

**An assessment of theoretical knowledge and psychomotor  
skills of Basic Life Support Cardio-Pulmonary Resuscitation  
provision by Emergency Medical Services in a province in  
South Africa**

**By**

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## **Declaration**

I, Jean-Paul T. Veronese, declare that this dissertation is my own unaided work. It is being submitted for the degree of Master of Science (Emergency Medicine) to the Faculty of Health Sciences, University of Cape Town. It has not been submitted before for any degree or examination at any other university.

Signature: \_\_\_\_\_

Signed this 2<sup>nd</sup> day of September, 2015

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# **ABSTRACT**

## **Introduction**

When high quality cardiopulmonary resuscitation (CPR) is performed, survival rates can approach 50% following witnessed out-of-hospital cardiac arrest. However, survival rates are more commonly much worse in both the in-hospital and out-of-hospital context and range from 0%-18%. There is a paucity of evidence surrounding the competency at which basic life support (BLS) CPR is provided among Emergency Medical Services (EMS) personnel in South Africa, and quality assurance mechanisms are generally scarce or do not exist.

## **Methods**

A descriptive analytical study design was used to assess theoretical knowledge and psychomotor skills of BLS CPR provision by EMS personnel in a province in South Africa. An assessment questionnaire from a 'BLS for healthcare providers' course was used to determine theoretical knowledge. Cardiac arrest simulations were video recorded to assess psychomotor skills. BLS instructors independently scored the latter.

## **Results**

Overall competency of BLS CPR among the participants (n=115) was poor. The median knowledge assessment was 50% and the median skills 22%. Only 25% of the items tested showed that the participants applied the relevant knowledge to the equivalent skill and the nature and strength of theory influencing skills was small. However, certain demographic and circumstantial variables such as sector of employment, guidelines they were trained according to, age, and location where trained had a significant effect ( $p < 0.05$ ) on knowledge and skills.

## **Discussion**

This study suggests that theoretical knowledge has a small but notable role to play in psychomotor skills performance of BLS CPR. Demographic and circumstantial variables that were shown to affect knowledge and skill may be used to improve training and therefore competency. The results of this study highlight the need for continuous, and perhaps tailored BLS CPR instruction to bring the diverse set of EMS personnel currently practicing in South Africa up to international competency standards.

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## List of Abbreviations

ACLS, Advanced Cardiac Life Support  
AEA, Ambulance Emergency Assistant  
AED, Automated External Defibrillator  
AHA, American Heart Association  
ALS, Advanced Life Support  
BAA, Basic Ambulance Assistant  
BLS, Basic Life Support  
CA, Cardiac Arrest  
CAB, Compressions – Airway – Breathing  
CCA, Critical Care Assistant  
CPD, Continuous Professional Development  
CPR, Cardio-Pulmonary Resuscitation  
CQI, Continuous Quality Improvement  
ECC, Emergency Cardiovascular Care  
ECG, Electro-Cardiogram  
EMS, Emergency Medical Services  
HCP, Health Care Provider  
HEI, Higher Education Institution  
HPCSA, Health Professions Council of South Africa  
MCQ, Multiple Choice Questionnaire  
NCD, Non-communicable diseases  
NQF, National Qualifications Framework  
OH, Out-of-hospital  
OHCA, Out-of-hospital cardiac arrest  
OSCE, Objective Structured Clinical Examination  
PI, Principal Investigator  
ROSC, Return of Spontaneous Circulation  
SA, South Africa  
SAQA, South African Qualifications Authority  
SCA, Sudden Cardiac Arrest  
USA, United States of America  
VF, Ventricular Fibrillation  
WHO, World Health Organisation

## Chapter 1 - Introduction

A significant challenge facing modern medicine is sudden death due to cardiac arrest. This is not only due to the substantial and growing number of cases each year, but also because of its social and economic impact (1). Cardiopulmonary resuscitation (CPR) is the first line treatment used and consists of a series of life-saving actions that improves the chance of survival following cardiac arrest (2). Despite this first line treatment and other important advances in prevention, sudden cardiac arrest (SCA) remains a substantial public health problem and a leading cause of death in many parts of the world (3). The terms 'sudden death' and 'cardiac arrest' are closely linked. These terms can be further described: "*Cardiac arrest' usually refers to a potentially reversible life-threatening cessation of effective cardiac mechanical activity, leading to loss of consciousness and accompanied by respiratory arrest*"; and "*sudden death' usually refers to the final stage of a cardiac arrest, with no resuscitation attempts taking place or attempts that have failed*" (1). Sudden death usually has cardiovascular causes with some studies estimating up to 80% of cases (4). Adults make up the vast majority of victims who suffer an in-hospital or out-of-hospital cardiac arrest (OHCA), whilst thousands of infants and children are also victims of cardiac arrest in these settings. This is likely the case in most settings, however data exists only from the United States of America (USA) and Canada (5, 6). Studies conducted on this topic reveal that sudden cardiac arrest is a very common cause of premature death, and that thousands of lives can be saved every year through improvements in CPR and related treatments.

Sudden cardiac arrest has many etiologies with the majority of causes (up to 80%) being a result of cardiovascular disease (1). Cardiovascular disease can lead to a lack of blood flow to areas of the heart muscle (coronary ischemia), and has been named the primary cause of sudden death and cardiac arrest by many institutions (1, 7). The association between cardiac arrest and cardiovascular disease has been recognised for centuries. Along with various other historic texts, the Ebers Papyrus from Egypt which dates back to 1550 BC notes that "*If a patient has pain in the arm and left side of the chest, there is a threat of death*" (8). Thus SCA and cardiovascular disease parallel one another (9-11). Of the 56 million deaths that occurred worldwide, 38 million were due to non-communicable diseases, principally cardiovascular diseases, of which there were 17.5 million (46.2% of NCD deaths) (12). The prevalence of this disease has been and is expected to continue increasing (12, 13). The resultant global

incidence of OHCA ranges from 20 to 140 per 100 000 people, and survival ranges from 2% to 11% (14). In high-income countries such as the United States of America (USA), cardiovascular disease remains their number one cause of death (15). Low- and middle-income countries such as South Africa (SA) and Argentina have historically focussed public health efforts on infectious disease, but a cardiovascular epidemic is on the rise in these countries (13). StatsSA report that heart disease is the 6<sup>th</sup> commonest cause of death in SA (16). Studies on the incidence of SCA in SA do not exist. There is however an ambitious effort underway to report the incidence of sudden cardiac death in African countries. The World Health Organisation (WHO) recently reported that “*non-communicable diseases (NCDs) are becoming a significant cause of morbidity and mortality in African countries*”, and that “*about 50% of this burden is attributable to cardiovascular disease*” (17, 18). This study is however not complete as yet, and aims to report results on the sudden cardiac death burden in the future. From the above, cardiovascular disease has been recognised as a threat to increasing the burden of death by CA in African countries, including SA.

Cardiac arrest occurs in a wide variety of settings, including both the in-hospital and OH setting. Studies conducted in the OH setting in high-income countries show survival rates from OHCA ranging from 2% to 16.3% (19, 20). The survival rate mentioned here is slightly higher to the global rate mentioned above. This could be due to the fact that cardiovascular disease has been shown to be the biggest killer in high-income countries, and so more resources would be targeted at combating this problem. In these studies performed in high-income countries, it was discovered that the time to CPR delivery and the quality of CPR delivered significantly affected outcome. Further, in some hospital settings the median survival rate reached as high as 18% (21). Even these in-hospital survival rates varied with poorer outcomes during night hours when patients are less monitored in the hospital (21). Patient survival has been shown to be linked to the quality of CPR performed. When rescuers compress at a depth of less than 3.8 centimetres (cm), survival-to-discharge rates for OHCA fall by 30% (22). Survival rates can even approach as high as almost 50% for the witnessed OHCA victim who receives high-quality CPR (23). This is important to note. Meaney highlights an incentive to improve outcomes based on what is revealed in these variations in performance and survival outcomes (24) in the different settings as a result of the quality of CPR delivered.

Cardiac arrest was already identified as a public health problem in the 60s, and as a result the American Heart Association (AHA) was formed and developed the first CPR

guidelines to help combat this issue (25). The AHA have since published these guidelines on CPR and Emergency Cardiovascular Care (ECC) every five years, with the latest set being published in 2010. These guidelines are based on the most current and comprehensive review of resuscitation literature (26). This evidence evaluation process included 356 resuscitation experts from 29 countries who reviewed, analysed, evaluated, debated, and discussed research and hypotheses during the 36 month period before the 2010 consensus conference. Among many other countries worldwide, SA recognises the AHA as the leading authority on CPR and ECC, and have been using these guidelines and recommendations to train and educate their health care providers (HCP) for several decades.

