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Defibrillator Devices at a Public Sector Hospital in Gauteng

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfillment of the requirements for the degree of Master of Medicine (Emergency Medicine)

Johannesburg, 2018

DECLARATION

I, S'fisosikayise Madi, declare that the research report is my own work. It is being submitted for the degree of Master of Medicine in the branch of Emergency Medicine to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.



25 March 2018

S'fisosikayise Madi Date

DEDICATION

To my Abba, my Heavenly Father and my Lord Jesus, my Redeemer and friend. All this is only possible through You and Your grace and mercy that You have shown me. May You continue being glorified.

To my best buddy and wife, Ntombizodwa Madi. Thank you for bearing with me through this challenge and being a constant source of love and support. It is finally done.

To my first born, Ngingowakhonkosiyami Madi. To encourage you to do better for your future.

To my parents, Alpheus and Annah Madi and my siblings, Tebogo, Themba, and Gugu. Thanks for the foundation that you have laid in me.

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- Louis Van Rensburg from the engineering department at Charlotte Maxeke Johannesburg Academic Hospital.
- Charlotte Maxeke Johannesburg Academic Hospital CEO, Ms Bigoshi for giving permission to collect the data.
- Wits REDCap (Research Electronic Data Capture) department for their training and permission to use the platform for data capturing.
- The statisticians from the Statistical department at the University of Witwatersrand.

ABSTRACT

Objectives: This was a prospective, clinical audit of all the external defibrillator devices (EDD) found at a public sector hospital in Gauteng.

Methods: The study was conducted at all sites within the hospital where the manual external defibrillator (MED) or automated external defibrillator (AED) was present and ready for clinical use.

Results: EDD were assessed in 112 out of a total 123 areas in the hospital. The entire hospital had a total of 143 EDD's (97.2% n=139 MED, 2.8% n=4 AED. There were 52 EDD's in the general wards (21 medical, 15 surgical, 7 paediatric, 9 obstetrics and gynaecology wards), 27 in the high dependency areas (19 intensive care areas, 8 emergency departments), 35 in non-sleep over areas (27 outpatients departments, 3 allied health areas, 5 radiology areas) and 25 in the theatre complex (23 in theatre rooms, 2 peri-op areas). Daily checklist books were available in 101 of 139 (72.7%) of MED's across the hospital with a statistical significance with regards to the presence of the checkbook and the location of the MED (p=0.00313). Of the MED with a checklist book, 25.7% (n=26) had documented checks being conducted at least once (am or pm check) daily over a 5 day period. The maintenance stamps were present in 59.7% (n83) of MED's with a statistically significant difference with regards to the location of the MED and the presence of the maintenance stamp (p<0.00001). Seven MED and one AED were found to have a critical problem.

Conclusions: The results of our study indicate that emphasis is needed on EDD checking and maintenance. Although 95% of the MED's were fully functional, the

consumables that were used to support the devices were inconsistently present throughout the hospital.

TABLE OF CONTENTS

DECLARATION i
DEDICATION ii
ACKNOWLEDGEMENTS iii
ABSTRACT iv
LIST OF FIGURES ix
LIST OF TABLES x
LIST OF ABBREVIATIONS xi
CHAPTER 1: INTRODUCTION 12
1.1 Background and significance of study 12
1.2 The aim of the study 14
1.3 Objectives 14
CHAPTER 2: LITERATURE REVIEW 15
2.1 The history of the defibrillator 15
2.2 Types of defibrillators and uses 16
2.2.1 Manual external defibrillators 16
2.2.2 Automated external defibrillators 17
2.3 Complications of external defibrillation 18
2.4 Medical device failure and manual external defibrillator failure 18
2.5 AED failure 20
2.6 Use of checklists and maintenance of defibrillators 20
2.7 Studies done in South Africa 22

CHAPTER 3: METHODOLOY 23
3.1 Design of the study 23
3.2 Site of the study 23
3.3 Inclusion criteria 23
3.4 Exclusion criteria 24
3.5 Data collection 24
3.6 Data Analysis 26
3.7 Ethical considerations 26
CHAPTER 4: RESULTS 28
4.1 Description of final sample 28
4.2 Total number of external defibrillator devices available in the hospital 28
4.3 Distribution of devices across the hospital 29
4.5 Availability of checklist booklet and frequency of checks in the last 24 hours 31
4.6 Maintenance of Devices: 33
4.7 Adherence to national checklist guidelines 35
CHAPTER 5: DISCUSSION 41
5.1 Total number of external defibrillator devices available in the hospital 41
5.2 Distribution of devices across the hospital 42
5.3 The prevalence of various brands of external defibrillator devices across the hospital 42
5.4 Availability of checklist booklet and frequency of checks in the last 24 hours 43
5.5 Maintenance of devices 45
5.5 Assessment of devices using EMMSA and AHA Guidelines 46
5.6 Limitations of the study 48
5.7 Recommendations 49

CHAPTER 6: CONCLUSION 50
CHAPTER 7: REFERENCES 51
APPENDICES 60
Appendix 1: Ethics Clearance Certificate 60
Appendix 2: Data Collection Sheet for Defibrillator Device 60
Appendix 3: Plagiarism Declaration 64
Appendix 4: Turnitin Report …..... 65

LIST OF FIGURES

Figure 1. Exclusion and final sample for analysis..... 28

LIST OF TABLES

Table 1 Description of overall distribution, availability of checklist books and maintenance record of external defibrillator devices (EDD's) at various locations across the hospital. 29

Table 2 Statistical analysis comparing various aspects of manual external defibrillators between the general wards, non-sleep over areas, high dependency areas and theatre complexes. 30

Table 3 Statistical analysis comparing various aspects of manual external defibrillators between the general wards 32

Table 4 Statistical analysis comparing various aspects of manual external defibrillators between the high dependency areas..... 33

Table 5 Statistical analysis comparing various aspects of manual external defibrillators between the non-sleep over areas. 34

Table 6. The averages achieved at the various locations in the hospital with regards to adherence to EMMSA defibrillator device checklist guidelines..... 36

Table 7. A description of the standard manual defibrillators that had failed 39

Table 8. The results from the investigation of the automated external defibrillators using AHA guidelines..... 40

LIST OF ABBREVIATIONS

AED:	Automated external defibrillator
AHA:	American Heart Association
AM:	Ante Meridiem
CMJAH:	Charlotte Maxeke Johannesburg Academic Hospital
ECG:	Electrocardiogram
ECRI:	Emergency Care Research Institute
ED:	Emergency department
EDD:	External defibrillator device
EMMSA:	Emergency Medicine Society of South Africa
EU:	Emergency unit
FDA:	Food and Drug Administration
ICD:	Implantable cardioverter-defibrillator
MED:	Manual external defibrillator
O&G:	Obstetrics and gynaecology
OPD:	Outpatients departments
PM:	Post Meridiem
REDCap	Research Electronic Data Capture
SVT	Supraventricular tachycardia
SC:	Synchronized cardioversion
VF:	Ventricular fibrillation
VT:	Ventricular tachycardia

CHAPTER 1: INTRODUCTION

1.1 Background and significance of study

Acute life threatening emergencies in hospitals are not limited to the emergency department (ED). These may take place in any location within the hospital including wards, theater, radiology departments, cafeteria and elevators. It is expected that the equipment used for these emergencies is in a good working condition and ready for any emergency, to assist in the diagnosis and management of the patient during the time of need (1).

Any delay in an emergency, including failure of the equipment used, often culminates into a poor outcome for the patient being treated (2)(3). One study found that equipment failure during an emergency may lead to a delay in cardiopulmonary resuscitative management in up to 18% of cases in patients with cardiac arrest (2) .

