and appropriate. Key words are used to index the article and may be published with the abstract.

Acknowledgements

In a separate section, acknowledge any financial support received or possible conflict of interest. This section may also be used to acknowledge substantial contributions to the research or preparation of the manuscript made by persons other than the authors.

References

Cite references in numerical order in the text, in superscript format (Format> Font> Click superscript). Please do not use brackets or do not use the foot note function of MS Word.

In the References section, references must be typed double-spaced and numbered consecutively in the order in which they are cited, not alphabetically.

The style for references should follow the format set forth in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals (http://www.icmje.org) prepared by the International Committee of Medical Journal Editors. Abbreviations for journal titles should follow Index *Medicus* format. Authors are responsible for the accuracy of all references. Personal communications and unpublished data should not be referenced. If essential, such material should be incorporated in the appropriate place in the text.

List all authors when there are six or fewer; when there are seven or more, list the first three, then “;et al.”; When citing URLs to web documents, place in the reference list, and use the following format: Authors of document (if available). Title of document (if available). URL. (Accessed [date]).

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.
2. Polgreen PM, Diekema DJ, Vandeberg J, Wiblin RT, Chen YY, David S, et al. Risk factors for groin wound infection after femoral artery catheterization: a case-control study. Infect Control Hosp Epidemiol [Internet]. 2006 Jan [cited 2007 Jan 5];27(1):34-7. Available from: http://www.journals.uchicago.edu/ICHE/journal/issues/v27n1/2004069/2004069.web. pdf.

More sample references can be found at:

http://www.nlm.nih.gov/bsd/uniform_requirements.html

Tables

Tables should be self-explanatory, clearly organised, and supplemental to the text of the manuscript. Each table should include a clear descriptive title on top and numbered in Arabic numerals (e.g. 1,2,3…) in order of its appearance as called out in text. Tables must me inserted in the correct position in the text. Authors should place explanatory matter in footnotes, not in the heading. Explain in footnotes all non-standard abbreviations.

For footnotes use the following symbols, in sequence:*,†,‡,§,||,**,††,‡‡

Figures

All figures must be inserted in the appropriate position of the electronic document. Symbols, lettering, and numbering (in Arabic numerals e.g. 1, 2, etc. in order of appearance in the text)

should be placed below the figure, clear and large enough to remain legible after the figure has been reduced. Figures must have clear descriptive titles.

Photographs and images

If photographs of patients are used, either the subject should not be identifiable or use of the picture should be authorised by an enclosed written permission from the subject. The position of photographs and images should be clearly indicated in the text. Electronic images should be saved as either jpeg or gif files. All photographs should be scanned at a high resolution (300dpi, print optimised). Please number the images appropriately.

Permission

Permission should be obtained from the author and publisher for the use of quotes, illustrations, tables, and other materials taken from previously published works, which are not in the public domain. The author is responsible for the payment of any copyright fee(s) if these have not been waived. The letters of permission should accompany the manuscript. The original source(s) should be mentioned in the figure legend or as a footnote to a table.

Review and action

Manuscripts are initially examined by the editorial staff and are usually sent to independent reviewers who are not informed of the identity of the author(s). When publication in its original form is not recommended, the reviewers' comments (without the identity of the reviewer being disclosed) may be passed to the first author and may include suggested revisions. Manuscripts not approved for publication will not be returned.

Ethical considerations

Papers based on original research must adhere to the Declaration of Helsinki on "Ethical Principles for Medical Research Involving Human Subjects"; and must specify from which recognised ethics committee approval for the research was obtained.

Conflict of interest

Authors must declare all financial contributions to their work or other forms of conflict of interest, which may prevent them from executing and publishing unbiased research. [Conflict of interest exists when an author (or the author's institution), has financial or personal relationships with other persons or organizations that inappropriately influence (bias) his or her opinions or actions.] **Modified from: Davidoff F, et al. Sponsorship, Authorship, and Accountability. (Editorial) JAMA 2001: 286(10) The following declaration may be used if appropriate: "I declare that I have no financial or personal relationship(s) which may have inappropriately influenced me in writing this paper."

Submissions and correspondence

All submissions must be made online at www.sajaa.co.za and correspondence regarding manuscripts should be addressed to:

The Editor, SAJAA, E-mail: toc@sajaa.co.za

Note: Ensure that the article ID [reference] number is included in the subject of your email correspondence.

Electronic submissions by post or via email

Authors with no e-mail or internet connection can mail their submissions on a CD to: SAJAA, PO Box 14804, Lyttelton Manor, 0140, Gauteng, South Africa.

All manuscripts will be processed online. Submissions by post or by e-mail must be accompanied by a signed copy of the following indemnity and copyright form. CLICK HERE to download and save it to your computer.

Submissions by email should be send as an attachment to

Tips on Preparing your manuscript

1. Please consult the “Uniform requirements for manuscripts submitted to biomedical journals” at www.icmje.org
2. Please consult the guide on Vancouver referencing methods at: http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=citmed.TOC&depth=2
3. The submission must be in UK English, typed in Microsoft Word or RTF with no double spaces after the full stops, double paragraph spacing, font size 10 and font type: Times New Roman.
4. All author details (Full names, Qualifications and affiliation) must be provided.
5. The full contact details of corresponding author (Tel, fax, e-mail, postal address) must be on the manuscript.
6. There must be an abstract and keywords.
7. References must strictly be in Vancouver format. (Reference numbers must be strictly numerical and be typed in superscript, not be in brackets and must be placed AFTER the full stop or comma.)
8. It must be clear where every figure and table should be placed in the text. If possible, tables and figures must be placed in the text where appropriate. If too large or impractical, they may be featured at the end of the manuscript or uploaded as separate supplementary files.
9. All photographs must be at 300dpi and clearly marked according to the figure numbers in the text. (Figure 1, Table II, etc.)
10. All numbers below ten, without percentages or units, must be written in words.
11. Figure numbers: Arabic, table numbers: Roman

Section 3: Draft article

Noise levels in the operating theatres at a central hospital

Alicia Carbonari, MBChB, DipPEC (SA), DA (SA)

Juan Scribante, PhD

Helen Perrie, MSc

Maria Fourtounas, MBChB, Dip HIV Man (SA), DA (SA), MMed (Anaes), FCA (SA)

Department of Anaesthesiology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand

Corresponding Author

AA Carbonari

Department of Anaesthesiology
Chris Hani Baragwanath Academic Hospital
26 Chris Hani Rd
Diepkloof, Soweto
Johannesburg
1860

alicia_a_carbonari@yahoo.com

Researcher Contact Number: (011) 933 9334

Key words: noise levels, operating theatre, decibels, anaesthetist

Abstract

Background

Noise in operating theatres has the potential to lead to miscommunication, noise-induced hearing loss and non-auditory health effects in operating theatre staff due to prolonged exposure and can be a stressor to operating theatre staff and patients. The aim of this study was to measure noise levels in the operating theatres at Chris Hani Baragwanath Academic Hospital (CHBAH).

Methods

A cross-sectional study design was followed. A convenience sampling method was used with a sample size of 24 theatres, 18 in elective operating theatres and six in emergency operating theatres. Noise level readings for different time points, during office hours and after hours, were obtained for each surgical discipline at CHBAH and in all emergency operating theatres using a Type 2 sound level meter, the Professional ET-958 model, with IEC61672-1 standard. The acceptable average noise levels in operating theatres in this study was ≤ 35 dB(A).