### **1.1 Background of the Study**

CPR is a series of life-saving actions that improve the chance of survival of cardiac arrest in both the OH (2) and in-hospital setting. The purpose of CPR is to provide blood flow to vital organs during cardiac arrest, especially the brain, which otherwise would die within four to six minutes (27). Whilst CPR consists of a series of actions, the most important actions that have been proven to significantly reduce mortality rates is considered to be the more basic actions of CPR, known as Basic Life Support CPR (BLS CPR). Other actions within the CPR realm, such as advanced life support (ALS) CPR (administering medications, ventilation, etc.), have been shown to have no significant effect on reducing mortality rates (27). This places greater emphasis on the need to optimise the actions that are considered to be basic and more easily attainable by a greater number of HCPs. Thus BLS CPR is considered to be the foundation to saving lives following cardiac arrest (27). The most important component of BLS CPR has been identified as chest compressions, which “*consist of forceful rhythmic applications of pressure over the lower half of the sternum*”. Intrathoracic pressure increases as a result of chest compressions, and directly compresses the heart which generates blood flow to the brain and heart (27). The next link of BLS CPR considered important is defibrillation. Defibrillation is a process in which an electronic device gives an electric shock to the heart. This helps to re-establish normal contraction rhythms in a heart typically experiencing a dangerous arrhythmia whilst in cardiac arrest, commonly known as ventricular fibrillation (VF) (28). Another common cardiac arrest arrhythmia similar to VF is known as pulseless ventricular tachycardia (VT).

The AHA has identified five links (or components as defined above) to care, called the Chain of Survival as depicted in Figure 1. When these links are implemented effectively, it translates into thousands of lives saved every year (29).



**Figure 1: The AHA Chain of Survival**

This means that even among witnessed VF cardiac arrest, survival rates can reach almost 50% (23, 30-32). However, survival rates have also shown to be as low as 3% (19). The disparity between survival rates differs mildly between areas and is attributed mostly to how effectively the links in the Chain of Survival are implemented, with emphasis on the quality of CPR delivered. Therefore, there is an opportunity for improvement by carefully examining the links, with a view to improving those that are weak. The two links that are directly impacted by the Emergency Medical Services (EMS) are early high quality CPR, and rapid defibrillation. These two links have been shown to have the biggest impact on reducing mortality rates for the patient experiencing VF CA in both the in-hospital and OH setting (27). No evidence exists regarding the efficiency with which these links are delivered by EMSs in SA. The epidemiology of OHCA has never been studied in an African population.

The EMS in SA is comprised of HCPs with a range of qualifications from basic to advanced levels. In short, the three tiers or levels that currently exist within the SA EMSs are basic, intermediate and advanced life support. These EMS HCPs respond to a variety of medical and trauma related calls, including those of cardiac arrest. Usually an ambulance with at least one basic HCP (a.k.a BAA) and one intermediate HCP (a.k.a Ambulance Emergency Assistant or AEA) will be sent to respond to a cardiac arrest victim. This combination of HCPs should carry the necessary skills to adequately provide BLS CPR. ALS paramedics will be sent in addition if they are available, but this does not happen for every cardiac arrest victim due to the limited number of HCPs who possess this qualification. It is also important to note that BAAs are largely not using Automated External Defibrillators (AED) to defibrillate at the time that this study was conducted. This is due to the skill only being introduced into their scope of practice in recent years, and updates in the use of an AED have been erratic

between different EMSs. Of the three tiers, AEAAs are the next level following the basic qualification where their scope allows them to manage a cardiac arrest patient with the use of a manual defibrillator when required. Even some of these HCPs have not been trained to use an AED, especially since most of the EMSs still incorporate the use of manual defibrillators. AEAAs therefore make up the second largest portion of pre-hospital workers in EMSs in the country. The outcome of survival rates from OHCA will therefore largely depend on the quality at which CPR with defibrillation is delivered by these HCPs. This information is further corroborated by those involved in the training that AEAAs make up the majority of HCPs who can perform CPR, with defibrillation, for the OHCA victim (33).

Historically, these qualifications were obtained through short-course based in-service training and so, today EMS consist mostly of HCPs with these short-course qualifications. Similarly to other health education courses, EMS education has recently begun the shift away from the short-course type qualifications and training towards qualifications that are in line with the National Qualifications Framework (NQF) so as to align with qualifications obtained from Higher Education Institutions (HEIs). The shift in EMS education has been relatively slower compared to other health education short-courses. This shift has largely been motivated by the Health Professional Council of South Africa (HPCSA). EMS personnel must be registered with the HPCSA in order to practice their profession within SA. The HPCSA is the governing body which regulates most health care professions in SA *“in aspects relating to registration, education and training, professional conduct and ethical behaviour, ensuring continuing professional development, and fostering compliance with health standards”* (34).

According to the 2013 annual report of the HPCSA, the SA EMSs employ approximately 16 000 workers in both the public and private sectors which is not expected to expand beyond 20 000 workers according to the Human Resources for Health 2030 plan (35). These statistics also reveal that there are 69 596 EMS qualified personnel registered with the HPCSA. It is unlikely that this inflated number of BAAs will be able find employment in SA, and has led to high rates of unemployment among those possessing this qualification. At the time that this study was performed, it is likely that the majority of these BAAs have not yet been trained to use an AED. This is due to AED use being added to their scope of practice only in 2006, with very few of them being updated in its use. Thus most of them do not provide the full scope of BLS CPR, inclusive of defibrillation, which is critical to survival. Nevertheless, AEAAs represent the second largest group of EMS qualified personnel registered in the country at a total

number of 8 515 (36). These figures are closely aligned to the information for this study whereby the number of AEs throughout the province employed in the public sector amounts to 578 of the total number of 2114 EMS staff. Thus, based on these figures, it is important to note that AEs are the most likely EMS workers to encounter OHCA victims who are capable of providing the complete skill set of BLS CPR, including defibrillation. This means that the quality of CPR that they provide will have the biggest impact on mortality rates.

## 1.2 Rationale

Cardiac arrest is mostly caused by cardiovascular disease (1), of which there is a high prevalence of this disease in SA (16). There are no studies that report on the number of cardiac arrest calls attended to by EMSs. Anecdotally, it is however believed that a large portion of calls attended to by EMS personnel are for cardiac arrest victims. CPR can significantly improve survival rates by up to almost 50% for OH VF CA victims if the quality at which it is delivered is of a high standard (23, 30-32). Conversely, it is understood that poor quality CPR is as effective as no CPR at all (37), whilst other studies report survival rates from poor quality CPR to be as low as 0 to 3% (19, 20). To date, the quality at which CPR is delivered by EMS personnel to the OHCA victim in SA remains unknown, as well as the impact this life saving intervention has on the associated survival rates.

Little is understood as to what SA is currently doing to mitigate the burden that cardiac arrest places on the SA population. Beck noted in 1960 that cardiac arrest victims have "*hearts too good to die*", and death occurs prematurely if poor or no resuscitation is attempted (38). This is not a new concept, and it appears as though the problem has failed to have been addressed completely. There is a strong association between health care systems that do not monitor the quality at which EMS HCPs perform CPR, and poor quality CPR delivery and survival rates (24). This information points out that due to there being no monitoring system in SAs EMSs, the opportunity to improve skills and save more lives is likely being missed. This will be validated if it is revealed that the quality of care in SA is shown to be substandard.

My hypothesis for this study is that the overall knowledge and psychomotor skills of BLS CPR will be sub-standard due to outdated training, and that better theoretical knowledge of BLS CPR will result in better psychomotor skill performance of BLS CPR.

### **1.3 Aim of the study**

The aim of this study is to investigate the performance of AEA personnel at providing BLS CPR in a simulated setting.

### **1.4 Research Objectives**

This study has four objectives:

1. to assess the level of theoretical knowledge of BLS CPR
2. to assess the level of psychomotor skills in BLS CPR provision
3. to understand the relationship between BLS CPR theoretical knowledge and psychomotor skills
4. to classify which demographic and circumstantial factors influence BLS CPR theoretical knowledge and psychomotor skills

# Chapter 2 - Literature Review

## Introduction

The review of literature focuses on important topics surrounding cardiac arrest and the effects that BLS CPR has on survival rates from cardiac arrest victims. Another important topic receiving attention in this section is factors influencing the quality of BLS CPR delivery among HCPs. These factors include: aspects that make up CPR competency, theoretical knowledge and psychomotor skills; the influence of theoretical knowledge on psychomotor skills of CPR; the important psychomotor skill components that describe effective CPR; Blooms taxonomy and psychomotor skill decay of BLS CPR performance; CPR education and instruction; methods and systems that can be used to improve psychomotor skill performance of BLS CPR among HCPs.

### 2.1 Cardiovascular disease, cardiac arrest and BLS CPR

The AHA states that “*Basic Life Support is the foundation for saving lives following cardiac arrest*” (27). They go on to mention that two of the four fundamental aspects to BLS are early CPR and rapid defibrillation. Despite advances in prevention, SCA continues to be a leading cause of death in the world. And although SCA has many etiologies, both cardiac and non-cardiac, the approach to resuscitation remains the same (3). Evidence shows that the prevalence of cardiac arrest as a result of cardiovascular death is on the rise globally (13), and that survival rates from OHCA can fall to very low rates (14). Zheng *et al* state that “*the high incidence, low rate of survival, and unpredictability of OHCA make it a significant public health issue*” (39). In SA, cardiovascular disease related deaths rank in the top ten causes of death (16). It is clear that cardiac arrest is a major killer in many parts of the world, including SA, which experiences a significantly high mortality rate as a result.