Medical device failures may be divided into five broad categories that may lead to injury and/or death to the patients being treated (4). The five categories include “device factors, external factors, system failures, tampering or sabotage, and user errors” (4). Regarding these categories, failure to perform pre-use inspection, improper storage, improper maintenance, testing, repair or lack thereof, failure of incoming inspection and power supply failure are the most common problems (4).

Early electrical defibrillation has become the most important therapy for the treatment of patients in cardiac arrest with ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT), as it saves lives (5–7). Different forms of electrical defibrillators are

available for clinical use. These include the manual external defibrillator (MED), the automated external defibrillator (AED) and the implantable cardioverter defibrillator. Other acute cardiac dysrrthymias such as unstable supraventricular tachycardia's (SVT), unstable atrial flutter, unstable atrial fibrillation, and unstable ventricular tachycardia's may also be managed using the defibrillator through synchronized cardioversion (SC) (8,9). Transcutaneous pacing may also be used for unstable bradyarrhythmia and pacing of SVT and VT (9).

There are two major causes of a defibrillator failing to shock during a resuscitation. These are operator errors and device failures (10). Operator error maybe mitigated by regular training (11–13) as the skills in resuscitation decline progressively with time (13,14). The design and user interface of the devices used also have a pivotal role in reducing operator errors (15–17).

Some of the factors that are associated with defibrillator device failure include poor checking and irregular maintenance (10). The use of checklists have not only been developed to ensure that the users maintain a comprehensive understanding of all aspects of the devices function and operation (1,18) but also to assist with guiding hospital staff in keeping the defibrillators functioning at an optimal level (19,20).

As external defibrillators are essential in the resuscitation of patients, mitigation of device failure is of the utmost importance. Regular auditing of these devices, including assessing that they are checked on a daily basis and are receiving their scheduled maintenance services may be an important step in the mitigation process.

We therefore conducted a prospective, clinical audit of all the external defibrillator devices found at a public sector hospital in Gauteng. The study was also beneficial from an asset registry and equipment maintenance point of view, as the hospital at which the study took place had no recent comprehensive record of all the external defibrillator devices present.

1.2 The aim of the study

To conduct a prospective audit of all the external defibrillator devices found at a public sector hospital in Gauteng.

1.3 Objectives

1. To describe the numbers, types and locations of all the external defibrillator devices present at all areas of the hospital.
2. To assess how often the devices are checked in accordance with guidelines.
3. To determine how often they are maintained in accordance with manufacturer specifications.
4. To inspect and audit each manual external defibrillator device as per the EMMSA guidelines and automated external defibrillator device as per American Heart Association (AHA) maintenance checklist.

CHAPTER 2: LITERATURE REVIEW

2.1 The history of the defibrillator

A defibrillator is an electrical device used to apply an electrical current through the heart to help restore a normal heart rhythm from that of the potentially life threatening, abnormal one (21). This electrical current causes depolarization of the heart muscle terminating all activity. This gives an opportunity for the hearts inherit pacemaker, the sinoatrial node to restore its normal sinus rhythm.

The use of electrical currents to restore a pulse was described in 1775 by Abidgaard who was conducting experiments on hens. He noted that these electrical impulses when used were able to both cause the hens to become pulseless and also to restore the pulse if transmitted through the hen's chest. The term 'fibrillation of the ventricles' was only defined in 1849 by Ludwig and Hoffa. Extensive work was also done by Kouwenhoven et al in not only designing the external defibrillator but also laying the foundation of critical aspects in cardiopulmonary resuscitation (22). It was only in 1947 that Becks et al performed the first successful human defibrillation using internal cardiac paddles. The first successful external human defibrillation was performed nine years later by Zoll et al in 1956 (23).

Henceforth, with the advancement in medical science, research and engineering, early electrical defibrillation has become the most important therapy for the treatment of patients in cardiac arrest with ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT), as it saves lives (5–7). Time is critical when the defibrillator is

needed, because with every minute delay to the defibrillation of a patient in cardiac arrest with VF or pulseless VT, the prognosis decreases by 7-10% (6–8).

2.2 Types of defibrillators and uses

There are various types of defibrillators available according to the needs of the patient being treated. They may be divided into external and internal defibrillators. The external defibrillators include the manual external defibrillator (MED), the automated external defibrillator (AED), and more recently the wearable cardioverter defibrillator which is mostly for temporary protection before Implantable cardioverter-defibrillator (ICD) insertion (34). The internal defibrillators include the ICD and manual internal defibrillator. The manual internal defibrillators pads need to be placed directly on the heart during use. They are used mostly during cardiothoracic surgical procedures (24).

2.2.1 Manual external defibrillators

These devices are primarily utilized by trained personnel in the prehospital environment and health care facilities (21). They have an electrocardiogram display which is used by the provider to diagnose a rhythm. The provider is then is able to determine how much energy they are going to use for therapy.

The present day defibrillators deliver their current in what may be termed ‘waveforms’ (25). Different devices have varying types of energy waveforms and energy levels. Monophasic devices deliver their current in one direction as opposed to biphasic which is bidirectional. The biphasic waveforms have been found to be superior to the monophasic waveforms when used in ICD’s (26,27). Some studies on MED have also shown the biphasic devices to be superior to the monophasic counterparts (28).

Triphasic waveforms are currently being studied, but are still in the experimental stages (28).

Besides being used for non perfusing rhythms such as VF and pulseless VT, MED may also be used for synchronized cardioversion (SC) and pacing (8,9). When SC is performed, the delivery of the current is synchronized to take place on the QRS complex of the ECG to prevent the shock causing VF. This is used for patients with heart rhythms that cause haemodynamic instability such as an unstable supraventricular tachycardia's (SVT), unstable atrial flutter, unstable atrial fibrillation, and unstable ventricular tachycardia's (8,9). Transcutaneous pacing may is be used for unstable bradyarrhythmia (24) and pacing of SVT and VT (29–31).

2.2.2 Automated external defibrillators

Due to growing public awareness of cardiac arrest, public access defibrillation has enabled the general public to perform rapid defibrillation. This has led to an increase in the chances of survival for patients in cardiac arrest (32–37). AED's have become increasingly available in public domains as they require minimal or no training in their use (33–37). This is enabled by the AEDs having technology to both analyze heart rhythms and provide defibrillation for shockable rhythms. Studies have shown that both children and nonmedical personnel are able to use AEDs in saving lives (35,38).

Although AEDs in out of hospital cardiac arrest have shown great merit and have a Class I recommendation by the International Liaison Committee on Resuscitation (39,40), their benefit has not been evident for in-hospital cardiac arrest. In a cohort study in the United States of America, Chan et al in 2010 found that use of the AED

was associated with increased mortality, particularly in patients with a non-shockable rhythm. This was noted in both monitored and unmonitored hospital units (41). Similar findings were noted in a study by Forcina et al and by Gibbison et al (42,43). The result of these findings, have led to the European Resuscitation Council to develop guidelines that have recommended the MED be preferred over the AED for in-hospital cardiac arrest, unless the MED is unavailable (44).

2.3 Complications of external defibrillation

Complications to transthoracic defibrillation include varying degrees of burns to the skin, which are mostly related to the energy used during defibrillation (45–47)**.** Although the complication of burns secondary to external defibrillation is often seen, failure to use conductive pads or gel may account for as much as 40% of the causes (48).

2.4 Medical device failure and manual external defibrillator failure

The Emergency Care Research Institute (ECRI), a nonprofit organisation that conducts research in medical device safety, published from their Medical Device Safety Report, five broad categories in the causes of medical device failures involving injuries and deaths. The five categories were “device factors, external factors, system failures, tampering or sabotage, and user errors”. Regarding these categories, failure to perform pre-use inspection, improper storage, improper maintenance, testing, repair or lack thereof, failure of incoming inspection and power supply failure were the most common problems (4).