Results

The highest single peak noise level recorded was 97.1 dB(A) and the lowest single noise level was 41 dB(A). The average noise levels range from 60.9 dB(A) in interventional radiology to 68.5 dB(A) in orthopaedic surgery. No significant difference was found when comparing induction, incision and emergence ($p=0.5227$). No significant difference was found between the noise levels in the emergency and elective operating theatres. None of the noise levels at different time points were found to be compliant with the recommendations of ≤ 35 dB(A).

Conclusion

The results of the study conducted at CHBAH found that the noise levels occurring in the operating theatres are not compliant with and exceed the acceptable noise levels for operating theatres according to the South African National Standards, World Health Organization and Environmental Protection Agency.

Introduction

Noise has been labelled as “the third pollution”, alongside air and water pollution (1), with studies (2-5) conducted in different countries showing noise levels in operating theatres to be higher than the recommendations of the regulatory bodies. The World Health Organization (6), as well as the Environmental Protection Agency (7), established regulations for noise levels in hospitals and operating theatres, with the World Health Organization (6) stating that it should not exceed an average of 35 dB(A), and the Environmental Protection Agency (7) limiting noise to 45 dB(A) on average. The South African National Standards (8), a division of the South African Bureau of Standards, has determined that average noise levels in operating theatres in South Africa should not exceed 35 dB(A).

Mean noise levels have been found to be between 51 and 75 dB(A) in operating theatres, with peak levels between 80 and 119 dB(A) (9). Sources of noise in the operating theatre can be air conditioning, anaesthetic machines and monitors, suction, forced air warming blankets, equipment falling, trolley movement and conversations (5, 10). Operating theatres are designed to be efficient and convenient to clean, with walls, floors and ceilings being made of hard and easy to clean material, resulting in a long reverberation time of the sound (1).

Communication is vital between operating theatre staff for safe and efficient performance. The signal to noise ratio is defined as “ a measure of how much useful information you receive, compared to information which is not useful” (11). For speech to be heard with 90% accuracy, the signal to noise ratio should be 10 – 15 dB(A) (12). Normal speech is said to be 50 dB(A), which implies that for normal communication to be heard, the background noise in the operating theatre should be a maximum of 35 dB(A). Noise in operating theatres has the potential to lead to miscommunication and errors (3, 12).

Noise can result in noise-induced hearing loss, a form of sensorineural hearing loss that cannot be treated medically, with operating theatre staff being vulnerable to this due to prolonged exposure to increased noise levels (13). Noise can be a stressor to operating theatre staff, which can have an additive effect on other

stressors, resulting in non-auditory health effects, such as fatigue, cognitive dysfunction, headaches, anxiety, insulin resistance, as well as cardiovascular effects (14). Studies show that noise levels in the operating theatre are loudest at induction and emergence, which may have a compounding effect on the anaesthetist as these are considered stressful periods (4, 15, 16).

A study by Liu et al (17) has shown that patients can be affected by noise in the operating theatre, inducing stress in up to 16% of patients. A randomised control trial conducted in South Korea showed a reduction in bispectral index scores for patients undergoing regional anaesthesia with propofol sedation when operating theatre noise was blocked by a headset (18). Dholakia et al (19) suggest a link between increased noise levels and surgical site sepsis.

Noise in operating theatres is a problem, with noise levels found to be in excess of recommendations globally (2, 3, 5, 20). No study has been conducted to determine if the noise levels in the operating theatres of Chris Hani Baragwanath Academic Hospital (CHBAH) are compliant with the recommendations. The aim of this study was to measure noise levels in the operating theatres at CHBAH.

Methods

An ethics waiver was obtained from the Human Research Ethics Committee (Medical) at the University of the Witwatersrand and other relevant authorities. A cross-sectional research design was followed in this study.

Noise level readings were obtained in the operating theatres of CHBAH. There are 25 functioning operating theatres during office hours at CHBAH, seven of which are emergency operating theatres. After hours there are six operating theatres for emergency procedures. The operating theatre complex has three dedicated elective orthopaedic surgery lists, two elective general surgery lists and one elective gynaecology and neurosurgery list daily. The other surgical disciplines share the remain operating theatres.
In this study, a convenience sampling method was used with a sample size of 24 theatres, 18 in elective operating theatres during office hours and six in emergency

operating theatres, three during office hours and three after hours. Noise level readings were obtained for each surgical discipline and in all emergency operating theatres during office hours or after hours. Time points were recorded by a single author (AC); time in, anaesthetic start time, incision time, closing time and time out.

In consultation with occupational hygienists at the National Institute for Occupational Health, a Type 2 sound level meter was selected to measure noise for this study as it was not for occupational health and safety purposes. There are two types of sound level meters, Type 1 and Type 2. A Type 2 sound level meter is considered less accurate than a Type 1 sound level meter which is used to measure noise levels in the workplace in terms of the Occupational Health and Safety Act (21). Due to financial constraints, a Type 2 sound level meter was used, the Professional ET-958 model, with IEC61672-1 standard. The sound level meter has software that allowed the readings to be downloaded onto a computer using the data logger and then further analysed.

Data were collected from 1 September to 31 October 2019. One sound level meter was used to collect data over the two month period. The sound level meter was placed by the single author (AC) above the door of the operating theatre and set to measure the noise level each second. Staff members were not informed about the presence of the sound level meter in an attempt to avoid bias. A note placed with the sound level meter requesting that the device should not touched or removed but with no elaboration of what the device was. For office hours, the sound level meter was placed in the operating theatre just prior to 07:00 and collected at 16:00. For after-hours the sound level meter was placed in the emergency and obstetric operating theatres just before 16:00 and collected at 06:30 the following morning. Once collected, the data on the sound level meter were downloaded onto a computer. A list of data points collected and the operating theatres in which the data was collected are shown in Table 1.

Table 1 – Data points collected and operating theatres where collected

Data	Operating theatres
Theatre number Surgical discipline Type of procedure Time in to theatre Anaesthetic starting time Incision time Closing time Time out of theatre Overall noise level (baseline, active time and down time) Noise level at induction Noise level at incision time Noise level at emergence.	Burns Ear, nose and throat surgery Emergencies General surgery Gynaecology Interventional radiology Maxillofacial surgery Neonatal surgery Neurosurgery Obstetrics Ophthalmology Orthopaedic surgery Paediatric surgery Urology Vascular surgery

Noise levels were recorded from when the patient arrived in the operating theatre, from time in to time out of the operating theatre (active time) and noise levels while the operating theatre was not in use, between time out and time in (down time). The baseline noise level was recorded when there was no activity in the operating theatre. Noise peaks and the lowest noise level were also described. The average noise levels for a period of time were calculated using a Microsoft Excel® spreadsheet by dividing each measurement by 10. The anti-log of these values was determined and the relevant values for the period added together and then divided by the total number of values used. The logarithm to the base 10 of the total was calculated and multiplied by 10 to obtain the average noise level (22). The acceptable noise level determined by the South African National Standards (8) for operating theatres is ≤ 35 dB(A) and was used as the acceptable noise level in this study.

Data were analysed using the statistical program STATA version 15.0 (StataCorp, USA). Noise levels were recorded in dB(A)s and were presented as means and standard deviations. Comparisons between the noise levels in elective and emergency operating theatres were made using the independent t-test. A p-value of < 0.05 was considered statistically significant.

Results

Twenty-four noise level recordings were taken from the operating theatres of the different disciplines. The operating theatre lists, number of recordings and time of recording are shown in Table 2.