### 2.2 CPR and survival rates from out-of-hospital cardiac arrest

Survival rates from OHCA as a result of CPR have been well documented. The ‘Chain of Survival’, which is an integrated set of coordinated actions, is used to achieve successful resuscitation following cardiac arrest. This concept is depicted in Figure 1. These actions or links include the following five steps: “*immediate recognition of cardiac arrest and activation of the emergency response system, early CPR with an*

*emphasis on chest compressions, rapid defibrillation, effective advanced life support, and integrated post-cardiac arrest care*" (29). In some communities, almost 50% of patients survive to hospital discharge after experiencing VF SCA (23). Unfortunately, and surprisingly, survival rates among these patients can be as low as 5% in some OH settings (19). The two major differences in survival rates in these communities have been attributed to early CPR and rapid defibrillation (23, 40). Similarly, most agree that the *"quality of CPR is likely an important contributor to successful outcome"* (41, 42). Further, studies have observed that when bystander CPR was initiated and professional pre-hospital rescuers arrived and judged their performance, higher quality CPR was correlated with improved survival (42-44). Thus, high quality BLS CPR that is provided early with defibrillation is vital to counter the high mortality rates that accompany OHCA victims.

### **2.3 The implementation of CPR in real-world practice**

The benefits of high quality CPR performance are clear, however the implementation of high-quality CPR and its practice also needs to be understood in order to limit these varying survival rates. Wik *et al* set out to study the quality of OH CPR performed by paramedics and nurse anaesthetists in a number of large cities including Stockholm and London. From their sample (n=176), they discovered that *"chest compressions were not delivered half of the time, and most compressions were too shallow"* (45). This appears to be in agreement with many other similarly conducted studies where CPR is of a poor quality. Abella *et al* set out to extend on the aforementioned research, but conducted it in the 'in-hospital' setting amongst hospital staff (46). Their study revealed similar results to Wik and concluded that *"the quality of multiple parameters of CPR was inconsistent and often did not meet published guideline recommendations, even when performed by well-trained hospital staff"*. Abella offers a remedy to this problem by suggesting that *"the importance of high-quality CPR suggests the need for rescuer feedback and monitoring of CPR quality during resuscitation efforts"* (46). This emphasizes the essential need to implement the component of feedback and CPR quality monitoring methods/devices that can support the quality of CPR delivery. This will be elucidated further in the section to follow.

## **2.4 The components that make up CPR competency among HCPs: theoretical knowledge and psychomotor skills**

In order to understand what makes a HCP competent in CPR, it is important to distinguish the components that make up competency. Broomfield identifies the components that make up CPR competency as being knowledge and psychomotor skills. He states that “*CPR competency is defined as having a cognitive knowledge domain and a psychomotor skills domain*” so that practitioners will be able to perform CPR in a cardiac arrest situation (47). In order to further identify knowledge, Bloom points out that knowledge, or the cognitive domain, consists of six successive levels, namely: knowledge, comprehension, application, analysis, synthesis, and application (48). This framework will be further elaborated on in the headings to follow. CPR requires a cognitive domain in order to apply the skill of CPR effectively in the psychomotor domain. However, when knowledge on CPR is tested on the BLS for HCPs course, they begin with a test that evaluates cognitive knowledge on the lower order skill level, namely theoretical knowledge. This tests the student’s ability to recall or recognize information, ideas, and principles in the approximate form in which they were learned (48). Theoretical knowledge on BLS CPR is tested at the beginning of the BLS for HCPs course through a multiple choice questionnaire in which the learner must get 84% or more to pass (49). Platt explains that “*psychomotor skill learning involves tasks that are physical in nature and often consist of coordinated muscle movements. But, psychomotor skills also require prior cognitive knowledge*”. Platt also points out that “*this fact is particularly true in the early developmental stages of psychomotor skills*” (50). From the statements above, it is clear that in order to be competent at any skill, including CPR, a command of both cognitive knowledge and psychomotor skills is necessary.

## **2.5 BLS CPR: The influence that theoretical knowledge has on psychomotor skills**

Ongoing theoretical knowledge retention is also just as important. The development of knowledge is an essential component of professional development in nurse education programs (51). Similarly among EMS personnel, Brown *et al* discovered that when a pre-hospital rescuer knows the guidelines theoretically, they perform BLS CPR better and in the correct sequence in terms of compression rate and compression to ventilation ratio. Even though theoretical knowledge is shown in these studies to have a positive effect on skills, overall performance still remained poor (52). Thus,

knowledge seems to only play a small role in better CPR skill performance. The type of CPR instruction also appears to influence knowledge development which affects overall CPR competency (53, 54). The function of CPR instruction is to ensure that nurses and other HCPs not only acquire knowledge, but that they maintain this knowledge to apply it competently to a cardiac arrest situation (47). Therefore, adequate knowledge of BLS CPR has a positive effect on the skill of BLS CPR among nursing and EMS personnel. Since this has not been investigated in the SA setting among EMS personnel, there remain many questions about CPR instruction, comprehension, and retention.

The link between the theoretical knowledge and its influence on psychomotor skills of CPR has been explored, most of which were in high-income countries. Brown *et al* set out to determine the relationship between CPR guideline knowledge and psychomotor skills related to BLS CPR and how each element affected overall CPR performance. Brown *et al* surmised that if there was a strong association between guideline knowledge and performance, educational techniques on CPR might be emphasized. However, if this association was weak, practice and feedback might be more useful. In their study they concluded that *“whilst knowledge of the guidelines appears to be associated with better performance, both cognitive and motor skill deterioration [were] well documented”* and that *“greater knowledge of the CPR guidelines [were] likely to improve some aspects of performance, but that skill retention and correct overall performance will continue to be a problem”* (52). From these studies we can see that knowledge plays a small positive role in skill performance of CPR, but that skill performance and retention is also influenced by other factors, such as ongoing skill practice.

## **2.6 Psychomotor skills components that define effective BLS CPR practice**

Further to the psychomotor skills domain and skill retention, skill decay has been well documented among HCPs with CPR skills. It has been significantly shown in the literature that HCPs both poorly acquire and retain the psychomotor skill of CPR. Whilst this mostly applies to advanced CPR, BLS CPR appears to be more easily attained (55), but also difficult to maintain among nurses and HCPs (56-58). Previous studies have not only described poor CPR techniques as performed by lay rescuers, but among all levels of HCPs (59). A cardiac arrest victim’s chance of survival is also dependant on the nurse or HCP’s ability to perform CPR (53, 60), and that evidence strongly suggests that some registered nurses lack competence in the performance of

CPR (47, 60). Most often, nurses and HCPs are the first responders to a cardiac arrest patient. If the competency at which they perform this life-saving skill is not of a high-quality standard, then the patient will not receive the optimal chance to survive. Studies report varied levels of competency in individual CPR psychomotor skills that change dramatically along a range from 0% to 100% (60, 61). Makhtori Nori *et al* conducted a study among nurses and their psychomotor skills results (n = 112). Prior to their course beginning they achieved an average of 18.7% (62). This poor result is consistent with other similar studies among pre-hospital HCPs (45).

The central goal of CPR is to deliver oxygen and substrate to vital tissues during cardiac arrest (24). As mentioned, this is done by performing a sequence of psychomotor skills. Studies consistently show that the core CPR skill of 'performing chest compressions' scores the lowest in psychomotor skill assessment (60, 61). Five main components of high-performance CPR have been identified, namely: chest compression rate, chest compression recoil, chest compression depth, ventilations, and chest compression fraction. These have been identified due to their important contribution to blood flow and impact on mortality rates (24). These components are defined as the following: the rate at which chest compressions should be performed are at least 100 compressions per minute; chest recoil means that the rescuer must allow the chest to re-expand after each compression to ensure maximal ventricular filling at the end of every compression delivered; depth of chest compressions should be at least five centimetres; and ventilations should not be too forceful or performed more than the required two breaths after 30 compressions. Failure of the rescuer to deliver any one of these components correctly constitutes poor quality CPR. Poor performance in any one of these categories in chest compressions is not surprising as CPR is an intricate task, and HCPs are required to remember and perform up to 50 psychomotor skills within their scope of practice (54, 63).