Defibrillator failure and its causes are of great importance. The two major causes of a defibrillator failing to shock during a resuscitation are operator error and device failure. In 1989, the Defibrillator Working Group, which was convened by the Food and Drug Administration (FDA) of the United States of America, investigated 1327 device and defibrillator related problems, including 594 defibrillator in-service inspections and 212 emergency care center site visits. They established that the incidence of defibrillator failure could be at an unacceptably high rate (10).

Their findings relating to device error stated that defibrillator testing was poor, with some machine's performance having deteriorated as a result of poor maintenance. In some instances, the defibrillators did not deliver within fifteen percent of the joules set during defibrillation. Periodic maintenance was common too, with most services taking place on a needs be basis. Less than twenty percent of the defibrillators within the study were serviced as per manufacturer warranty. Another finding was that the older defibrillators were associated with increased possibility of defibrillator failure. Keeping defibrillators in service long after their operational life lead to component deterioration and thus failure. Some recommendations from the study included shift checklists which should be done by the clinical operators at the beginning of each shift and adhering to the scheduled periodic maintenance of the defibrillator as per manufacturer (10).

The design of the various types of external defibrillator device brands may also be effective in helping negate errors during use. On investigating the usability of three different external defibrillator devices, Fidler et al found that the design and user interface of the devices may uncover human factor issues. These were noted in how

health care workers performed when using the device in different emergent scenarios when they needed to be utilized. Though in their findings the 3 devices, namely the Phillips MRx, Zoll R-Series Plus and Physio-Control LifePak 15, had their own strengths and weakness, the participants in the study preferred the Phillips brand as their first choice (15).

2.5 AED failure

AED failures have also been studied, even though the reports of these are fairly low. De Luca et al in 2012 published an analysis of AED failures that were reported to the FDA. These were collected over a 15 year period from the Manufacturer and User Device Experience Database in the United States of America. Of the 40 787 AED related events, 1150 were analysed for the fatalities that had occurred. In 45% of the cases, there was a failure to charge and deliver a recommended shock. In another 22% of these cases the AED failed to complete rhythm analysis after powering on. Pad connection and battery or power failures were found to be the common problems related to failure. The fact that some of the failures took place in scenarios where a recommended attempted shock was occurring, highlighted a problem with the AED's maintenance and checks, as the errors that occurred were not recognized during the devices self-test sequences (49).

2.6 Use of checklists and maintenance of defibrillators

As part of the recommendations made by the FDA on ensuring that defibrillator devices are kept in a state of readiness, one of the major functions of the checklists that were developed was to ensure that the users maintain a comprehensive understanding of all aspects of the devices function and operation (1,18). In South

Africa, the potential benefit of this may be lost as it is the ‘non-users’, being the nursing staff, that have been assigned for the most part in performing the checks and completing the checklists. There is however evidence to support nurse initiated defibrillation after appropriate teaching (50). This is a rarely witnessed in clinical practice more especially in state hospitals. It is understood that attitudes, beliefs and hospital policies are the core obstacles restricting nurses to the use of the devices (51).

Various checklists have been suggested and studied in aiding to assist with guiding hospital staff in keeping the defibrillators function at an optimal level. Dyson and Smith et al on investigating the common faults that arise in resuscitative equipment, published a suggested regime for the checking of defibrillators. This included checks for every staff shift and checks daily, weekly, monthly and six monthly (19).

The Emergency Medicine Society of South Africa (EMMSA) in December 2010, also released a review on their practice guideline on defibrillator use. The details thereof had the purpose of defining the standard of care to be employed by both prehospital and hospital settings in the use of defibrillators. An operator checklist was also released based on the recommendations from the FDA on maintaining defibrillator readiness. It includes a list on which details constitute a daily check. It is also noted that all facilities perform audits on their defibrillators (20).

While the EMMSA guidelines are well comprehensive, some of the consumables attached which are part of the checklist are not critical to the function of the device. Slight changes in the checklist have been observed internationally from when the

FDA's Defibrillator Working Group first published checklist for both AED and MED (1,18). In 2011 the ECRI published a checklist which had a reduced number of items in the supply category but without significant changes to the other parameters in the checklist (52).

2.7 Studies done in South Africa

In South Africa, Louw et al performed a voluntary audit with the use of a questionnaire, on the effective use of defibrillators in emergency centers in the Western Cape at district, regional and central hospital level. It was revealed that the knowledge on the use of the defibrillator was poor. They also found that only 52% of the emergency centers performed daily defibrillator test, with only 26% of these having been documented into a dedicated logbook (53).

CHAPTER 3: METHODOLOGY

3.1 Design of the study

The study is a prospective, clinical audit of external defibrillator devices at a tertiary-quaternary level hospital.

3.2 Site of the study

The study was conducted at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH). CMJAH is a tertiary-quaternary academic hospital located in Johannesburg, Gauteng with a total of 1066 beds and a staff compliment that exceeds 4000 individuals. CMJAH employs doctors with various levels of experience and qualification, from medical officers and interns to academic professors involved in various medical and surgical specialties and subspecialties. The study investigated all the general admission wards, ICU's, ED's, non-sleep over areas (OPD's, allied health departments, radiology department) and theatre complexes.

3.3 Inclusion criteria

All areas within the hospital were included in the study. This included:

- All the general admission wards
- All ICU areas
- All ED areas
- All non-sleep over areas (OPD's, allied health departments, radiology department)
- All theatre complex areas.

3.4 Exclusion criteria

The following external defibrillator devices were excluded from the study:

- Devices that were not in clinical use i.e. devices used strictly for teaching and training purposes
- Devices that were set aside in the hospital's central equipment storage and regarded as either non-functional, out of order, awaiting repair / maintenance or condemned by the hospital equipment engineer.

3.5 Data collection

- Data collection was initiated after the necessary permissions to commence the study were obtained.
- REDCap™ (54)(Research Electronic Data Capture) was used to collect and manage electronic data capture.
- The researcher attended an introductory workshop on REDCap™ (Research Electronic Data Capture) and data collection methods.
- A tablet device (Samsung Galaxy Tab A) was used to capture the data into a specifically designed data collection sheet that was created in REDCap™. REDCap uses a MySQL database via a secure web interface. Excess to the data was only possible through a password-protected profile on REDCap which was only known to the researchers. There was therefore no prospect for the records to have been tampered with.
- The researcher was not blinded to the study aims and objectives.
- Data collection was initiated on 1st May 2016
- The study supervisors were frequently consulted during the period of data collection.

- Frequent data checks were performed during data entry to ensure accurate data recording.
- The data was collected systematically, starting at one block of the hospital covering all the floors with the various wards, departments, OPD areas, theatres, radiology department, allied health departments, ED's and critical care areas. This was continued until all areas within the hospital had been investigated.
- The exact location of the external defibrillator device/s in the ward or area within the hospital, was established with the aid of the unit manager of the ward/area or the sister in charge during the time of the investigation. The meeting was unscheduled in order not to bias the results. The data was collected at each site where the external defibrillator device was stationed.
- The captured data included the location of the device, the area type (e.g. ward, OPD, etc.), the number and types of devices present at the various location, the exact brand and model of each specific device, whether each device had a maintenance stamp present, the various time intervals that the last maintenance service had taken place if the maintenance stamp was present, whether each device had their own check book, whether the morning (AM) and evening (PM) checks had been regular conducted over a 5 day period if a check book was present, the assessment of each device MED as per EMMSA guidelines and the assessment of each AED as per AHA guidelines.