Table 2 – Operating theatre list, number of recordings and time of recording

Operating theatre list	Time of day			Time of week	
	Recordings	Office hours	After hours	Weekday	Weekend
	Number (%)	Number			
Burns	1 (4.2)	1	0	1	0
Ear, nose and throat surgery	1 (4.2)	1	0	1	0
Emergencies	6 (25)	3	3	4	2
General surgery	2 (8.3)	2	0	2	0
Gynaecology	2 (8.3)	2	0	2	0
Interventional radiology	1 (4.2)	1	0	1	0
Maxillofacial surgery	1 (4.2)	1	0	1	0
Neonatal surgery	1 (4.2)	1	0	1	0
Neurosurgery	1 (4.2)	1	0	1	0
Obstetrics	1 (4.2)	0	1	1	0
Ophthalmology	1 (4.2)	1	0	1	0
Orthopaedic surgery	3 (12.5)	3	0	3	0
Paediatric surgery	1 (4.2)	1	0	1	0
Urology	1 (4.2)	1	0	1	0
Vascular surgery	1 (4.2)	1	0	1	0
Total	**24**	**20**	**4**	**22**	**2**

The highest single peak noise level recorded was 97.1 dB(A) in the burns operating theatre. The lowest single noise level of 41 dB(A) was in a paediatric surgery operating theatre. The average noise levels range from 60.9 dB(A) in interventional radiology to 68.5 dB(A) in orthopaedic surgery. The mean peak noise level of 88.9 dB(A) was significantly higher than the noise levels at the other time points (p=0.001) and the mean lowest noise level of 46.6 dB(A) was significantly lower than the noise levels at the other time points (p=0.001). Table 3 shows the peak and minimum noise levels recorded in the operating theatres.

Table 3 – Peak and minimum noise levels in the different operating theatres

Operating theatre	Noise level (dB(A))	
	Peak	Minimum
Burns	97.1	45.6
Emergencies	95.7	44.5
Orthopaedic surgery	95.3	41.4
Paediatric surgery	93.1	41.0
General surgery	92.3	44.4
Obstetrics	88.9	44.0
Maxillofacial surgery	88.5	45.1
Ear, nose and throat surgery	88.5	47.1
Gynaecology	88.2	42.3
Urology	88.0	43.7
Ophthalmology	87.3	46.8
Interventional radiology	86.4	50.7
Vascular surgery	85.5	51.9
Neonatal surgery	85.2	44.3
Neurosurgery	84.8	53.0

The mean noise levels of the operating theatres at the different time points and the mean maximum and minimum noise levels for the time points are shown in Table 4.

Table 4 – Operating theatre noise levels at the different time points

Time point	Noise levels in dB(A)		
	Mean (SD)	Minimum	Maximum
Baseline	63.4 (4.1)	52.4	71.6
Induction	65.4 (2.7)	59.2	68.9
Incision	64.8 (2.4)	58.1	69.1
Emergence	65.1 (2.4)	59.9	70.3
Active time	64.9 (2.2)	59.8	69.2
Down time	65.5 (2.0)	61.7	69.3
Overall	65.2 (2.0)	60.9	68.5

No significant difference was found when comparing induction, incision and emergence ($p= 0.5227$).

In the emergency operating theatres, 4 after-hours operating theatres had noise level recordings, with the overall noise level mean (SD) found to be 64.7 (2.4) dB(A) and office-hours overall noise level of 65.4 (1.0) dB(A). The comparison between the noise levels in elective and emergency operating theatres at the different time points are shown in Table 5. No significant differences were found.

Table 5 – Comparisons between noise levels in elective and emergency operating theatres

Measurement time	Noise levels in dB(A)		P-value
	Elective theatre	Emergency theatre	
	Mean (SD)		
Baseline	63.6 (2.8)	62.9 (6.1)	0.7530
Induction	65.5 (2.6)	65.0 (2.9)	0.6598
Incision	64.9 (2.6)	64.4 (1.9)	0.5615
Emergence	65.3 (2.6)	64.7 (1.9)	0.5986
Active time	65.1 (2.4)	64.5 (2.1)	0.5729
Down time	65.5 (1.8)	65.6 (2.5)	0.8974
Peak	88.9 (3.7)	88.9 (3.7)	0.9723
Lowest	46.2 (3.9)	47.4 (3.6)	0.4840
Overall	65.3 (2.1)	65.1 (1.7)	0.8112

None of the time point noise levels were found to be compliant with the recommended ≤ 35 dB(A). The 15 procedures noted to have the highest peak noise levels are shown in Figure 1, which depicts the peak noise levels during surgical procedures. The South African National Standards acceptable noise level for operating theatres is indicated by the red line.

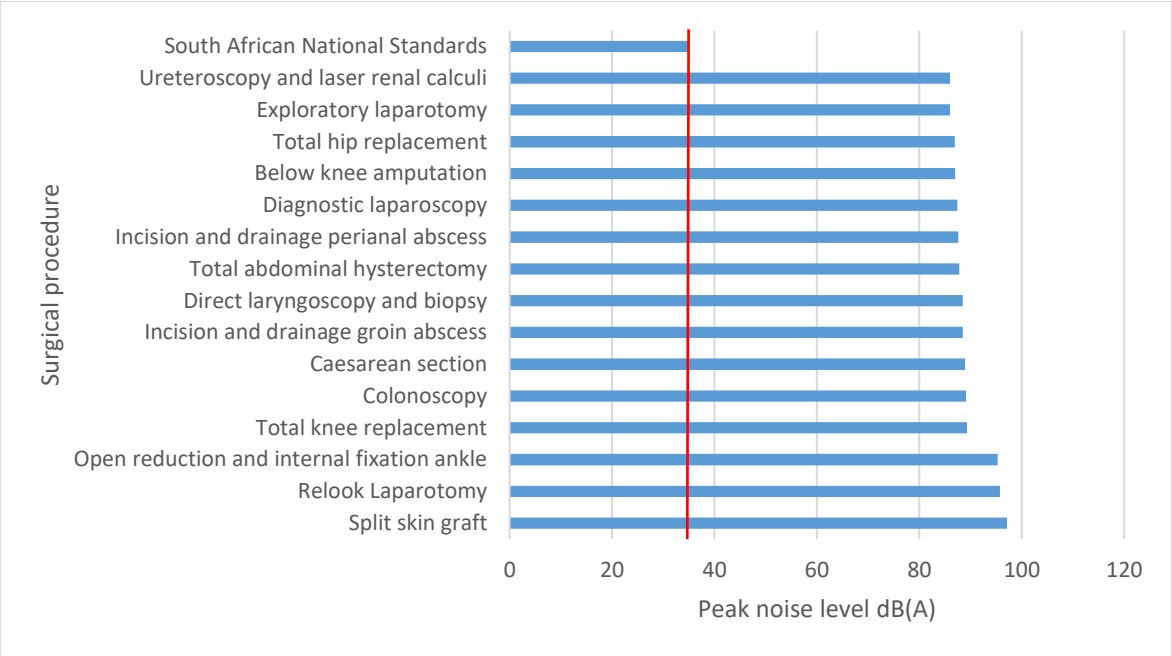


Figure 1 – The 15 highest peak noise levels and surgical procedure

Discussion

Noise in the operating theatre has the potential to lead to miscommunication and errors (3). Complex mental tasks, performed by all operating theatre staff, are at risk of being disrupted, with up to 84% of anaesthetists reporting that noise affected their ability to perform tasks – with short-term memory tests being negatively affected (15).

When speech is not heard clearly, people often use visual cues to clarify the communication; however, this is hindered in the operating theatre due to the use of surgical masks and making speech harder to hear as it can be muffled by the mask (12). The Lombard effect occurs when the background noise is high and an individual raises their voice, talking louder in order to be heard above the background noise, resulting in higher noise levels (23).