## **2.7 Blooms taxonomy: psychomotor skills decay resulting in poor CPR performance**

Another common barrier that leads to poor CPR performance is skill decay. This occurs when HCPs go through prolonged periods of time without attending CPR refresher/training courses and not actually performing CPR (64). Skill decay appears to significantly affect CPR psychomotor skills. Whilst Bloom *et al* produced an elaborate compilation for the cognitive and affective domains, the psychomotor domain was addressed but poorly developed. However, there have been three other authors

who have created psychomotor models. Whilst all three models are similar, the one which closely approximates to the skill of CPR is the model created by Dave. Dave *et al* listed the steps in succession as: imitation, manipulation, precision, articulation, and naturalization (65). Several authors (66-70) further describe learning behaviour that generally follows a regularity known as a power of law of practice. The relationship between practice and skill proficiency is defined by this law. Newell *et al* go on to mention that “*as practice trials increase, task completion times decrease but at a diminishing rate resulting in a power law:  $Time = Trials^{-\alpha}$ , where  $\alpha$  represents the rate at which performance time changes*” (68). This information shows the importance of practicing skills on a regular basis so as to avoid skill decay. Greig *et al* define CPR retention “*as retaining the capacity to perform CPR effectively at a certain point in time after CPR training*” (61). It is also stated that the retention of CPR knowledge is critical in determining CPR competence (47). There is, however, universal evidence to suggest that CPR knowledge is poorly retained across populations and overall CPR competence is poor (47, 56, 71). Not only are knowledge and skills both poorly retained, but CPR skills appear to decay more rapidly than knowledge (72). This places greater emphasis on continuous skills practice in order to minimize or mitigate the decay of CPR skills.

## **2.8 CPR education and instruction**

The approach to improving CPR quality is not a simple task. Studies have shown that CPR is inherently inefficient as it provides only 10 to 30% of normal blood flow to the heart and 30 to 40% of normal blood flow to the brain when delivered according to the guidelines (73, 74). This inefficiency highlights the need for rescuers to deliver the highest quality CPR possible. Meaney references several studies in his 2013 publication on CPR quality (24) that skills attained in both basic and advanced life support courses deteriorates rapidly (within 6-12 months) if not used regularly (75-79). The AHA strongly recommends that “*methods should be developed to improve the quality of CPR delivered at the scene of cardiac arrest by healthcare providers and lay rescuers*” (24). The AHA goes on to say that more focus needs to be placed on “*education, training, assistance or feedback from biomedical devices, mechanical CPR, and electronic monitoring*” for CPR to be highly effective (24). Instructor led programs have been shown to influence the quality of training (75, 80, 81). The AHA however, does not concede an ideal training or education design. They do however recommend that continuous training in the form of mock codes and frequent, repetitive

training be used to maintain competency and minimize both knowledge and skill decay (24).

## **2.9 Methods and systems that improve CPR performance and patient outcomes**

Certain methods have been shown to improve CPR performance among HCPs. The AHA emphasize these methods and concepts for systems which aim to deliver professional CPR. They emphasize that the factors that should be focused on and implemented are: “*processes of continuous quality improvement that include monitoring the quality of CPR delivered at the scene of cardiac arrest, other process-of-care measures (e.g., initial rhythm, bystander CPR, and response intervals), and patient outcome up to hospital discharge*” (29). This evidence has been shown to maximize the quality of CPR delivered by HCPs. (29). Variability in clinician performance has undermined efforts to reduce healthcare-associated complications, and therefore the aim has been to implement a standardized approach which will improve outcomes and reduce preventable harms (82). One of these approaches is a systematic continuous quality improvement (CQI) approach which has been shown to optimize outcomes in a number of urgent healthcare conditions (83-85). It has been reported that the quality of resuscitation varies when these approaches or systems are not used, and the result is the loss of opportunity to save more lives (24). CQI systems monitoring CPR performance do not currently exist in SA, which appears to be similar to other healthcare systems where only a few apply these systems to consistently monitor CPR quality and outcomes (24). Thus, the above-mentioned factors surrounding each CPR event, the circumstances surrounding the event, the quality at which CPR was delivered, and the outcomes of the cardiac arrest victim should all be studied. In this way, systems can use the results as a form of feedback to ensure continuous quality assurance and move towards high-quality CPR delivery.

Another method to improve the quality at which CPR is delivered by HCPs is a form of feedback through automated devices. There has been a growing body of evidence demonstrating that CPR quality on a manikin is improved when monitoring and feedback are provided to and utilised by HCPs (86-88). Though it is noted that these studies do not necessarily represent a real cardiac arrest scenario, they are the closest and most practical way of observing what would occur in a real cardiac arrest situation. Training institutions responsible for qualifying HCPs have relied on this method for decades in order to formally assess their graduates. Moreover, a study by Abella *et al* has “*demonstrated modest improvements in the quality of CPR delivered during actual*

*in-hospital cardiac arrests with the use of a CPR-sensing and feedback-delivering monitor/defibrillator” (89). This appears to be a very easy and practical solution to enhance in-hospital and OHCA for HCPs and bystanders. A study by Platt concluded that there was a significant improvement in percentage of correct compressions and percentage of correct ventilations when computer-assisted feedback was used (50). The results showed that amongst experienced HCPs, CPR skills are enhanced. This study suggests that the use of computer feedback may be beneficial for skill development of novice learners as well.*

More research needs to be done to discover the practicality of these methods and measure the outcome to survival. In addition, research should be conducted to explore the benefits that these devices would have in a middle-income country like SA. SA faces different challenges to high-income countries where most of the literature on cardiac arrest emanates from. An analysis should be performed to determine the need of these devices based on the quality of BLS CPR provided by EMS personnel in SA. Along with this, a cost-benefit analysis would need to be performed to see whether the improvement from SCA, particularly VF SCA, mortality rates would significantly increase. The benefit would be especially noticed if other poor performing factors were mitigated, such as delayed response times which are a common issue faced by SA EMS and would certainly effect mortality.

## **Chapter 3 - Methodology**

### **3.1 Research design**

This study used a descriptive analytical design to assess the theoretical knowledge and psychomotor skills of BLS CPR provision of AEA's within EMSs in a province in SA. To assess theoretical knowledge we used a 20-part questionnaire (Annexure A) (90). Questions taken from this questionnaire were created by and validated by the AHA.

For psychomotor skills performance, we used a validated AHA skills sheet taken directly from the Advanced Cardiac Life Support (ACLS) provider manual (Annexure B) (91). Each performance was video recorded using multiple camera angles which were consolidated and sent off to independent reviewers (IR) for assessment. The IRs were BLS instructors from different professions but all were familiar with CPR training, and their purpose was to rate each participants' psychomotor skill performance. Data collection occurred during the month of November 2013, over a 3-week period.

Ethical clearance was obtained (HREC ref no: 575/2013) prior to study commencement.

### **3.2 Research participants**

#### **3.2.1 Population**

The target population was comprised of pre-hospital EMS personnel who were registered with the HPCSA as an AEA. It is unknown what the breakdown of qualifications in private EMS is due to the wide variety of EMS companies that exist throughout the province. However, in the public EMS, the total number of pre-hospital personnel in the province at the time of the study was approximately 2,114. This number of EMS personnel can be further broken down into 36 paramedics (2% at advanced level), 578 AEA's (27% at intermediate level), and 1500 Basic Ambulance Assistants (BAA or 71% at basic level) (33). The accessible population used was operational AEA's from both the private and public EMS from both urban and rural areas within the province.

### **3.2.2 Sampling Strategy**

Non-probabilistic convenience sampling was employed to select participants for this study. A sample of 115 AEs from both public and private departments throughout the province were used. All the volunteers were eligible and gave consent to participate. This group comprises of the largest group of EMS personnel in both the province and the country who are capable of performing the specific skill set that is being studied. The main EMS stations in each district were contacted by phone and informed that a continuous professional development (CPD) activity on an update in CPR would be held in their respective areas and a specified date was provided. It was the EMS base manager's responsibility to contact at least 20 personnel in their area and provide a list of those confirmed members in each district who would be attending the CPR update. They were informed that this update was aimed at operational staff. The update and data collection took place at each district's main EMS station. AEs interested in attending confirmed their interest to attend prior to the course date, and thus were added to the attendance list. AEs that attended the class and participated in the study were either off duty or were able to get time off during their shift to attend the class. There was no set number of participants for the various refresher courses. Of the seven districts throughout the province, six of the districts were reached during the allotted study period.

The IRs who observed the videos were instructors in the field of BLS training. Their instruction is in line with the current 2010 AHA BLS CPR guidelines. One doctor, one nurse, and one paramedic met the above criteria and were recruited. Once the three IRs agreed to participate, no further reviewers were recruited.

### **3.3 Measuring instruments**

Objective one was achieved by using a questionnaire that tested knowledge on BLS CPR (Annexure A). The questions were taken from actual AHA BLS CPR questionnaires. This questionnaire was available to the learners in English, the medium in which all learners in EMS are taught. In addition, a demographics and background survey (Annexure B) was issued to the participants and descriptive statistics were calculated. Information that was collected included age, gender, years of experience, public vs. private sector EMS, qualification, amount of times CPR was performed in the last year, last CPR certification, where training was received, which

CPR guidelines trained under (name and year), whether the participant was working according to them at present, or which guidelines they were currently working according to (name and year).