3.6 Data Analysis

All data were categorical in nature and were analysed by means of frequencies and proportions that were summarised in multiple tables. The data was further analysed for statistical significance using the programme: IBM SPSS version 24.0 (International Business Machines Corporation, Armonk, New York, United States of America). The Pearson Chi-square test and Fisher's Exact test were used to investigate for significant differences between the following: the locations in the hospital and specific wards; the presence of the check book; the maintenance stamp on the devices and the performance of the various locations in the hospital using the EMSSA guidelines. A p-value of <0.05 was regarded as significant.

3.7 Ethical considerations

Permission to conduct this study was granted by the Charlotte Maxeke Johannesburg Academic Hospital management. Ethics clearance was obtained from the Human Research Ethics Committee (medical) of the University of the Witwatersrand (clearance certificate M 160210 – Appendix 1, page 61). No patient care was compromised in performing the study i.e. if the relevant device was in use at the time of investigation; the researcher rescheduled another date to investigate the device. The anonymity of the various wards, units and areas investigated was maintained at all times. Devices with critical functional errors were immediately reported to the unit operational manager as well as the hospital equipment engineer before the data was anonymized. The anonymity of external defibrillator device brands was also maintained when investigating the locations of the devices, presence of the checklist book, presence of the maintenance stamp and assessment using the EMMSA

guidelines for each device. A copy of the study's full report has been forwarded to the hospital equipment engineer and hospital management.

CHAPTER 4: RESULTS

4.1 Description of final sample

External defibrillator devices were assessed in 112 out of a total 123 (91.1%) areas in the hospital. Figure 1 describes how this final sample was achieved. Of the 11 areas that were excluded from the study, an external defibrillator device (EDD) was not present in 10 areas (8.1%), whilst consent for study participation could not be obtained from 1 area (0.8%).

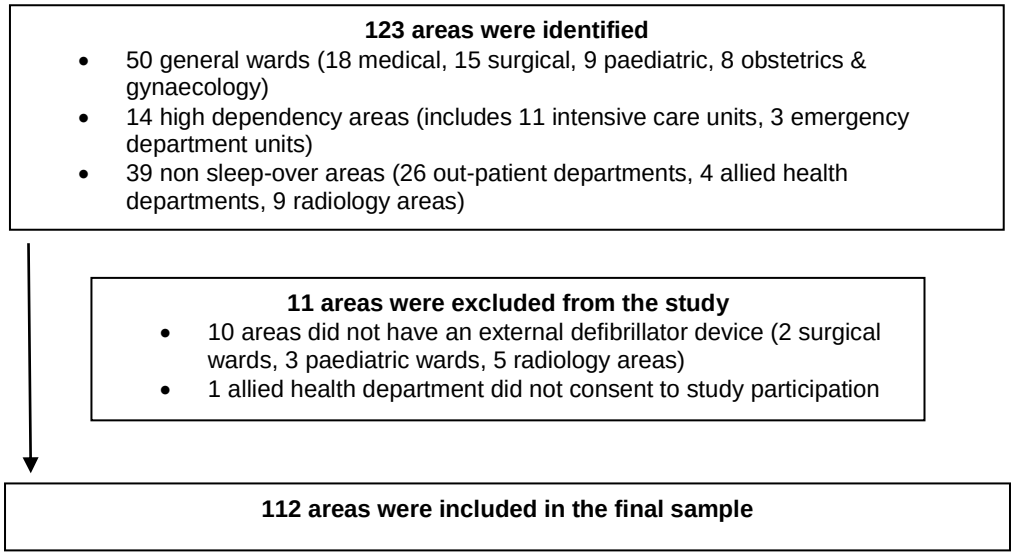


Figure 1. Exclusion and final sample for analysis

4.2 Total number of external defibrillator devices available in the hospital

There were a total of 143 EDD's in the entire hospital. This comprised 139 (97.2%) MED's and 4 (2.8%) AED's. Most areas assessed had only one device available (n=73, 78.5%), however 20 (21.5%) areas had more than one device (Table 1).

Table 1 Description of overall distribution, availability of checklist books and maintenance record of external defibrillator devices (EDD's) at various locations across the hospital.

Areas assessed	Areas assessed for the presence of an MED	Areas with one or more MED's (n,%)	Total number of MED's (n)	Total number of MED's with a checklist book (n,%)	Total number of MED's with checklist book having at least 1 documented check daily over last 5 days (n,%)	Total number of MED's with a maintenance stamp (n,%)	Total number of MED's that had documented maintenance in the last 12 months (n,%)
General wards	50	45(90%)	52	43(82.6%)	14(32.6%)	28(53.8%)	19(36.5%)
Medical	18	18(100%)	21	19(90.5%)	8(42.1%)	10(47.6%)	5(23.8%)
Surgical	15	13(86.6%)	15	13(86.7%)	5(38.4%)	9(60%)	7(46.7%)
Paediatric	9	6(66.6%)	7	6(85.7%)	0(0%)	5(71.4%)	3(42.8%)
O&G	8	8(100%)	9	5(55.6%)	1(20%)	4(44.4%)	4(44.4%)
High dependency areas	14	14(100%)	27	26(96.3%)	4(15.4%)	22(81.5%)	17(63%)
ICU's	11	11(100%)	19	18(94.7%)	3(16.7%)	15(78.9%)	13(68.4%)
ED's	3	3(100%)	8	8(100%)	1(12.5%)	7(87.5%)	4(50%)
Non-sleep over areas	38	33(86.8%)	35	15(42.9%)	3(20%)	16(45.7%)	11(31.4%)
OPD's	26	26(100%)	27	14(51.9%)	3(21.4%)	14(51.8%)	9(33.3%)
Allied health	3	3(100%)	3	0(0%)	0(0%)	0(0%)	0(0%)
Radiology areas	9	4(44.4%)	5	1(20%)	0(0%)	2(40%)	2(40%)
Theatre complex	20	20(100%)	25	17(68%)	5(29.4%)	17(68%)	10(50%)
Theatre rooms	18	18(100%)	23	16(88.9%)	5(31.2%)	17(73.9%)	10(55.5%)
Peri-op areas	2	2(100%)	2	1(50%)	0(0%)	0(0%)	0(%)

MED - manual external defibrillator
ED's - emergency departments (Adult medical and surgical, adult trauma, paediatric)
ICU's - intensive care units (Adult multidisciplinary ICU, adult multidisciplinary high care, trauma ICU, neurosurgical ICU, cardiology ICU, cardiothoracic ICU, neonatal ICU, neonatal high care, paediatric ICU, obstetrics high care
Allied health departments - physiotherapy, occupational therapy, dietician
O&G - Obstetrics and gynaecology

4.3 Distribution of devices across the hospital

The overall distribution of EDD's over various locations within the hospital are also described in table 1. EDD's were available in all (100%) of the high dependency wards (n=14) and theatres complex areas (n=20), whereas EDD's were available in 90.0% and 86.8% of the general wards (n=45) and non-sleep over areas (n=33) respectively. There was however no significant difference on the locations of the MED's at the different areas (p=0.64382, see table 2). Of the 4 AEDS in the hospital, 2 (50.00%)

Table 2 Statistical analysis comparing various aspects of manual external defibrillators between the general wards, non-sleep over areas, high dependency areas and theatre complexes.