The anaesthetist is particularly vulnerable to the effect of noise on hearing loss due to prolonged exposure to operating theatre noise (15). The Department of Labour in the Environmental Regulations for Workplaces in South Africa (21) states that the maximum noise exposure allowed is 85 dB(A) for eight hours with a

3 dB(A) exchange rate rule, with every increase in 3 dB(A) the duration of exposure should be halved. If exposure is more than this, hearing protection should be implemented. This study did not find the need for hearing protection according to the above regulations. However, Wallace et al (24) showed that anaesthetists' younger than 55 years of age, when compared to the general population, had significant deficits in their hearing, with 66% showing abnormalities in audiograms. Operating theatre noise is also of concern for patients as the protective reflex of the stapedius muscle contracting when a loud noise is heard is decreased or abolished by many anaesthetic agents. This is a risk and can affect patient hearing as there is transmission of the sound energy to the inner ear. Elderly patients and those exposed to long noisy procedures are particularly susceptible to damage (15).

Mean noise levels have been found to be between 51 and 75 dB(A) in operating theatres, with peak levels between 80 and 119 dB(A) (9). This is in keeping with the findings of this study, with the mean overall noise level of 65.2 dB(A) and the peak noise level of 97.1 dB(A). According to the South African National Standards (8), none of the operating theatres in the hospital complex were found to be compliant with the average noise levels exceeding the stated maximum of 35 dB(A).

The air conditioning unit contributes to the baseline noise of the operating theatre, with baseline noise levels averaging 50 dB(A) at the John Hopkins Hospital (20) and 53 dB(A) at the Indiana University Medical Centre (25). In the operating theatres of CHBAH, the mean baseline noise level was found to be 63.4 dB(A).

When describing noise levels at induction, incision and emergence, the mean noise levels were found to be higher at induction at 65.4 dB(A), then emergence at 65.1 dB(A), with incision being the lowest at 64.8 dB(A). This finding is in keeping with other studies, such as the study conducted at the University of Hautepierre in France, which found mean noise levels from the patient entering the operating theatre until prior to incision of 56.5 dB(A), from incision to dressing application of 53.1 dB(A) and from the completion of dressing application until the patient exited the operating theatre of 55.5 dB(A) (4). In Greek public hospitals, presurgical time

was found to be the noisiest, with surgical time the quietest (5). Ginsberg et al (16) in New Brunswick, New Jersey, found that noise at induction and emergence was notably higher when compared to baseline and skin incision. In this study the mean noise level during down time was the highest, possibly due to cleaning and preparing the operating theatre.

It was hypothesised that the noise levels in the emergency operating theatres would be higher than in the elective operating theatres due to the nature of the procedures. No statistically significant difference was found, with the mean overall noise level in elective operating theatres of 65.3 dB(A) and emergency operating theatres of 65.1 dB(A).

The noise levels found in emergency operating theatres during office hours were higher overall when compared to the noise levels after hours, with a mean overall noise level of 65.4 dB(A) and 64.7 dB(A), respectively. Although the highest peak noise level, 95.7 dB(A), in the emergency operating theatres occurred after hours. A study by Yarar et al (26) in Istanbul, Turkey, found similar results with the noise levels being higher during the week between 13:00 – 14:00 and the lowest on Saturday between 03:00 – 04:00.

Studies have found orthopaedic surgeries to have the highest noise levels due to the tools used (27-29). The Department of Anaesthesia at Cork University in Ireland documented mean noise levels of 63 dB(A) with a peak noise level of 92.8 dB(A) (23). At CHBAH, the highest peak noise level of 97.1 dB(A) was found in the burns operating theatre, with the mean noise level in this operating theatre of 66.9 dB(A). Orthopaedic surgery had the third-highest peak noise level, occurring during an open reduction and internal fixation of an ankle, of 95.3 dB(A) and with a mean noise level of 64.1 dB(A).

Limitations of this study are that it is a contextual study done at CHBAH and cannot be generalised to other hospitals and that the sources of the noise levels were not assessed. Due to the small sample size, the comparisons are underpowered.

Recommendations are for in-house training of all the operating theatre staff regarding noise reduction, as well as signage requesting silence in the operating theatres and a follow-up study to assess any improvement after the above-mentioned interventions.

Conclusion

The aim of this study was to measure noise levels in the operating theatres at CHBAH. The results of the study found that the noise levels occurring in the operating theatres are not compliant with and exceed the acceptable noise levels for operating theatres according to the South African National Standards (8), World Health Organization (6) and Environmental Protection Agency (7).

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

Acknowledgement

This research was done in partial fulfilment of a Master of Medicine degree.

References

1. Shapiro R, Berland T. Noise in the operating room. N Engl J Med. 1972;287(24):1236-8. DOI: 10.1056/NEJM197212142872407.
2. Giv M, Sani K, Alizadeh M, Valinejadi A, Majdabadi A. Evaluation of noise pollution level in operating rooms of hospitals: A study in Iran. Interv Med Appl Sci. 2017;9(2):61-6. DOI: 10.1556/1646.9.2017.15.
3. Wang X, Zeng L, Li G, Xu M, Wei B, Li G, et al. A cross-sectional study in a tertiary care hospital in China: Noise or silence in the operating room. BMJ Open. 2017;7(e016316):1-6. DOI: 10.1136/bmjopen-2017-016316.
4. Alshammari D, Sica M, Osailan S, Tuan V, Talon I, Schneider A, et al. Noise in a university operating theatre during the course of pediatric surgical procedures. Current Pediatric Research. 2017;21(4):572-6.
5. Tsiou C, Efthymiatos G, Katostaras T. Noise in the operating rooms of Greek Hospitals. J Acoust Soc Am. 2008;123(2):757-65. DOI: 10.1121/1.2821972.
6. World Health Organization. Guidelines for community noise, 1999. Available from: http://www.who.int/docstore/peh/noise/guidelines2.html [Date accessed 7 Nov. 2017].
7. U.S Environmental Protection Agency. EPA identifies noise levels affecting health and welfare, 1974. Available from: http://archive.epa.gov/epa/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare.html [Date accessed 7 Nov. 2017].
8. South African National Standards. The measurement and rating of environmental noise with respect to annoyance and to speech communication. Guidelines: 10103:2008. Pretoria, South Africa: Standards South Africa; 2008 Available from: http:///C:/Users/Alicia/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/SANS10103%20(1).pdf [Date accessed 30 April 2019].
9. Hasfeldt D, Laerkner E, Birkelund R. Noise in the operating room: What do we know? A review of the literature. J Perianesth Nurs 2010;25(6):380-6. DOI: 10.1016/j.jopan.2010.10.001.