The second objective, to assess psychomotor skills, was measured using a skills sheet that assesses Adult BLS CPR with the use of an AED (Annexure C). The skills sheet was derived from the AHA, which is considered to be the benchmark against which all CPR guidelines are measured against in SA. AHA practices are taught by all major universities and colleges involved with training all skills related to emergency care and especially all forms of CPR (child and adult). All BLS and ACLS training centres are also based on the AHA guidelines and were therefore used to measure psychomotor skills in this study. Whilst this skills sheet could also be used to assess the HCP using a manual defibrillator, there were some important components of BLS CPR that could not be adequately studied or assessed during the skill of CPR. Therefore, the PI and an additional, independent, BLS instructor added a number of additional skill assessment steps to the skills sheet for a more complete, albeit modified, assessment. Thus, two scores were derived by the IRs; the original score and a modified score. The modified score has all of the original steps in it, plus several additional steps.

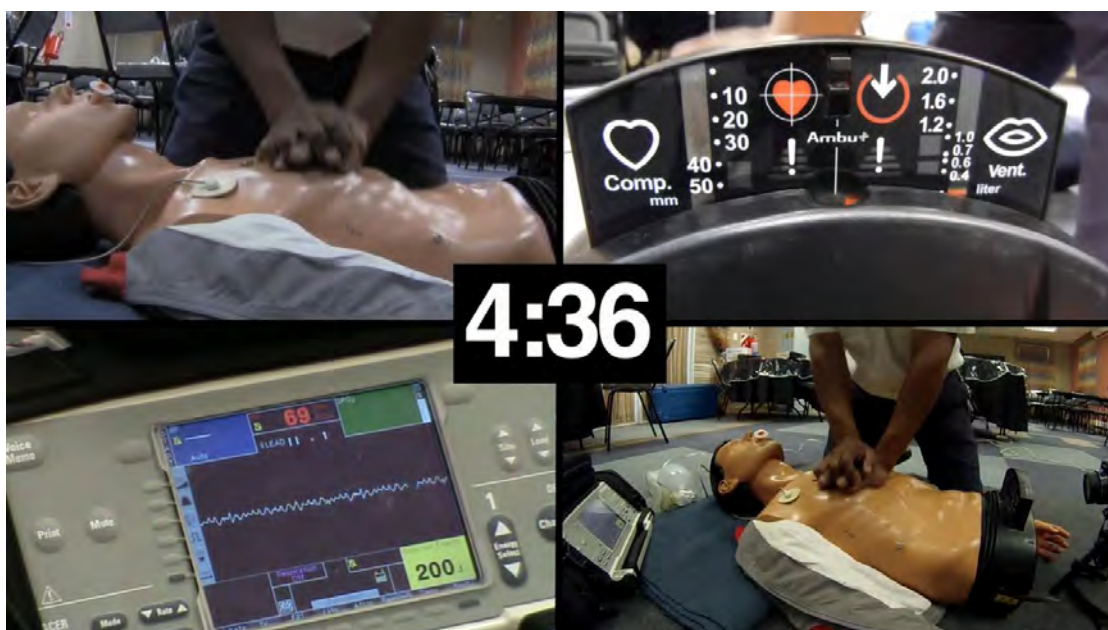
A correlational analysis was performed between both scores to understand whether there was a statistically significant positive correlation between the measurement scores. If the step was performed correctly, the step was marked with an "X". If the step was not performed correctly or not performed at all, then the step was left blank. Spearman's rank correlation was used to determine inter-rater and intra-rater reliability between the IRs.

The IRs were also asked to give an overall impression of psychomotor skills performance at the end of each assessment. This was done on a scale of 1 to 5, with one being the lowest score which was described as 'very poor'. A score of 3 and above would indicate a 'pass' to a 'pass with excellence'. All participants failed the assessment based on the skills sheet criteria, with 66% scoring 'very poor' (score of 1) and 34% scoring 'poor' (score of 2).

### **3.4 Procedure**

The purpose of the study was explained to all EMS personnel in detail on the day of data collection prior to the assessment taking place. Anonymity was guaranteed to all

participants in both the explanation as well as the consent form. All participants were required to hand in all telecommunications devices before the study commenced as would be done in typical exam conditions. Groups of participants completed the questionnaire at the same time, in the same venue, under typical exam conditions. The participants were then asked to wait in the same room or multiple rooms if available, and were called when it was their turn to perform the psychomotor skill of BLS CPR. This was facilitated by one or two experienced EMS lecturers and took the form of an observed structured clinical exam (OSCE, herein referred to as skills test), which is commonly used in health education. One of these facilitators was the PI. It was the responsibility of the facilitator to read out the scenario, as well as initiate the video recording of the BLS CPR psychomotor skill performance of each participant. This process was repeated for each participant in a systematic, standardized, and controlled manner. Each assessment was videotaped. Four video angles captured the skills performance of each participant, as seen below in Figure 2.



**Figure 2: Four camera angles used by independent reviewers for psychomotor skills assessment**

The multiple camera angles ensured that every aspect measured was accurately captured. The following angles were captured during the performance: right side of the manikin looking across the chest to confirm hand position; below the patient's torso looking upwards and focussing on the dial which displays chest compression depth, ventilation adequacy, and hand position; an angle focussing on the ECG monitor screen; and lastly a camera angle was placed to the right and at the feet of the manikin

focussing upward in order to provide an overall impression of the entire scenario. The four videos were then consolidated and synchronized onto one screen. A timer was placed in the middle of the screen to keep time throughout the skills assessment. This made the assessment of the performance standardized in such a way for the IR to make an accurate evaluation of the relevant skill. The procedure of assessing the psychomotor skills of all participants' BLS CPR performance was undertaken using both methods of inter and intra-rater reliability among IRs. This process revealed the level of agreement between IRs' scores, and agreement within the IR's themselves respectively.

Initially, all three IRs assessed 38 unique participants' performances by watching and reviewing the video recordings. Thus, the total sample was 114 participants' unique assessments captured on the AHA BLS CPR skills sheet. One participant could not perform the BLS CPR skills assessment due to a pre-existing orthopaedic injury, thus making the total skills performance 114 of the original 115 that completed the theoretical questionnaire. During this same initial step, a randomly selected sub-sample of 10 participants' videos from each IR's group was then used to determine the inter-rater reliability between the IRs. The IRs thus analysed a sub-sample of videos which were also reviewed by the other two IRs (i.e. each IR analysed an additional 20 videos, 10 from each of the other two IRs groups, plus their own). Thus, on the initial assessment, 58 videos were analysed by each IR. Videos were randomised using a random number generator (Random.org), and allocated to each IR in this manner. The choice to use ten from each IRs group to test inter-rater reliability was recommended by the statistician, due to no other literature being available to suggest differently. The scores given by each IR were compared to the other two reviewers' scores. Therefore, if participant 1 obtained a specific score by IR 1, then IRs 2 and 3 independently assessed participant 1's score. Thus, all 30 randomised videos were each scored by each IR, and then compared to each other to measure inter-rater reliability. The results of this testing is reported on in Chapter 4, and further discussed in Chapter 5.

The second step in testing for reliable scoring was to facilitate intra-rater reliability testing, where sub-sample assessments took place three weeks after the initial assessment. At this later time, each IR assessed 15 separately randomised participants' videos selected from his/her original group. The randomise function was used in Microsoft Excel to randomise this second set of videos. Thus, each IR assessed 15 of their original videos on the subsequent assessment in order to test intra-rater reliability.

### **3.5 Ethical considerations**

Ethical clearance was obtained from the university prior to conducting this study as per normal procedure (Annexure D/E, HREC ref no: 575/2013). Following this, permission from the public EMS training manager and the EMS Director (Annexure F) was obtained in order to conduct this study among their EMS staff. Similarly, permission was obtained from the private EMS manager (Annexure G) who also agreed to allow their staff to participate in this study. Permission was also sought and obtained from the Provincial Health Departments research committee (Annexure H) in order to conduct this study among the Health Departments staff.

EMS personnel were asked to participate whilst off duty on a designated day to ensure that the study did not interfere with their work duties. On-duty staff were also approached and asked to participate, provided they were not busy with a call or with any calls that were outstanding. Participants and IRs alike signed written informed consent and confidentiality forms (Annexure I) to ensure non-disclosure of any observations made during the entire course of this study or thereafter. Since comparing the competency of public EMS versus private EMS was not the aim of the study, specific differences between the two services were not measured. Likewise, since comparing the competency between genders or ethnicities were not aims of the study, differences were not measured. The principal investigator (PI) performed all video-taping either by himself, or with an assistant. All videotapes will be safeguarded by the PI after the necessary data has been analysed and the dissertation has been approved. This data may be useful in future studies.

The PI provided all participants the opportunity to participate in a BLS CPR refresher activity in order to improve any shortcomings that may have been experienced during the skills assessment. The refresher course was a CPD course accredited activity and therefore assisted participants by gaining required CPD points toward continued education and learning requirements. This course focussed on teaching and coaching both generally and individually of each respective group of participants. Common errors were identified, discussed and corrections were given on how to perform high-quality CPR. This course comprised of both an update in the latest AHA CPR guidelines, with a focus on both knowledge and skills application of BLS CPR.