	Areas Assesses for Statistical Significance	**P Values obtained (p<0.05 as significant using Pearson Chi-square)**	**Post Hoc Analysis if applicable for areas with significant p values after Bonferroni correction (Corrected significant p<0.00313)**
Areas with one or more MED	General wards High dependency areas Non-sleep over areas Theatre Complex	p=0.64382	N/A
Total number of MED's with a checklist book	General wards High dependency areas Non-sleep over areas Theatre Complex	p<0.003125	GW vs TC p=0.00062
Total number of MED's with checklist book having at least 1 documented check daily over last 5 days	General wards High dependency areas Non-sleep over areas Theatre Complex	p<0.00001	NSOA vs TC p=0.0005 GW vs HDA p,0.00001
Total number of MED's with a maintenance stamp	General wards High dependency areas Non-sleep over areas Theatre Complex	p<0.00001	GW vs NSOA p=0.0004 GW vs HDA p=0.00049 HDA vs NSOA p<0.00001 NSOA vs TC p=0.00003
Total number of MED's that had documented maintenance in the last 12 months	General wards High dependency areas Non-sleep over areas Theatre Complex	p<0.00001	GW vs HDA p=0.00007 HDA vs NSA p<0.00001 GW vs NSOA p=0.00138 NSOA vs TC p<0.0001 HDA vs NSOA p=0.0029

GW- General ward
HDA High dependency areas
NSOA- Non-sleep over areas
TC- Theatre complex

were in the outpatients department, while the other 2 (50.00%) devices were located in a surgical ward and the radiology department respectively.

4.5 Availability of checklist booklet and frequency of checks in the last 24 hours

Daily checklist books were available with almost three quarters (101, 72.7%) of the 139 MED's across the hospital. The high dependency wards had the highest percentage (96.3%, n=26) whereas the non-sleep over areas had the lowest percentage (42.9%, n=15). The overall prevalence of the checklist books are described in table 1. There was a statistically significant difference with regards to the area where the MED's were located and the presence of the checklist book ($p=0.00313$, see table 2). However there was no statistically significant difference when comparing the different locations within the areas (General wards $p=0.173$, high dependency areas $p=0.497$, non-sleep over areas $p=0.344$, see tables 3,4,5). On assessing how regularly checks were being conducted, 25.7% (n=26) of the MEDs with a checklist book had a documented check at least once (am check or pm check) daily over a 5 day period.

A statistical significance was noted with regards to the location of the MED and daily checks being conducted ($p<0.00001$) with the general wards completing the most checks (32.6%, n=14) and the high dependency areas the least (15.4%, n=4). On assessing the individual areas within the locations, daily checks were completed more frequently over a 5 day period in the medical wards (42.1%, n=8) whereas no frequent checks were being completed in the pediatric wards, allied health areas, radiology areas and peri-op areas in the theatre complex (see table 1). There was a statistically significant difference when comparing the individual areas within the locations in the

general wards and non-sleep over areas (p<0.0001, see table 3 and 5) together with the high dependence areas (p=0.007, see table 4). No AED was found to have a checklist booklet.

Table 3 Statistical analysis comparing various aspects of manual external defibrillators between the general wards

	Areas Assesses for Statistical Significance	**p Values obtained (p<0.05 as significant using Pearson Chi-square)**	**Post Hoc Analysis applied to areas with significant P values. Bonferroni correction used to calculate for corrected p value (p<0.00313)**
Areas with one or more MED	Medical Surgical Paediatric O&G	p=0.173	N/A
Total number of MED's with a checklist book	Medical Surgical Paediatric O&G	p=0.456	N/A
Total number of MED's with checklist book having at least 1 documented check daily over last 5 days	Medical Surgical Paediatric O&G	p<0.0001	Medical vs Paediatric p<0.00001
Total number of MED's with a maintenance stamp	Medical Surgical Paediatric O&G	p<0.0001	O&G vs Paediatric p<0.00001
Total number of MED's that had documented maintenance in the last 12 months	Medical Surgical Paediatric O&G	p<0.0001	No difference found p > 0.00313

O & G- Obstetrics and gynaecology wards

Table 4 Statistical analysis comparing various aspects of manual external defibrillators between the high dependency areas

	Areas Assesses for statistical significance	**P Values obtained (p<0.05 as significant using Fisher Exact test)**
Total number of MED's with a checklist book	ICU ED	p=0.497
Total number of MED's with checklist book having at least 1 documented check daily over last 5 days	ICU ED	p=0.007
Total number of MED's with a maintenance stamp	ICU ED	p=0.347
Total number of MED's that had documented maintenance in the last 12 months	ICU ED	p<0.00001

ICU's – Intensive care units (Adult multidisciplinary ICU, adult multidisciplinary high care, surgical high care, trauma ICU, neurosurgical ICU, cardiology ICU, cardiothoracic ICU, neonatal ICU, neonatal high care, paediatric ICU, obstetrics high care
ED- emergency departments (Adult medical, adult trauma, paediatric)

4.6 Maintenance of Devices:

Maintenance stamps were found in 59.7% (n83) of MED's in the hospital. The high dependency wards (81.5%, n=22) and theatres (68%, n=17) were the areas that had the highest prevalence of maintenance stamps (Table 1). These two locations also had the most devices that had been serviced within the last 12 months (63%, n= 17 and 50% n=10 respectively). These results were statistically significant for both the presence of a maintenance stamp and servicing (p<0.00001 see table 2). On investigating the time since the last maintenance, 8.4% (n=7) of the MED's had been serviced within 6 months of data collection, 60.3% (n=50) between 7-12 months and 31.3% (n=25) had their last service more than 12 months from data collection.

Table 5 Statistical analysis comparing various aspects of manual external defibrillators between the non-sleep over areas.

	Areas Assesses for Statistical significance	**P Values obtained (p<0.05 as significant using Pearson Chi-square)**	**Post Hoc Analysis applied to areas with significant P values. Bonferroni correction used to calculate for corrected p value**
Areas with one or more MED	**OPD Allied Health Radiology Department**	p=0.344	N/A
Total number of MED's with a checklist book	**OPD Allied Health Radiology Department**	p=0.430	N?A
Total number of MED's with checklist book having at least 1 documented check daily over last 5 days	**OPD Allied Health Radiology Department**	p<0.0001	No difference found using (Corrected significant p<0.00556)
Total number of MED's with a maintenance stamp	**OPD Allied Health Radiology Department**	p=0.579	N/A
Total number of MED's that had documented maintenance in the last 12 months	**OPD Allied Health Radiology Department**	p=0.022	No difference found using (Corrected significant p<0.00556)

OPD- Out patients departments

On assessing the individual areas within the locations, the paediatric wards had the most devices with the maintenance stamp (71.4%, n=5 see table 1), whereas the O & G wards the least (44.4%, n=4). These were the only areas where the differences were statistically significant (p<0.00001, see table 3). There were no significant difference between various locations within the high dependency wards and non-sleep over areas (p=0.347, p=0.579 respectively). Tables 2-5 summarises results of statistical analysis comparing the various locations and areas with regards to the presence of a maintenance stamp. With regards to the AED's, 2 of the 4 devices

(50.0%) were found to have a maintenance stamp, both of which were within 12 months of their last service date. These 2 AED's were found in the OPD areas.

4.7 Adherence to national checklist guidelines

Regarding the inspection and audit of the MED's as per the EMMSA guidelines, none of the devices were able to meet all the requirements as set out on the guidelines checklist. On assessing the devices using average scores, the theatre complex achieved the highest average (82.1%) whereas the general wards had the lowest average (70.6%, $p<0.00001$).