10. Hodge B, Thompson J. Noise pollution in the operating theatre. Lancet. 1990;335(8694):891-4. DOI: 10.1016/0140-6736(90)90486-O.
11. Hornby A. Oxford advanced learners dictionary. 6th ed. Oxford, United Kingdom: Oxford University Press; 2000. p. 1367.
12. Way T, Long A, Weihing J, Ritchie R, Jones R, Bush M, et al. Effects of noise on auditory processing in the operating room. J Am Coll Surg. 2013;216(5):933-8. DOI: 10.1016/j.jamcollsurg.2012.12.048.
13. Chen L, Brueck S, Nirmrier M. Evaluation of potential noise exposures in hospital operating rooms. AORN J. 2012;96(4):412-8. DOI: 10.1016/j.aorn.2012.06.001.
14. Stansfeld S, Matheson M. Noise pollution: Non-auditory effects on health. Br Med Bull. 2003;68(1):243- 57. DOI: 10.1093/bmb/ldg033.
15. Katz J, Levy J. Noise in the operating room. Anesthesiology. 2014;121(4):894-8. DOI: 10.1097/ALN.0000000000000319.
16. Ginsberg S, Pantin E, Kraidin J, Solina A, Panjwani S, Yang G. Noise levels in modern operating rooms during surgery. J Cardiothorac Vasc Anesth. 2013;27(3):528-30. DOI: 10.1053/j.jvca.2012.09.001.
17. Liu E, Ta S. Patients' perception of sound levels in surgical suites. J Clin Anesth. 2000;12(4):298-302. DOI: 10.1016/s0952-8180(00)00155-0.
18. Kang J, Lee J, Kim D, Kim J, Kim C, Hahm T, et al. Blocking noise but not music lowers bispectral index scores during sedation in noisy operating rooms. J Clin Anesth. 2008;20(1):12-6. DOI: 10.1016/j.jclinane.2007.06.005.
19. Dholakia S, Jeans J, Khalid U, D'Souza C, Nemeth K. The association of noise and surgical-site infection in day-case hernia repairs. Surgery. 2015;157(6):1153-6. DOI: 10.1016/j.surg.2014.12.026.
20. Kracht J, Busch-Vishniac I, West J. Noise in the operating rooms of Johns Hopkins Hospital. J Acoust Soc Am. 2007;121(5):2673-9. DOI: 10.1121/1.2714921.
21. Department of Labour. Occupational Health and Safety Act: Noise-induced Hearing Loss Regulations, 85. Sect. 43 (2003) Available from: http://www.labourguide.co.za/health-and-safety/848-health-and-safety-downloads [Date accessed 11 Nov. 2017].

22. Roberts C. Noise data averaging: How to average noise measurements. 2013. Available from: https://www.cirrusresearch.co.uk/blog/2013/01/noise-data-averaging-how-do-i-average-noise-measurements/. [Date accessed 11 Oct. 2019]
23. Fitzgerald G, O'Donnell B. Anaesthetists noise exposure in orthopaedic operating theatres. Ir Med J. 2012;105(7):239-41. PMID: 23008884.
24. Wallace M, Ashman M, Matjasko J. Hearing acuity of anesthesiologist and alarm detection. Anesthesiology. 1994;81(1):13-28. DOI: 10.1097/00000542-199407000-00005.
25. Fritsch M, Chacko C, Patterson E. Operating room sound level hazards for patients and physicians. Otol Neurotol. 2010;31(5):715-21. DOI: 10.1097/MOA.0b013e3181d8d717.
26. Yarar O, Temizsoy E, Gunay O. Noise pollution level in a pediatric hospital. Int J Environ Sci Technol. 2018;16(2):5107-12. DOI: 10.1007/s13762-018-1831-7.
27. Ullah R, Bailie N, Crowther S, Cullen J. Noise exposure in orthopaedic practice: Potential health risk. J Laryngol Otol. 2004;118(6):413-6. DOI: 10.1258/002221504323219509.
28. Mullett H, Synnott K, Quinlan W. Occupational noise levels in orthopaedic surgery. Irish J Med Sci. 1999;162(2):106. DOI: 10.1007/BF02946475.
29. Love H. Noise exposure in the orthopaedic operating theatre: A significant health hazard. ANZ J Surg. 2003;73(10):836-8. DOI: 10.1046/j.1445-2197.2003.02276.x.

Section 4: Proposal

Noise levels in the operating theatres at a central hospital

Alicia Carbonari

1598405

Supervisor	Juan Scribante Department of Anaesthesiology
Co-supervisor	Helen Perrie Department of Anaesthesiology
Co-supervisor	Maria Fourtounas Department of Anaesthesiology

4.1 Introduction and problem statement

Sound is defined as “continuous rapid movements or vibrations that travel through air or water and can be heard when they reach a person’s or animal’s ear” (1). Noise is a sound and is defined as “random, fluctuating, inharmonious waveforms that interfere with desired signals” (2). Its effect will depend on the level of noise, type of noise, predictability, controllability, complexity of the task being performed at the time as well as individual tolerance to the noise. Noise is subjective and differs between individuals with sound becoming a noise when it is found to be disruptive and having a negative impact on an individual’s work, communication or health (3).

Sound is measured as the force per unit area produced by the sound wave and expressed in decibels, which is a logarithmic scale. The pitch of the sound is determined by frequency, which is the number of waves per second. The range of human hearing is between 20 and 20 000 hertz, with the decibel A (dB(A)) scale most in keeping with this frequency range (2, 4).

The noise levels of objects encountered in daily life vary; the rustling of leaves creates approximately 10 dB(A) of noise, normal conversation roughly 60 dB(A), a lawnmower creates 90 dB(A), while an ambulance siren is 120 dB (A). A shotgun is 130 dB(A) when fired, and a jet engine during take-off is 140 dB (A) (3, 5).

The World Health Organization (6) as well as the Environmental Protection Agency (7) established regulations for noise levels in hospitals and operating theatres, with the World Health Organization stating that it should not exceed 35 dB(A) (6), and the Environmental Protection Agency limiting noise to 45 dB(A) on average (6, 7). The South African National Standards, as part of the South African Bureau of Standards, has determined that average noise levels in operating theatres in South Africa should not exceed 35 dB(A) (8).

Communication is vital between operating theatre staff for safe and efficient performance. For speech to be heard with 90% accuracy, the signal to noise ratio should be 10 –15 dB(A). Normal speech is said to be 50 dB(A), which implies that

for normal communication to be heard the background noise in the operating theatre should be a maximum of 35 dB(A). Noise in operating theatres has the potential to lead to miscommunication and errors (9, 10).

Mean noise levels have been found to be between 51 and 75 dB(A) in operating theatres, with peak levels between 80 and 119 dB(A) (11). Sources of noise in the operating theatre can be air conditioning, anaesthetic machines and monitors, suction, forced air warming blankets, equipment falling, trolley movement and conversations (3, 12). Operating theatres are designed to be efficient and convenient to clean with walls, floors and ceilings being made of hard and easy to clean material, resulting in a long reverberation time of the sound (13).

Noise can result in noise-induced hearing loss, a form of sensorineural hearing loss that cannot be treated medically with operating theatre staff having been found to be vulnerable to this due to the prolonged exposure to increased noise levels (14, 15). Noise can be a stressor to operating theatre staff, which can have an additive effect on other stressors, resulting in non-auditory health effects, such as fatigue, cognitive dysfunction, headaches, anxiety, insulin resistance, as well as cardiovascular effects (16). Studies show that noise levels in the operating theatre are loudest at induction and emergence, which may have a compounding effect on the anaesthetist as these are considered stressful periods already (15, 17, 18).

A study by Liu et al (19) has shown that patients can be affected by noise, inducing stress in up to 16% of the patients. It may also affect the care provided to the patient as it impairs communication between the operating theatre staff (16), may affect performance of complex mental tasks (15), and Dholakia et al (20) suggesting a link between increased noise levels and surgical site sepsis.

Noise has been labelled as “the third pollution”, alongside air and water pollution (13), with studies (10, 12, 17, 21) conducted in different countries showing noise levels in operating theatres to be higher than the recommendations of the regulatory bodies. No study has been conducted to determine if the noise levels in the operating theatres of Chris Hani Baragwanath Academic Hospital (CHBAH) are compliant with the recommendations.

4.2 Aim and objectives

4.2.1 Aim

The aim of this study is to measure noise levels in the operating theatres at CHBAH.