### **3.6 Data analysis**

The statistical analyses performed used both descriptive statistics to determine important demographic variables related to the sample as well as inferential statistics in the form of correlational analysis to determine the strength and relationship between CPR theoretical knowledge and psychomotor skills.

For each of the three sections (demographic information, CPR theoretical knowledge, and CPR skills performance/psychomotor skills) the numerical data were summarised by medians and percentiles or means and standard deviations. Categorical data was summarised using frequencies and percentages.

The effect of each of the demographic variables on the overall theoretical knowledge and psychomotor skills results was investigated. For continuous data, the Pearson's correlation analysis and simple regression analysis were used respectively to determine the relationship and effect of the independent variables (demographic information) on the dependent variables (overall theoretical knowledge and psychomotor skills results). For categorical data, the Kruskal-Wallis test was used to compare median values for the different categories of independent variables.

Lastly, the results of the related theory questions and skills were compared by cross-tabulating the two variables and using McNemar's test to evaluate whether the row and column marginal frequencies were equal.

A significance level ( $\alpha$ ) of 0.05 was used throughout the study.

### **3.7 Data management**

Data were transcribed from the assessments sheet and captured by the researcher in Microsoft Excel. SAS Version 9.2 was used to sort and clean the data and to set up a database. The data collected from the study was kept in a secure file to ensure confidentiality and anonymity of the participants.

## Chapter 4 – Results

### Introduction

The results of the analysis are presented in this chapter in the following order: demographic information; training and experience; theoretical knowledge results; psychomotor skills results; comparison between knowledge and skills; comparison of demographic variables to both knowledge and skills. Data analysed from the demographic questionnaire, the theoretical knowledge questionnaire and the psychomotor skills assessment produced statistical results. Demographic variables were then further compared to both theoretical knowledge and psychomotor skills in order to produce statistical results in order to quantify relationships and interactions between demographic variables to knowledge and skills performance. We also compared theoretical knowledge variables to the equivalent skill performed in order to quantify the relationship to understand to what extent knowledge influences skills.

A total of 115 participants were enrolled in the study. One participant could not perform the psychomotor skills assessment due to a pre-existing orthopaedic injury. So whilst 115 participants completed the theoretical knowledge assessment, 114 participants were able to perform the psychomotor skills assessment.

Table 1 provides a summary of the number of participants from each district. The overall median scores per district for both theoretical knowledge and psychomotor skills performance are also briefly displayed here. The seventh district could not be reached within the allotted time. Ten of the participants from District 1 were not included in this summary as they were from the private EMS sector and their results would have significantly altered the results of the table. In short, the private EMS personnel scored much higher than the rest of the participants. All other analyses performed throughout the study included all participants including both public and private personnel, and are displayed as such in throughout this chapter, and discussed further in Chapter 5.

**Table 1: Summary of the theoretical knowledge and psychomotor skills results by district (N = 105). Values are median % (IQR of the %)**

District	N	Theoretical Knowledge	Original Skills	Modified Skills
1	45	40 (35.0 – 55.0)	25 (16.7 – 58.3)	17.4 (13.0 – 43.5)
2	15	45 (30.0 – 55.0)	29.2 (16.7 – 41.7)	19.6 (13.0 – 30.4)
3	9	55 (50.0 – 65.0)	50 (16.7 – 66.7)	43.5 (8.7 – 56.5)
4	16	37.5 (32.5 – 57.5)	25 (16.7 – 45.8)	21.7 (15.2 – 26.1)
5	9	40 (40.0 – 65.0)	33.3 (25.0 – 58.3)	21.7 (8.7 – 39.1)
6	11	50 (35.0 – 55.0)	33.3 (16.7 – 41.7)	21.7 (8.7 – 39.1)

It is of note that even though a larger number of participants came from district 1, performances from all districts were not significantly different from each other in both knowledge and skill.

The summary of theoretical knowledge and psychomotor skills performance found in Table 1 showed no significant difference between the median scores of the six districts for both theoretical knowledge ( $p = 0.6524$ ) or psychomotor skills (original ( $p = 0.8730$ ) and modified ( $p = 0.9301$ )). While the results from Table 1 have excluded private EMS participants, the remaining data analysis that follows in all remaining sections of this study includes all participants' data.

#### **4.1 Demographic information, CPR training and experience**

The average age was 42 ( $\pm$  SD of 8 years) with 79% male. A majority (90%) of the participants were employed in the public sector while 53% stated that they were employed in the rural sector. The median number of years the participants possessed a BAA qualification was 13 (inter-quartile range (IQR): 9 to 19) and an AEA qualification 8 years (IQR: 4 to 14). The institutions where they obtained their qualifications included own provincial government college (76%); an outside government college (13%); a local private college (6%) and an outside private college (5%).

Only 10% of participants stated that they were trained according to the most recent 2010 guidelines, whilst the rest mentioned outdated guidelines or were not able to mention any relevant guidelines. Table 2 provides a complete summary of the participants' CPR training and experience.

**Table 2: CPR training and experience (n = 115).**

Theme	Items	%
Most recent type of training	Actual AEA course	55
	AEA refresher course	32
	One day CPR update	9
	Could not remember when last trained in CPR	3
	Other form of training	2
Type of guidelines last trained according to	Unrecognizable guidelines	43
	Did not know which guidelines	30
	2010 AHA Guidelines	10
	2005 AHA Guidelines	11
	Other relevant guidelines (did not mention AHA)	7
Adhere to the guidelines they were trained according to	Adhere to 2010 Guidelines	100
	Adhere to Other relevant guidelines	100
	Adhere to 2005 Guidelines	92
	Adhere to unrecognizable guidelines	80
	Did not know which guidelines	80
Number of times CPR was performed in the last year	0	36
	1	28
	2	17
	3	4
	>3	14

Note: AEA = Ambulance Emergency Assistant, AHA = American Heart Association, CPR = Cardiopulmonary resuscitation

The median number of years the participants last received CPR training was four (IQR: 1 to 9). The largest group of participants (n = 41, 36%) did not perform the skill of CPR on a patient at all in the previous year. All participants stated that CPR is the most important skill in their profession, above any other skill that they possess.

### 4.3 CPR theoretical knowledge

A total of 115 participants completed the theoretical knowledge assessment. The six factors used to measure the quality of chest compressions were depth, rate, recoil, hand placement, immediately following defibrillation with chest compressions, and hands-off chest time. The theoretical knowledge on the quality of chest compressions was assessed using 20 multiple choice questions (MCQ). The median score for the overall theoretical assessment was 50% (IQR: 35 to 65%). In the BLS for HCPs course, a participant intending to pass the course must achieve a minimum of 84% (49). Less

than one percent of participants (n=1) achieved a score above 84% for the theoretical assessment. Tables 3 and Table 4 summarize the percentage of participants that answered each MCQ in the assessment correctly.

**Table 3: Theoretical knowledge assessment results on BLS CPR according to the basic CPR categories (n = 115).**

General CPR category	Theoretical Knowledge Assessed	Question no.	% correct
Pulse check	Length of time a pulse check should take	Q 2	49
	Appropriate time pulse should be reassessed after initiating CPR	Q 17	15
CAB sequence	Compressions is the first action the rescuer should take following confirmation of cardiac arrest	Q 1	38
	Correct sequence of actions for CPR: CAB	Q 15	42
	Correct compression to ventilation ratio	Q 16	74
Defibrillation and rhythm analysis	Correct placement of the paddles of the defibrillator	Q 11	48
	Correct time rhythm should be analysed by the AED/ECG, and shocked if in a shockable rhythm	Q 12	68
Rescue breaths	Delivering breaths effectively	Q 9	50
	Correct rate of delivering rescue breaths to the patient in whom ROSC has been established	Q 20	62
ROSC	Assess inadequate respiratory rate in order to initiate rescue breaths following ROSC	Q 19	60

*Note: CAB = Compressions Airway Breathing, CPR = Cardiopulmonary resuscitation, ROSC = Return of spontaneous circulation*