Most units were found to be clean (97.6%, $p=0.053$) with functional cables (95.8%, $p=0.061$). The general condition of defibrillator paddles at the general wards and theatre complexes were found to be inferior to that of the average achieved in the other areas (73.1% and 70.4% respectively, $p<0.0001$). On assessing the consumables that are listed in the supplies category in the EMSSA guidelines, all areas had low averages, specifically with regards to the presence of alcohol wipes (32.2%, $p<0.0001$), hand towels (22.9%, $p<0.0001$), scissors (2.3%, $p=0.775$), spare ECG paper (25.5%, $p<0.0001$) and razors (25.7, $p<0.00001$). The presence of conductive gel was lowest in the high dependency areas (45.7%) and the general wards (48.1%), while the theatre complex had the highest average (92.6%). More than 90% of the MED's were found to be plugged into a live outlet ($p=0.008$). Adequate ECG paper was found in 74.7% of MED's ($p<0.0001$) while only 73.5% of the MED's were able to print their recordings ($p<0.0001$). The other findings are described in table 6.

Table 6. The averages achieved at the various locations in the hospital with regards to adherence to EMMSA defibrillator device checklist guidelines

Items Investigated	General wards (n=52)	Theatre complex (n=25)	High dependency areas (n=27)	Non-sleep over areas (n=35)	Total (n=139)	Statistical Significance
Defibrillator Unit Clean / no spills / clear of objects on top / casing intact	90.4	100.0	100.0	100.0	97.6	p=0.053
Paddles Clean / not pitted	73.1	70.4	94.3	92.0	82.4	p<0.00001 GW v HDA p<0.00001
Paddles Release from housing easily	98.1	100.0	97.1	100.0	98.8	p=0.844
Cables / Connectors Inspect for cracks / broken wire / damage (Yes if intact)	90.4	74.1	97.1	96.0	89.4	p=0.025 HDA v GW p=0.00020
Cables / Connectors engage securely and are not damaged	94.2	88.9	100.0	100.0	95.8	p=0.061
Supplies a. Monitoring electrodes	55.8	81.5	91.4	96.0	81.2	P<0.00001 GW vs TC p=0.00028 NSOA vs GW p=0.00156
Supplies b. Alcohol wipes	11.5	40.7	28.6	48.0	32.2	P<0.00001 NSOA vs HDA p<0.00001
Supplies c. Hand towel	5.8	25.9	20.0	40.0	22.9	p<0.00001 TC vs GW p=0.0009
Supplies d. Scissors	1.9	7.4	0.0	0.0	2.3	p=0.775
Supplies e. Razor	13.5	40.7	8.6	40.0	25.7	p<0.00001 HDA vs GW p<0.00001 GW vs TC p<0.00001
Supplies f. Spare ECG paper	15.4	18.5	40.0	28.0	25.5	P<0.00001 GW vs HDA p=0.00105 GW vs NSOA p<0.00001 GW vs TC p=0.00009
Supplies g. Gel or other conductive medium present and stored properly	48.1	92.6	45.7	88.0	68.6	p<0.00001 NSOA vs GW P=0.00174 NSOA vs TC p<0.00001 GW vs HDA p=0.00011
Power Supply a. Plugged into live outlet to maintain battery	90.4	88.9	88.6	96.0	91.0	p=0.008 No difference on post hoc analysis

Items Investigated	General wards (n=52)	Theatre complex (n=25)	High dependency areas (n=27)	Non-sleep over areas (n=35)	Total (n=139)	Statistical Significance
Power Supply b. Test on battery power and reconnect to line power	92.3	96.3	94.3	100.0	95.7	p=0.190
Power Supply c. Battery charging: 'low battery' light off	80.8	85.2	68.6	96.0	82.6	p=0.001 HDA vs GW p=0.00278
Power Supply d. Correct time displayed	88.5	77.8	80.0	84.0	82.6	P<0.00001 HDA vs TC p<0.00001 NSOA vs TC p<0.00001
ECG Display a. Power on Display	96.2	100.0	100.0	96.0	98.1	p=0.609
ECG Display b. Self-test Okay	88.5	88.9	97.1	100.0	93.6	p=0.007 GW vs NSOA p=0.00001 HDA vs NSOA p=0.00241
ECG Display c. Monitor display functional	100.0	100.0	100.0	100.0	100.0	n/a
ECG Recorder a. Adequate ECG paper	82.7	63.0	77.1	76.0	74.7	p<0.00001 GW vs HDA p=0.0004 HD vs NSOA p<0.00001 TC vs NSOA p<0.00001
ECG Recorder b. Recorder prints	80.8	63.0	74.3	76.0	73.5	p<0.00001 GW vs HDA p<0.00001 GW vs NSOA p<00001 GW vs TC p<0.00001
Charge- Display Cycle a. Disconnect AC plug - battery backup unit	86.5	92.6	94.3	100.0	93.3	p=0.001 GW vs NSOA p<0.00001
Charge- Display Cycle b. Charges to manufacturer's recommended test energy level	90.4	92.6	97.1	100.0	95.0	p=0.157
Charge-Display Cycle c. Charge indicators working	96.2	96.3	100.0	100.0	98.1	p=0.634
Charge-Display Cycle d. Discharge as per manufacturer's instruction	92.3	100.0	92.6	97.1	95.5	p=0.063

Items Investigated	General wards (n=52)	Theatre complex (n=25)	High dependency areas (n=27)	Non-sleep over areas (n=35)	Total (n=139)	Statistical Significance
Overall Average Achieved	**70.6**	**75.4**	**75.5**	**82.0**	**75.9**	p<0.00001 GW vs HDA p<0.00001 GW vs NSOA p<0.00001 GW vs TC p<0.00001

GW - general ward
HAD - high dependency areas
NSOA - non-sleep over areas
TC - theatre complex

Seven devices (5.0%) were assessed as having critical problems. All of these devices were unable to discharge after charging. These devices were located in the medical wards (n=3), intensive care units (n=2), surgical ward (n=1) and the outpatients department (n=1). Power supply and battery problems were the chief critical problems. Table 7 gives a description of the MED's that had failed. It was noted that two of the MED's were still able to discharge only when plugged into a live outlet. Included in the seven, was a device that had been condemned by the operational manager in the unit. This device was included in the study as it was placed on a resuscitation trolley alongside a functional device. They were 13 devices that were not plugged into a live outlet. Three of these devices had failed the initial discharge test as the battery had failed. After charging, the devices were able to discharge as per manufacture's instruction. The initial assessment was entered into the final results.

Table 7. A description of the standard manual defibrillators that had failed

Location	**Presence of Maintenance Stamp**	**Checkbook Presence**	**Critical Problem**
Ward (Medical)	Yes (6-12months)	Yes	Battery power not functional
Ward (Medical)	No	No	Doesn't charge and deliver shock
Ward (Medical)	No	No	Battery and power supply problem
Ward (Critical Care Unit)	Yes (6-12months)	No	Doesn't charge and deliver shock
Ward (Critical Care Unit)	Yes (6-12months)	Yes	Battery and power supply Problem
Ward (Surgical)	No	No	Battery and power supply Problem
OPD	No	No	Battery power not functional

OPD- Out patients department

In terms of the AED's, we found that none of the devices were able to comply with the full AHA maintenance checklist. Most of the deficits on scoring were related to the fact that none of the units had two sealed AED pads (three had only one pad, with the fourth having no pads at all). There was one AED with a critical problem which was power related (Table 8).