4.2.2 Objectives

The primary objectives of this study are to:

- measure noise levels in the operating theatres
    - overall (baseline, active time and down time)
    - at induction
    - at skin incision
    - at emergence
- describe compliance with recommendations.

The secondary objectives of this study are to**:**

- compare noise levels between emergency and elective operating theatres
- compare noise levels between office hours and after hours in emergency operating theatres
- compare noise levels in different surgical disciplines
- compare noise levels at different time points.

4.3 Research assumptions

The following definitions will be used in this study.

Sound level meter: The professional ET-958 Type 2 sound level meter with data logger measuring noise levels in dB(A) will be used in this study.

Office hours: will be from 07:00 to 16:00.

After hours: will be from 16:00 to 06:30, including weekends.

Weekends: will be taken from 16:00 on Friday until 06:30 on Monday.

Elective surgery: is planned in advance as it does not involve a medical emergency.

Emergency surgery: is surgery to treat trauma or acute illness.

Time in: is the time documented when the patient is brought into the operating theatre.

Time out: is the time documented after the surgery when the patient is taken out of the operating theatre.

Induction: will be the anaesthetic start time and the following five minutes.

Emergence: will be from closing time and the following 10 minutes.

Active time: will be from time in to time out of the operating theatre.

Down time: will be between time out and the subsequent time in and may including operating theatre cleaning and setting up.

Acceptable noise level: according to the South African National Standards is an average noise level below 35 dB(A).

4.4 Demarcation of study field

The study will be conducted in the operating theatres of CHBAH affiliated to the Department of Anaesthesiology at the University of the Witwatersrand. CHBAH is a 2 888-bed hospital. The hospital has 25 operating theatres and on average 65 000 surgeries are performed annually.

4.5 Ethical considerations

No data pertaining to the patient and staff members in operating theatre will be collected, therefore an ethics waiver will be requested from the Human Research Ethics Committee (Medical). Approval to conduct the study will be obtained from the Graduate Studies Committee of the University of the Witwatersrand. Further

approval will be obtained from the Medical Advisory Committee (Appendix A) and the Head of Department Anaesthesiology of CHBAH (Appendix B).

The study will be anonymous as only sound levels will be measured and not individual voices. Only the researcher and supervisors will have access to the raw data ensuring confidentiality.

If the noise levels measured are found to be higher than the acceptable levels, the Head of Department will be notified and The Occupational Health and Safety Department consulted.

Data will be stored securely for six years in a locked cupboard and a password-protected database. The study will be conducted according to the principles of the Declaration of Helsinki (22) and the South African Guidelines for Good Clinical Practice Research methodology (23).

4.6 Research methodology

4.6.1 Research design

A cross-sectional research design will be followed in this study. A cross-sectional study involves the collection of data at a single time point with different participants (24). This study will be cross-sectional as it will be measuring noise levels in each operating theatre at CHBAH for a set period of time.

4.6.2 Study population

The study population consists of the noise levels in the operating theatres of CHBAH.

4.6.3 Study sample

Sample size

There are 25 operating theatres that work during office hours at CHBAH, seven of which are emergency operating theatres. After hours there are six operating theatres for emergency surgeries.

The sample size will consist of 35 readings:

- Office hours 18 elective operating theatres
  7 emergency operating theatres
- After hours 6 emergency operating theatres
- Weekends 4 emergency operating theatres (excluding obstetric operating theatres).

Sampling method

In this study, a convenience sampling method will be used. Convenience sampling is where subjects or objects are included in the study because they are available when the study is being conducted (25). This study will make use of convenience sampling as the noise levels will be obtained from operating theatres that are in use at the time of data collection.

4.6.4 Data collection

Sound level meter

In consultation with Occupational Hygienists at the National Institute for Occupational Health, a Type 2 sound level meter was selected to measure noise for this study as it is not for Occupation Health and Safety purposes. There are two types of sound level meters, a Type one and a Type two. A Type two sound level meter is considered less accurate than a type one sound level meter which is used to measure noise levels in the workplace in terms of the Occupational Health and Safety Act (26). Due to financial constraints a Type two sound level meter will be used. The sound meter is a Professional ET-958 model, with IEC61672-1 standard. It has A and C frequency weighting options, sampling time of 2 times/sec, and a meter memory of 262 100 readings. The sound level meter has software that will allow the readings to be downloaded onto a computer using the data logger and will then be further analysed. The recommended recalibration cycle suggested by the manufacturers is one year.

Data collection process

Data will be collected over the period of September to October 2019. The sound level meter will be placed above the door of the operating theatre and set to measure the noise level each second. Staff members will not be formally informed of the presence of the sound level meter, in an attempt to avoid bias. A note will be placed with the sound level meter requesting that people do not touch or remove the sound level meter.

For office hours the sound level meter will be placed in the operating theatre just prior to 07:00 and will be collected at 16:00. For after-hours the sound level meter will be placed in the emergency and obstetric operating theatres just before 16:00 and will be collected at 06:30 the following morning. Once collected the data on the sound level meter will be downloaded onto a computer.

A data collection sheet (Appendix C) will be used which will include the following information:

- operating theatre number
- discipline in operating theatre
- type of procedure
- time in to the operating theatre
- anaesthetic starting time
- incision time
- closing time
- time out of the operating theatre
- overall noise level (baseline, active time and down time)
- noise level at induction
- noise level at incision time
- noise level at emergence.

The sound level meter will be placed in different operating theatres, to obtain a sample of the different surgical disciplines practiced at CHBAH, namely:

- Burns
- Ear, nose and throat surgery
- Emergencies
- General surgery
- Gynaecology
- Interventional radiology
- Maxillofacial surgery
- Neonatal surgery
- Neurosurgery
- Obstetrics
- Ophthalmology
- Orthopaedic surgery
- Paediatric surgery
- Urology

The data collected will give noise levels for the time when the patient is in the operating theatre, that is from time in to time out of the operating theatre and noise levels while the operating theatre is not in use, which is between time out and time in will also be documented. Noise peaks will also be described. The average noise levels for a period of time will be calculated using a Microsoft Excel® spreadsheet by dividing each measurement by 10, calculating the anti-log of these values, adding the relevant values for the time period and dividing the total by the number of values used. The logarithm to the base 10 of the total will be calculated and multiplied by 10 to obtain the average noise level (27).

4.6.5 Data analysis

A Microsoft Excel® spreadsheet will be used to capture data. Data will be analysed in consultation with a biostatistician using the statistical program STATA version 15. (StataCorp, USA). Noise levels will be recorded in dB(A). Averages will

be presented as means and standard deviations if normally distributed or as medians and interquartile ranges if not normally distributed. Comparisons between the noise levels in elective and emergency operating theatres will be done using the independent t-test or Mann Whitney test. A p value of <0.05 will considered statistically significant.

4.7 Significance of the study

This study will provide information regarding noise levels experienced in the operating theatres of CHBAH. Noise has been shown to have detrimental effects on operating theatre staff as well as on patients, as it has a compounding effect on stress. Operating theatre staff are vulnerable to noise levels, due to the prolonged exposure with auditory and non-auditory adverse health effects (15). With regards to the anaesthetist, studies have shown that noise levels are higher at induction and emergence, the two periods considered extremely stressful (10). If the noise levels measured in the operating theatres are found to be higher than the recommended limits, the Occupational Health and Safety Department will be informed, and further evaluation and interventions could be undertaken to make the operating theatre environment safer.