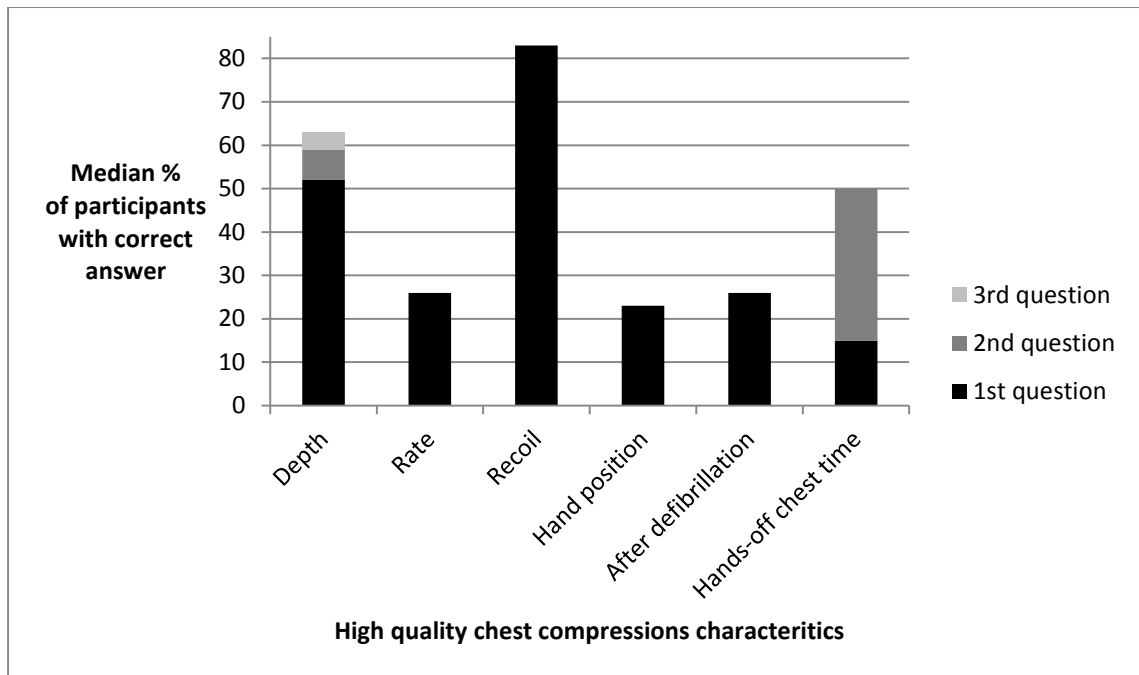
Of the 10 items in Table 3, participants scored 50% or more for half of the items. The highest score achieved for an item was 74% for correct compression to ventilation ratio. The lowest score achieved was 15% for assessing the pulse at the correct time after CPR has been initiated. The mean score achieved for the five general CPR categories was 51%.

**Table 4: Theoretical knowledge assessment results on BLS CPR according to the quality of chest compression characteristic (n = 115).**

Quality of chest compression characteristic	Theoretical Knowledge Assessed	Question no.	% correct
Depth	Correct chest compression depth (1 <sup>st</sup> question)	Q 5	63
	Correct chest compression depth (2 <sup>nd</sup> question)	Q 7	52
	Correct chest compression depth (3 <sup>rd</sup> question)	Q 14	59
Rate	Correct rate for performing chest compressions is at least 100 per minute	Q 4	26
Recoil	Importance of chest recoil	Q 6	83
Hand position	Correct hand placement for chest compressions is on the lower half of the sternum	Q 3	23
After defibrillation	Initiated chest compressions immediately after the shock has been delivered	Q 13	26
Hands-off chest time	Minimizing hands-off chest time (1 <sup>st</sup> question)	Q 8	15
	Minimizing hands-off chest time (2 <sup>nd</sup> question)	Q 10	50
Additional	Knowledge on rescuer fatigue and how often the rescuer should rotate the compressor role	Q 18	69

The theoretical knowledge assessment tested the delivery of high quality chest compressions. The results were especially poor and the participants scored under 30% in four of the six chest compression characteristics, namely: rate, hand position, initiating compressions immediately after defibrillation, and minimizing hands-off chest time. In the remaining two categories, depth and chest recoil, participants scored above 50%. The theoretical question with the worst outcome was “minimizing hands-off chest time”, the first of two questions, with only 15% of participants answering correctly. On the other hand, 83% of participants understood the importance of chest recoil, earning the highest percentage of correct responses.

Figure 3 summarizes the six characteristics of chest compressions that constitute high-quality chest compressions in the theoretical knowledge assessment. Characteristics that had more than one question were ‘depth’ and ‘hands-off chest time’ and are overlaid in the figure.



**Figure 3: Summary of the characteristics that constitute high-quality chest compressions in the theoretical knowledge assessment.**

Figure 3 shows that the three questions asked on ‘depth’ were all within 10% of each other and were therefore considered to be similarly scored. Whilst the two questions tested on the category ‘hands-off chest time’ were vastly apart in percentage, knowledge was still poor and remained below 50% for each item.

#### 4.4 CPR psychomotor skills

The scenario given to each participant was presented in a similar, standardised manner (Annexure C). In the scenario, the participant was told that they arrived alone on scene with a patient (manikin) that was unconscious. They would have to approach the scenario like they would for any unconscious patient in the OH setting. If they did this correctly, they would have determined that the patient was pulseless, and if the ECG monitor was attached then it would have displayed a shockable rhythm (VF). Among several other steps needing to be performed in this scenario, chest compressions and defibrillation were of the most important steps to be performed according to AHA guidelines requirements, as noted in the psychomotor skills sheet (Annexure D).

#### **4.4.1 Overall impression and remediation**

A total of 114 participants completed the psychomotor skills assessment. The overall impression of the participants' performance according to the IRs was rated from 1 to 5, namely: 1 being 'very poor'; 2 being 'poor'; 3 being 'meets minimum standard'; 4 being 'very good'; and 5 being 'outstanding'. A score of 3 and above meant the participant passed the skills assessment according to AHA criteria. 66% (n = 75) achieved an overall impression of 'very poor', whilst 34% (n = 39) achieved an overall impression of 'poor'.

#### **4.4.2 Psychomotor skills performance**

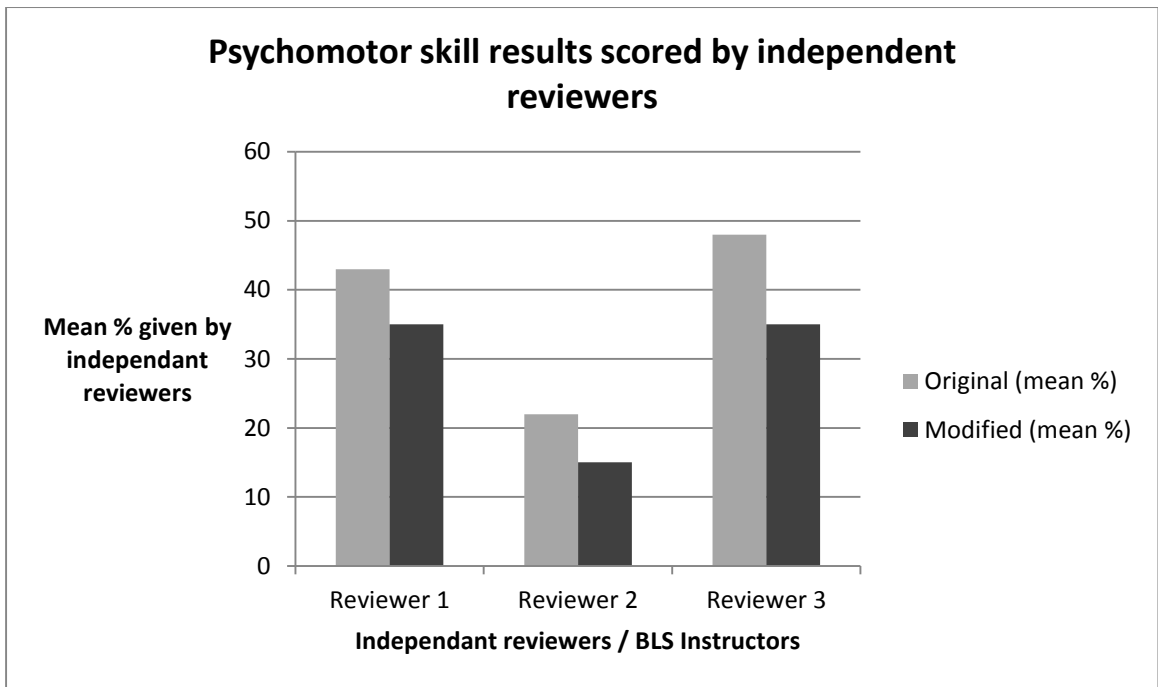
The original AHA skills sheet consisted of 12 items and the modified AHA skills sheet consisted of 23 items. For the original skill performance the participants achieved an overall median score of 33.3% (IQR: 16.7 to 58.3%) and for the modified, 21.7% (IQR: 13.0 to 43.5%). The median difference of 7.9% between the two paired scores was significantly different from zero ( $p < 0.0001$ ), thus implying that the results from the modified skill performance is not the same as the results from the original skill performance. Thus, for the remainder of this section the two skill performance results will be reported separately. Tables 3 and 4 summarize the percentage of participants that correctly performed each step of the psychomotor skills of BLS CPR as rated by the IRs who are qualified BLS Instructors. One participant could not participate in the skills assessment due to a pre-existing orthopaedic injury, thus only 114 results were recorded in this section.