Table 8. The results from the investigation of the automated external defibrillators using AHA guidelines

Items Investigated	Location of the 4 AED's Investigated			
	Ward	**Radiology Department**	**OPD**	**OPD**
Placement visible, unobstructed and near phone	No	Yes	Yes	No
If placement not correct, specify why (choice=obstructed placement)*	Checked	Unchecked	Unchecked	Checked
If placement not correct, specify why (choice=not near phone)*	Checked	Unchecked	Unchecked	Unchecked
Verify battery installation	Yes	Yes	Yes	Yes
Check status / Service indicator light	on	off	off	off
Absence of visual or audible service alarm	present	absent	absent	absent
Inspect external components and sockets for cracks	absent	absent	absent	absent
Supplies: AED pads in sealed packages	no pads present	only one pad present	only one pad present	only one pad present
Supplies: Check expiration date on pad packages	n/a	not expired	not expired	not expired
Supplies: Pocket valve with one-way valve	absent	present	absent	absent
Supplies: Bag Valve Mask Present in Resus Trolley *	Yes	No	No	Yes
Supplies: Examination Gloves	Present	Present	Present	Present
Supplies: Razor	Present	Absent	Absent	Absent
Supplies: Absorbent gauze or hand towels	Present	Present	Present	Absent

*Not included on AED maintenance checklist from American Heart Association 2001

OPD- Outpatients department

CHAPTER 5: DISCUSSION

5.1 Total number of external defibrillator devices available in the hospital

With regards to the total number of devices within the hospital, there was no literature found to compare this nor any guidelines to suggest how many devices are expected within a healthcare facility.

A large proportion of the defibrillator devices were of the standard manual type (97.2%, n=139). This may be understandable as the setting of the investigation was a tertiary-quaternary hospital, where it is expected that most of the operators of the devices will be professionals who have the knowledge and skill on how to use them effectively. Further studies will be needed to investigate if this is true at this facility. Regarding the AED, the few numbers present in the hospital may be justified in that they are being used in areas where skills in using a MED may not be present, particularly in rhythm analysis. Current literature also supports the use of MED's as opposed to AED for in-hospital cardiac arrest, as AED's have not been found to improve patient outcomes (41,55).

Most of the areas had at least one EDD (n=73, 78.5%). The high dependency areas had the most wards with more than one device. These areas are expected to be where most cardiac arrests are likely to take place. There was however no literature that was found to suggest that having more than one EDD in a ward improves patient's outcomes.

5.2 Distribution of devices across the hospital

The general wards had the most MED's (37.4%, n52). This is likely due to the general wards having the greater number of areas within the hospital that were assessed (41%, n=50). The radiology areas and paediatrics wards had the lowest prevalence of EDD's (44%, n=4 and 66.6%, n=7 respectively). The rarity of shockable rhythms in the paediatric inhospital cardiac arrest may have impacted on the number of devices in the paediatric wards (56–58). Cardiac arrest in the radiology departments is also very rare. Hope et al found an incidence rate of 0.002% in their study(59). All this may lead to these departments not requiring extra EDD's.

5.3 The prevalence of various brands of external defibrillator devices across the hospital

A large majority of the MED brands were the Phillips (Koninklijke Philips N.V., Amsterdam, Netherlands), Nihon Kohden (Nihon Kohden Corporation, Tokoyo, Japan) and Zoll (ZOLL Medical Corporation, Massachusetts, United States of America) brands. A new procurement contract by the hospital whereby only one type of device was being procured has likely influenced this. The potential benefits of having a single device in a facility are that the staff member's and users may become more acquainted with the device's functions. This then may lead to fewer errors during a resuscitation within any location in the hospital. There is a paucity of evidence to clearly demonstrate any benefit of this, which therefore may be a potential area of study as well.

5.4 Availability of checklist booklet and frequency of checks in the last 24 hours

Each EDD is expected to have a checklist booklet to document completed daily device checks (1,18). No AED was found to have a booklet while only 72.7% (n=101) of MED's had a checklist booklet. No other study with a similar design was found to compare the prevalence of the checklist booklets with the EDD. In South Africa, Louw et al found that 26% of the devices at emergency centers investigated had a dedicated logbook for the checks having been performed. It is difficult to compare the studies as our study was investigating EDD's at a hospital as a whole, while the other study compared EDD's in the emergency centers at district, regional and central hospitals using a questionnaire design (53). The studies do however highlight the challenges which are present with regards to the checklist booklets and checks being conducted at health care facilities in South Africa. A dedicated checklist booklet is important as it provides evidence that checks on the devices are taking place consistently together as a quality assurance policy, to mitigate errors and device failures which may take place during an emergency. It is a recommendation by the AHA that devices are maintained in a state of readiness with checklists being useful in identifying any deficiencies that may be present (8).

There may be a number of reasons why the checklist booklets were not present at some of the locations in our study. These may include:

1. Lack of understanding in the importance of the checklist booklet
2. Lack of understanding of the defibrillator and its functions
3. Poor teaching or knowledge in performing the checks on the devices, especially with junior inexperienced staff that are entrusted with the task of performing the checks.

4. Checks are taking place, but there is poor documentation and data capturing of the check printout.
5. The devices aren't being used in the relevant area as there are very few emergencies in that unit or ward that require defibrillation, thus the devices are not routinely cared for and tested.

The high dependency areas, medical wards and theater rooms had the highest prevalence of the booklets (96.3% n=26, 90.5% n= 19, 88.9% n=16 respectively). This may help support the notion that the relevance of the device to that unit also determines whether it is checked.

The presence of the checklist booklet did not necessarily mean that daily checks were taking place with only 25.7% (n=26) of the devices with a checklist booklet having completed a check consistently over a 5 day period. This wide frequency of checking was also noted in the Western Cape study by Louw et al, with 67% of the emergency centers conducting tests but only 52% of these being conducted daily (53).

There may also be a number of possibilities why there were no consistent completed checks on the devices. These include:

1. That its junior staff that are given the duties to perform the checks but have not been adequately trained on how to do so.
2. The allocations of the checking of the defibrillators are not given priority. This may be due to the fact that the devices are not used regularly in some locations, though this was note investigated.

3. That checking is very sporadic. Thus the checks are possibly performed only during the early parts of the week and later during the week the device is overlooked.

These postulations may serve again as a potential area of research as evidence for this in national and international literature is poor.

5.5 Maintenance of devices

On investigating the maintenance of the EDD, a significant number of the MED's did not have the stamp (40.3% n=56). There are a number of reasons why this might have been the case. It must be considered that:

1. Some of the devices were newly acquired during the year and had not needed their maintenance as yet. The study did not investigate this and it was not clear on the devices when the operational date was.
2. The maintenance stamp had been removed or fallen off the device.
3. That the devices were recently serviced and stamps were not placed for various reasons.
4. Finally, that the devices were still to be serviced.

The location of the MED needs to be considered as a factor relating to the presence of the stamp. The statistical significance in the relationship with regards to the presence of the maintenance stamp and the location of the MED supports this ($p<0.0001$). There were more maintenance stamps and services being conducted in areas where emergencies were most likely to occur such as high dependency areas and theater

complex (81.5% n22, 68% n=17) respectively. The non-sleep over areas and general wards therefore need more support and encouragement to keep their devices in a state of readiness even though they may not be used frequently.

The results investigating the distribution of the timelines at which the services on the MED's were done was significantly biased by the fact that over 40% of the devices did not have a stamp on them. As described above, there may be a number of reasons for this. It is therefore difficult to extrapolate unbiased analysis on the distribution of the service stamps. There were no other studies that had been found with our similar study design investigating maintenance of the devices in hospital. The Defibrillator Working Group survey in 1989 however did reveal the problem of periodic maintenance of the devices in hospitals and ED's, with 20% of the devices having not had their scheduled maintenance (10).