4.8 Validity and reliability of the study

The validity of a study is “the degree to which a measurement represents a true value”, or that the results of the study are accurate based on the design and interpretation of the data. The reliability of a study is that the same results will be obtained if the measuring instrument is applied in different scenarios (28). The validity and reliability of this study will be ensured by:

- using an appropriate research design
- using a calibrated sound level meter
- data being collected by one data collector
- data being analysed in consultation with a biostatistician.

4.9 Potential limitations

As this is a cross-sectional study, it is only measuring the noise levels in the operating theatre complex of CHBAH for a set period of time, and therefore cannot be generalised to other hospitals and other times. The readings will be a “snap-shot” and may not accurately represent the noise levels in the operating theatre.

4.10 Project outline

4.10.1 Time frame

Activity	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019	Sep 2019	Nov 2019	Dec 2019	Jan 2020
Proposal preparation									
Literature review									
Proposal submission									
Ethics approval									
Postgraduate approval									
Data collection									
Data analysis									
Draft article									
Submission									

4.10.2 Budget

Item	Price per page	Number of pages	Copies	Total
Proposal	1	17	10	R 170
Postgraduate form	1	2	6	R 12
Complete report	1	100	4	R 400
Sound level meter				R 3335.00
Grand total				**R 3917.00**

The Wits Department of Anaesthesiology will incur the costs of paper and printing. The sound level meter has been purchased by the student.

4.11 References

1. Hornby A. Oxford advanced learners dictionary. 6th ed. Oxford, United Kingdom: Oxford University Press; 2000. p. 1408.
2. Kam P, Kam A, Thompson J. Noise pollution in the anaesthetic and intensive care environment. Anaesthesia. 1994;49(1):982-6. DOI: 10.1111/j.1365-2044.1994.tb04319.x.
3. Hodge B, Thompson J. Noise pollution in the operating theatre. Lancet. 1990;335(8694):891-4. DOI: 10.1016/0140-6736(90)90486-O.
4. Oliveira C, Arenas G. Occupational exposure to noise pollution in anesthesiology. Rev Bras Anestesiol. 2012;62(2):253-61. DOI: 10.1016/S0034-7094(12)70123-X.
5. Shambo L, Umadhay T, Pedoto A. Music in the operating room: Is it a safety hazard? AANA J. 2015;83(1):43-8. PMID: 25842633.
6. World Health Organization. Guidelines for community noise, 1999. Available from: http://www.who.int/docstore/peh/noise/guidelines2.html [Date accessed 7 Nov. 2017].
7. U.S Environmental Protection Agency. EPA identifies noise levels affecting health and welfare, 1974. Available from: http://archive.epa.gov/epa/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare.html [Date accessed 7 Nov. 2017].
8. South African National Standards. The measurement and rating of environmental noise with respect to annoyance and to speech communication. Guidelines: 10103:2008. Pretoria, South Africa: Standards South Africa; 2008 Available from: http:///C:/Users/Alicia/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/SANS10103%20(1).pdf [Date accessed 30 April 2019].
9. Way T, Long A, Weihing J, Ritchie R, Jones R, Bush M, et al. Effects of noise on auditory processing in the operating room. J Am Coll Surg. 2013;216(5):933-8. DOI: 10.1016/j.jamcollsurg.2012.12.048.

10. Wang X, Zeng L, Li G, Xu M, Wei B, Li G, et al. A cross-sectional study in a tertiary care hospital in China: Noise or silence in the operating room. BMJ Open. 2017;7(e016316):1-6. DOI: 10.1136/bmjopen-2017-016316.
11. Hasfeldt D, Laerkner E, Birkelund R. Noise in the operating room: What do we know? A review of the literature. J Perianesth Nurs 2010;25(6):380-6. DOI: 10.1016/j.jopan.2010.10.001.
12. Tsiou C, Efthymiatos G, Katostaras T. Noise in the operating rooms of Greek Hospitals. J Acoust Soc Am. 2008;123(2):757-65. DOI: 10.1121/1.2821972.
13. Shapiro R, Berland T. Noise in the operating room. N Engl J Med. 1972;287(24):1236-8. DOI: 10.1056/NEJM197212142872407.
14. Chen L, Brueck S, Nirmrier M. Evaluation of potential noise exposures in hospital operating rooms. AORN J. 2012;96(4):412-8. DOI: 10.1016/j.aorn.2012.06.001.
15. Katz J, Levy J. Noise in the operating room. Anesthesiology. 2014;121(4):894-8. DOI: 10.1097/ALN.0000000000000319.
16. Stansfeld S, Matheson M. Noise pollution: Non-auditory effects on health. Br Med Bull. 2003;68(1):243- 57. DOI: 10.1093/bmb/ldg033.
17. Alshammari D, Sica M, Osailan S, Tuan V, Talon I, Schneider A, et al. Noise in a university operating theatre during the course of pediatric surgical procedures. Current Pediatric Research. 2017;21(4):572-6.
18. Ginsberg S, Pantin E, Kraidin J, Solina A, Panjwani S, Yang G. Noise levels in modern operating rooms during surgery. J Cardiothorac Vasc Anesth. 2013;27(3):528-30. DOI: 10.1053/j.jvca.2012.09.001.
19. Liu E, Ta S. Patients' perception of sound levels in surgical suites. J Clin Anesth. 2000;12(4):298-302. DOI: 10.1016/s0952-8180(00)00155-0.
20. Dholakia S, Jeans J, Khalid U, D'Souza C, Nemeth K. The association of noise and surgical-site infection in day-case hernia repairs. Surgery. 2015;157(6):1153-6. DOI: 10.1016/j.surg.2014.12.026.
21. Giv M, Sani K, Alizadeh M, Valinejadi A, Majdabadi A. Evaluation of noise pollution level in operating rooms of hospitals: A study in Iran. Interv Med Appl Sci. 2017;9(2):61-6. DOI: 10.1556/1646.9.2017.15.

22. World Medical Association. Declaration of Helsinki: Ethical principles for medical research involving human subjects. Brazil: World Medical Association;, 2013. Available from: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/ [Date accessed 28 April 2019].
23. Department of Health. Guidelines for good practice in the conduct of clinical trials with human participants in South Africa Pretoria: Department of Health, 2006. Available from: http://www.kznhealth.gov.za/research/guideline1.pdf [Date accessed 11 Nov. 2017].
24. Brink H, Van der Walt C, Van Rensburg G. Fundamentals of research methodology for healthcare professionals. 4th ed. Caremont, South Africa: Juta; 2018.
25. Burns N, Grove S. The practice of nursing research. 6th ed. ed. Missouri, United States of America: Saunders Elsevier; 2009.
26. Department of Labour. Occupational Health and Safety Act: Noise-induced Hearing Loss Regulations, 85. Sect. 43 (2003) Available from: http://www.labourguide.co.za/health-and-safety/848-health-and-safety-downloads [Date accessed 11 Nov. 2017].
27. Roberts C. Noise data averaging: How to average noise measurements. 2013. Available from: https://www.cirrusresearch.co.uk/blog/2013/01/noise-data-averaging-how-do-i-average-noise-measurements/. [Date accessed 11 Oct. 2019]
28. Botma Y, Greeff M, Mulaudzi F, Wright S. Research in health sciences. Cape Town, South Africa: Pearson; 2010.

4.12 Appendices

Appendix A: Letter of permission from Medical Advisory Committee

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 14th August 2019

TITLE OF PROJECT:

Noise levels in the operating theatres at a central hospital.

UNIVERSITY: Witswatersrand

Principal Investigator: Dr A Carbonari

Department: Anaesthesiology

Supervisor : Dr J Scribante

Permission Head Department (where research conducted): Yes

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- **Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.**
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

.....
Recommended
(On behalf of the MAC)
Date: 14/08/2019

.....
Approved/~~Not Approved~~
Hospital Management
Date: 19/08/2019

Appendix B: Letter of permission from Head of Department

Dr Alicia Carbonari
Department of Anaesthesiology
University of the Witwatersrand
alicia_a_carbonari@yahoo.com

29 April 2019

Dear Dr Lines

I am a registrar in the Department of Anaesthesiology. I am conducting a study as part of my Master of Medicine in Anaesthesiology titled: Noise levels in the operating theatres at a central hospital.

The study will involve a noise level meter being placed in the operating theatre and recording noise levels. The operating theatre register will also be looked at, to determine relevant times during the procedure as well as the type of procedure performed. The aim of the study is to determine whether noise levels encountered in theatre are in keeping with the recommendations. No conversations will be recorded, and no staff or patient information will be collected.

An ethics waiver will be requested and approval from the Graduate Studies Committee of the University of the Witwatersrand.

This study will not result in additional cost to the hospital.

The results of the study will be made available to you on request.

Kind regards

Dr Alicia Carbonari

02/05/2019.

Approval Granted

DR. D. LINES
Acting clinical H.O.D
Dept. Anaesthesiology
CHBAH

Appendix C: Data collection sheet

Date: _____

Theatre No.									
Paeds	Gynae	Ortho	Neuro	Vascular	ENT	Emergency	Urology	Radiology	Obs
General	Burns	Ophthalm	Max-fac						

Peak noise level: _____

Baseline noise level: _____

	Overall	Active time	Down time
Average Noise level dB(A)			

Type of procedure	Time in	Anaesthetic start time	Noise level dB(A)	Incision time	Noise level dB(A)	Closing time	Noise level dB(A)	Time out	Peak noise level dB(A)

Section 5: Annexures

5.1 Ethics waiver

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Ref: W-CP-190510-1

10 May 2019

TO WHOM IT MAY CONCERN:

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical).

Investigator:	**Alicia Ann Carbonari (student no 1598405)(Staff A0048078)**
Co-Investigators:	**Helen Perrie and Maria Fourtounas**
Supervisor:	**Juan Scribante**
Faculty:	Health Sciences
School:	Clinical Medicine
Department:	Anaesthesiology
Project title:	Noise levels in the operating theatres at a central hospital
Reason:	Recording sound levels in operating theatres at Chris Hani Baragwanath Academic Hospital

Dr Clement Penny

Chair: Human Research Ethics Committee (Medical)

Copy – HREC (Medical) Secretariat

5.2 Graduate studies approval

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG | FACULTY OF HEALTH SCIENCES

5th August 2019
Person Number: 1598405

PAG

Dr Alicia Ann Carbonari
Plot 12 Johan Road
Honeydew
Johannesburg
2170 Gauteng South Africa

Dear Dr Carbonari

Master of Medicine – Anaesthesia : Approval of Protocol

We have pleasure in advising you that your title has been approved;

Title: Noise levels in the operating theatres at a central hospital

UNIVERSITY OF THE WITWATERSRAND
05 AUG 2019

Yours sincerely

Mrs Zaheera Khan
On behalf of Mrs Sandra Benn
Faculty Registrar

5.3 Turnitin report

a0048078:Turnit_in_document.docx

ORIGINALITY REPORT

12%	6%	8%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Bernadette Stringer, Ted A Haines, John D Oudyk. "Noisiness in Operating Theatres: Nurses' Perceptions and Potential Difficulty Communicating", Journal of Perioperative Practice, 2017 Publication	1%
2	Kristjan Ukegjini, Theresa Kastiunig, Bernhard Widmann, Rene Warschkow, Thomas Steffen. "Impact of intraoperative noise measurement on the surgeon stress and patient outcomes. A prospective, controlled, single-center clinical trial with 664 patients", Surgery, 2020 Publication	1%
3	pdfs.semanticscholar.org Internet Source	1%
4	Submitted to University of Witwatersrand Student Paper	1%
5	www.tandfonline.com Internet Source	1%

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | FACULTY OF HEALTH SCIENCES

23 November 2020

The Chairperson
Graduate Studies Committee
Faculty of Health Sciences
University of the Witwatersrand

Dear Professor Papathanasopoulos

Re: M Med: **Noise levels in the operating theatres at a central hospital**

Dr Alicia Carbonari, student number: 1588405, has submitted her research report to Turnitin which revealed a similarity index of 12%. These similarities appear not to be plagiarism but mainly the use of common terminology and phrases specific to the topic of the research.

Yours sincerely,

Juan Scribante
Supervisor

5.4 Sample size letter

DEPARTMENT OF
ANAESTHESIOLOGY
UNIVERSITY OF THE
WITWATERSRAND, JOHANNESBURG
Tel.(011)933-9334/5 / Fax
(011)933-1843

23 November 2020

To whom it may concern,

I herewith give details regarding the difference in sample size stated in my proposal and the data collected. The original sample size was an arbitrary number selected based on the number of theatres and specialities available at Chris Hani Baragwanath Academic Hospital. The proposal sample size was 35 readings of which 18 were elective theatres and 7 were emergency theatres during office hours, with 6 emergency theatres during after hours.

The following table outlines the theatres/specialities readings where obtained for:

Specialty	**Theatre no.**	**Data Collected (no.)**
Paediatric / neonatal	11 / neonates	Yes (1 / 1)
Gynaecology	Gynaecology elective	Yes (1)
Orthopaedics	1 / 5 / 3	Yes (3)
Neurosurgery	13	Yes (1)
Vascular surgery	12	Yes (1)
ENT	11	Yes (1)
Urology	1	Yes (1)
Radiology	Interventional radiology	Yes (1)
General surgery	16 / 15	Yes (2)
Burns	Burns	Yes (1)
Ophthalmology	St Johns	Yes (1)
Maxillofacial surgery	14	Yes (1)
Gynaecology	Gynaecology emergency	Yes (1)
Obstetrics	Obstetric emergencies	Yes (1) – night
JDA emergency corridor	7	Yes (1) – weekday day
	8	Yes (2) – weekday day, weeknight
	9	Yes (1) – weekend day
	10	Yes (2) – weekday day, weekday day
		TOTAL: 24

I collected data in one of the obstetric operating theatres overnight, as the two operating theatres are identical and located next to each other with the same procedures occurring 24 hours a day. The emergency operating theatres in the main hospital complex are also located in a corridor next to each other, and run 24 hours a day. I collected data in each emergency operating theatre, with samples in at least one for office hours, after hours and weekends.

The above mentioned was discussed with Prof Maria Papathanasopoulos who confirmed that if the aims and objectives of the study are unchanged that the sample size could be different.

The correspondence with Prof Papathanasopoulos is attached.

Kind regards,

Alicia Carbonari

Maria Papathanasopoulos <maria.papathanasopoulos@wits.ac.za>
To: alicia_a_carbonari@yahoo.com
Cc: maria.fourtounas@gmail.com, Juan Research, Helen Perrie

Fri, 28 Aug at 14:48



Dear Alicia,

I hope you are well. It is not up to me to give you permission to change your sample size for your study. Research projects often change from what is written on the project proposal, and as long as your overall study aims and objectives remain the same, you wouldn't be required to amend your protocol.

You need to consider whether the data you have collected will allow you conduct appropriate data analysis, statistics, etc, and to write up a research report that will be passed by examiners. You certainly don't want examiners to come back and say you haven't collected enough data, and ask you to continue data collection. Your supervisors are best suited to guide you on that, and if you are planning of doing statistics on your data you can consult with the Faculty biostatisticians.

Kind Regards,
Maria