5.5 Assessment of devices using EMMSA and AHA Guidelines

On investigating the MED as per EMMSA guidelines, none of the devices were able to meet all the parameters described. There were no other studies to give any relative comparison with our findings, including using any other guideline. Of note, a significant proportion of the low percentages were in the supplies categories for the MED's. These included the presence of the monitoring electrodes (81.2%), alcohol wipes (32.2%), hand towels (22.9%), scissors (2.3%), razors (25.7%), spare ECG paper (25.5%) and conductive gel (68.6%). On finding reasons why these might not be present, anecdotally medical supplies in government hospitals are sporadically available. With the non-sleep over areas performing the best with overall compliance, its supplies were on average better that the other areas in the hospital. A possible

reason for this is that the devices and consumables are not used frequently in these areas thus not having any difficulties with reordering of supplies.

Battery and power supply problems with MED's are a well-established concern. The Defibrillator Working Group in 1989 found that of the 676 defibrillator failures that were reported, battery failures were found in 25% of the devices (10). In our study five out the seven devices with a critical problem (71.4%) had a battery related failure which was significantly higher. The battery failures from the Defibrillator Working Group survey though were in devices that had already failed during use, where as we investigated the devices before potential use. This may thus pose as a bias for the results reported. It was also not documented whether these battery related problems were also observed during the in-service inspections of the devices. There were unfortunately no other recent studies on MED's with a comparable study design as our study to liken these results.

The four AED devices present also had not complied fully with the AHA AED maintenance checklist. Two of the devices were in obstructed areas which then nullifies the concept of public assess defibrillation (60,61). The supplies with the devices was also sporadic with one device having no pads. All this questions the need of the AED's at this facility.

5.6 Limitations of the study

Firstly, this is a single centre study conducted in a tertiary-quaternary academic hospital in one of the main metropolitan cities of South Africa. Consequently, the findings of this study may not be comparable to other geographic parts of South Africa let alone private hospitals.

With regards to the devices, the site at which the study took place did not have an exact figure with regards to how many external defibrillator devices were present. There was also no clear registry of where in the hospital these devices may have been located. Bearing this in mind, together with the assurance that the researcher was meticulous in the locating of the devices, it must be considered that the researcher may have not investigated all the devices present.

It must also be noted that in our study we did not evaluate how exactly the checks were being conducted by the staff. This may have highlighted some of the shortfalls that are potentially present when conducting the daily checks on the devices.

Another area that may have been investigated was assessing how frequently the devices were used at each of the locations for patient management. This might have helped clarify if they may have been any association between how often a device is used, and how well they are checked and maintained. These are also potential areas where further studies may be done.

5.7 Recommendations

As this hospital moves towards the standardization of the equipment and use a single brand for the MED, it is expected that this would improve both the checking and maintenance of the devices. This would then help ensure that they are at an optimal level of functioning as external defibrillators are indispensable in the management of patients during resuscitation. This study helps highlight potential areas where interventions may be placed to decrease the possibility of defibrillator failure. Further emphasis is needed in teaching and encouraging the staff to check and maintain the devices together with ensuring that the supporting equipment for the devices are present. Additional audits or studies need to be done to help assess the scope of knowledge of the staff members on the devices at this facility, as this may have direct implications on how the devices are checked and maintained. AED’s have a limited role during in-hospital cardiac arrest, and thus may at this facility be of use in more public domain areas such OPD’s as opposed to the wards.

CHAPTER 6: CONCLUSION

The results of our study indicate emphasis is needed on external defibrillator checking and maintenance. Although 95% of the MED's were fully functional, the consumables that are used to support the devices were inconsistently present throughout the hospital. Due to the paucity of research on the auditing of EDD's at health care facilities in South Africa and internationally, additional studies are needed to help give further insight into this subject matter.

CHAPTER 7: REFERNENCES

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APPENDICES

Appendix 1: Ethics Clearance Certificate

R14/49 Dr S'fisosikayise Madi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160210

NAME: (Principal Investigator)	Dr S'fisosikayise Madi
DEPARTMENT:	Emergency Medicine Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	Delibrillator Devices at a Public Sector Hospital in Gauteng
DATE CONSIDERED:	26/02/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Ferooza Motara
APPROVED BY:	Professor P. Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	01/04/2016

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

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004, 10th floor, Senate House/2nd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.**

Principal Investigator Signature

Date 05/04/2016

Appendix 2: Data Collection Sheet for Defibrillator Device

Please encircle / indicate appropriate response

Part 1: General
Area number in hospital: _____
Location within hospital:
Ward / theatre / OPD / radiology / ED / allied health department /
Other (specify): _____
If ward, specify type:
Medical / surgical / Paediatric / O+G / ICU /
Other (specify):_____
Number of devices present at location: _____
Defibrillator devices types present:
Standard manual defibrillator (quantity: __), if present please also complete part 2
Automated external defibrillator (quantity: __), if present please also complete part 3
Device make / manufacturer: Zoll / Phillips / Lifepak / Nihon Kohden /
Other (specify): _____
Maintenance service stamp present: Yes / No
If yes, last maintenance service date:
0-6 months / 7-12 months / >12 months
Daily checklist book present: Yes / No
If yes:
AM daily checks completed in the last 5 days: Yes / No
PM daily checks completed in the last 5 days: Yes / No

Part 2: Standard Manual Defibrillator
Manual defibrillator investigated (no.): _____

ITEM	**Yes**	**No**
1. Defibrillator Unit		
a. Clean		
b. No objects placed on top		
c. Casing intact		
2. Paddles		
a. Clean		
b. Easily releases from housing		
4. Supplies and consumables		
a. Two sets of defibrillation pads in sealed packages, within expiry date		
b. Monitoring electrodes		
c. Alcohol wipes		
d. Hand towel		
e. Scissors		
f. Razor		
g. Spare ECG paper		
h. Spare charged battery available		
i. Appropriate conductive medium		

5. Power Supply		
a. Battery-powered units		
i. Verify fully charged battery in place		
ii. Spare charged battery available		
iii. Follow appropriate battery rotation schedule as per manufacturer's recommendations		
b. AC / battery back-up units		
i. Plugged into live outlet to maintain battery		
ii. Test on battery power and reconnect to line power		
e. Battery charging: "low battery" light off		
f. Correct time displayed		
6. Indicators / Display		
a. Power on display		
b. Self-test passed		
c. Monitor display functional		
d. "Service" message display off		
e. Battery charging: "low battery" light off		
f. Correct time displayed		
7. ECG Recorder		
a. Adequate ECG paper		
b. Recorder printer functional		
8. Charge-Display Cycle for Paddle or Adhesive Pads		
a. Disconnect AC plug – battery back-up units		
b. Charge to manufacturer's recommended test energy level		
c. Charge indicators working		
d. Discharge as per manufacturer's instructions		
e. Reconnect line power		
9. Pacemaker		
a. Pacemaker function available (if yes, please indicate below answers)		
b. Pacer output cable intact		
c. Pacer pads present		
d. Inspect as per manufacturer's operational guidelines		

Additional comments: _____
_____
_____
_____

Part 3: Automated External Defibrillator (AED)
AED investigated (no.): _____

ITEM	Yes	No
1. AED		
a. Placement visible / unobstructed		
b. Verify battery installation		
c. Check the functional status/service indicator light		
d. Note absence of visual/audible service alarm		
e. Inspect exterior components and sockets for cracks		

2. Supplies		
a. Two sets of AED pads in sealed packages		
b. Expiration date on pad packages		
c. Pocket mask with one-way valve		
d. Examination gloves		
e. Razor		
f. Absorbent gauze or hand towel		

Additional comments: _____
_____
_____
_____

Appendix 3: Plagiarism Declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I S'fisosikayise Madi (Student number: 784965) am a student registered for the degree of Master of Medicine (Emergency Medince) in the academic year 2013.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.



S'fisosikayise Madi

10 November 2017

Date

Appendix 4: Turnitin Report

784965:S_Madi_MMED.doc

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