#### **4.4.3 Inter-rater and intra-rater reliability testing scores among IRs**

Intra-rater reliability on psychomotor skills performances was tested to determine how IRs compared to their own individual scores. This type of method is used throughout various medical disciplines and especially in the medical educational environment during observational assessments, and is key to examining CPR performance by instructors who possess a relevant medical qualification. *"A kappa of 1 indicates perfect agreement, whereas a kappa of 0 indicates agreement equivalent to chance"* (92). The level of agreement for the original skills sheet for exact matches was 'fair' (Kappa Statistic = 0.40) compared to 'good' agreement (Kappa Statistic = 0.70) in the modified skills sheet. According to Landis, a kappa level agreement of 0.41 is considered to be 'moderate', whilst 0.7 is considered to be 'substantial' agreement.

When close matches were considered, that is, when one IR classifies a subject into group B and the other into group C, this is closer than if one classifies into A and the other into D. The calculation of weighted kappa, below, assumes the categories are ordered and accounts for how far apart the two IRs' scores are. This calculation uses linear weights. A weighted kappa statistic was calculated using close matches; these were defined as one IR classifying a subject into group B and the other into group C, as this was closer than if one classified a subject into group A and the other into group B. Then the level of agreement for the original skills sheet improved to moderate (Kappa statistic = 0.59), while the level of agreement for the modified skills sheet improved by 4% and remained 'good' or 'substantial' (Kappa statistic = 0.74). Although weighted kappa assigns less agreement when categories are further apart, this method further validates the level of agreement. In this case the level of agreement remained good for both kappa and weighted kappa.

When all three IRs were compared to each other for both the original and the modified skills sheet, there was a significant difference between their scores ( $p < 0.0001$ ). To determine more specifically the difference between IRs, IRs 1 and 3 were compared to each other. No significant difference between psychomotor skills scores for either original or modified skills sheet scores was found ( $p = 0.9785$  and  $p = 0.9785$ , respectively). However, when IRs 1 and 2 were compared to each other, or when IRs 2 and 3 were compared to each other, there were significant differences ( $p < 0.05$  between psychomotor skill scores for both original and modified versions. Figure 4 provides a visual overview of the different scores given by all three IRs when rating the performances of participants taken from the same group.



**Figure 4: Psychomotor skills results scored by independent reviewers (n = 30)**

Figure 4 show how similar the scores are given by IRs 1 and 3 for the original and modified psychomotor skills, and also shows the significant difference ( $p < 0.05$ ) in IR 2's scores of the same performances. With the scoring by IR 2 being significantly different from the other two IRs who were similar, we suggest that the scoring given by IR 2 was more stringent than the other two IRs. The reasons for this are unknown, but could show variation between professions and their perspective on BLS CPR. We would however need to include more IRs from the three professions in order to validate this statement. With this being said, all scores are exceptionally low, as scores given by the two agreeing IRs (1 and 3) were well below 50%, whilst IR 2's scores were well below 30%. When considering the pass requirement for the skills assessment is 100%, these scores are extremely low regardless of the IR who scored them.

**Table 5: Original and modified psychomotor skills assessment result according to the general CPR categories (n = 114).**

<b>General CPR categories</b>	<b>Description of psychomotor skills assessed</b>	<b>Item no.</b>	<b>% correct</b>
Initial approach and assessment	Checks responsiveness and breathing correctly	1	39
	Activates the emergency response system and calls for the AED/ECG monitor	2	18
Pulse check	Checks the carotid pulse, no less than 5 seconds and no more than 10 seconds	3	52
CAB sequence	Delivers a total of 5 cycles of compressions before analysing pulse/ECG	19*	18
	Analyses rhythm following final breaths at the end of the 5th cycle of CPR	20*	10
Defibrillation and rhythm analysis	AED/ECG arrives and immediately stops CPR to analyse the rhythm	9*	5
	Turns ECG on and ensures it is connected correctly	10	38
	Clears patient to analyse rhythm (must be visible and verbal check)	11	11
	Correctly and safely operates the defibrillation paddles	12*	25
	Selects the correct energy dose for defibrillation	13*	36
	Clears patient to shock/presses shock button (must be visible and verbal check; maximum time from AED arrival less than 45 seconds)	14	18
Rescue breaths	Performs Head-tilt-chin-lift and inserts OPA	7*	31
	Gives 2 breaths (over 1 second each)	8	31
	Gives 2 breaths (1 second each) with visible chest rise	17	29
	Initiates rescue breaths at a rate of 1 breath every 5-6 seconds for 2 minutes	23*	13
ROSC	Correctly identifies that there is ROSC and stops CPR	21*	22
	Correctly identifies that the patients breaths are inadequate	22*	24

Note: (\*) = modified skills step, AED = Automated External Defibrillator, CAB = compressions airway breathing, CPR = Cardiopulmonary resuscitation, ECG = Electro Cardiogram, OPA = Oropharyngeal airway

Table 5 on psychomotor skills is summarized into categories similarly to previous tables on theoretical knowledge. The steps taken from the skills sheet are both the original and modified psychomotor skills steps. The steps in Table 5 include the general CPR categories, and do not include the high quality chest compression categories. Of the 17 items in Table 5 that have been summarized into six general CPR categories, only one item, the 'pulse check', was scored above 50%. A score between 5 and 39% was scored for the remaining 16 items.

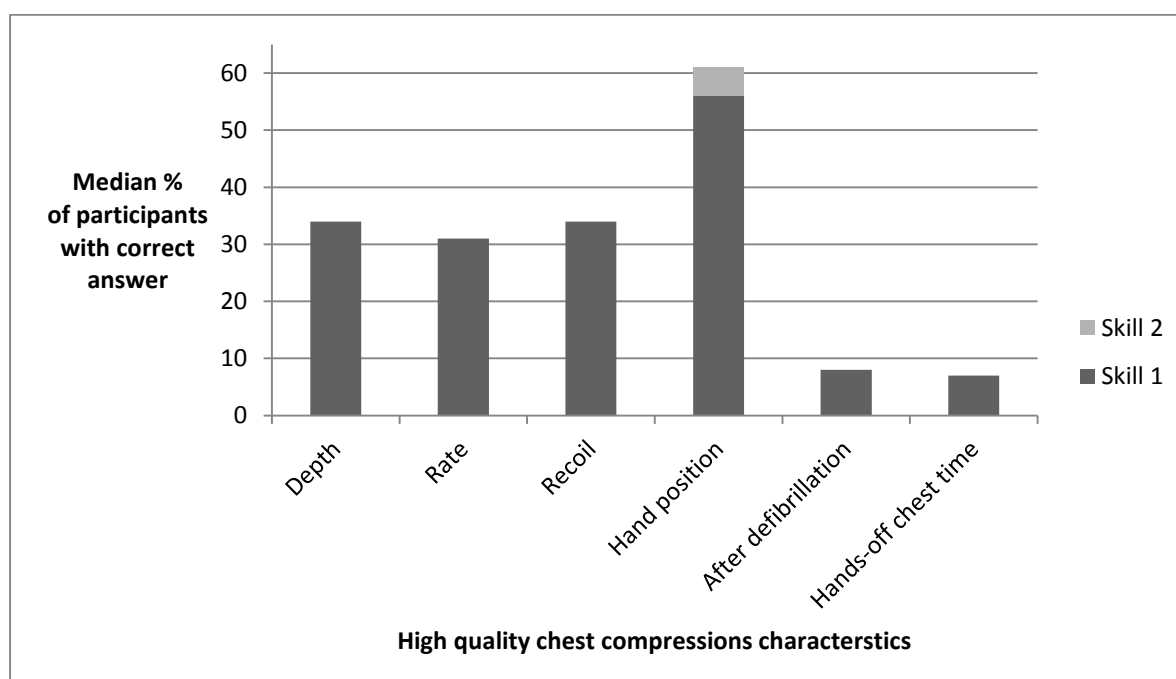
**Table 6: Original and modified psychomotor skills assessment result according to the quality of chest compression categories (n = 114).**

High quality chest compression characteristics	Description of psychomotor skills assessed	Item no.	Percentage participants with a correct answer
Depth and recoil	Delivers third cycle of compressions of adequate depth with complete chest recoil (acceptable: greater than 23 compressions)	18	34
Rate	Immediately initiates chest compressions (at a rate of 30 compressions in 18 seconds or less)	5	31
Hand position	Bares patient's chest and locates the correct CPR hand position	4	61
	Delivers second cycle of compressions at correct hand position (acceptable: greater than 23 of 30 compressions)	16	56
After defibrillation	Immediately initiates chest compression (does not analyse pulse/ECG)	15*	8
Hands-off chest time	Avoids hands off chest time between cycles (no more than 10 seconds)	6*	7

Note: (\*) = modified skills step, CPR = Cardiopulmonary Resuscitation, ECG = Electro-cardiogram

Similar to the theoretical knowledge assessed, the quality of skills performance at which chest compressions are delivered is also poor in all settings. Of all the performances, 4.4% (n = 5) of participants did not perform chest compressions at all during their skills assessment. Of those who did perform chest compressions, the median time to initiating chest compressions from the beginning of the assessment was 61 seconds (IQR: 30 to 93 seconds). The initiation of chest compressions is three times slower than what is required by the AHA, and these effects are further discussed

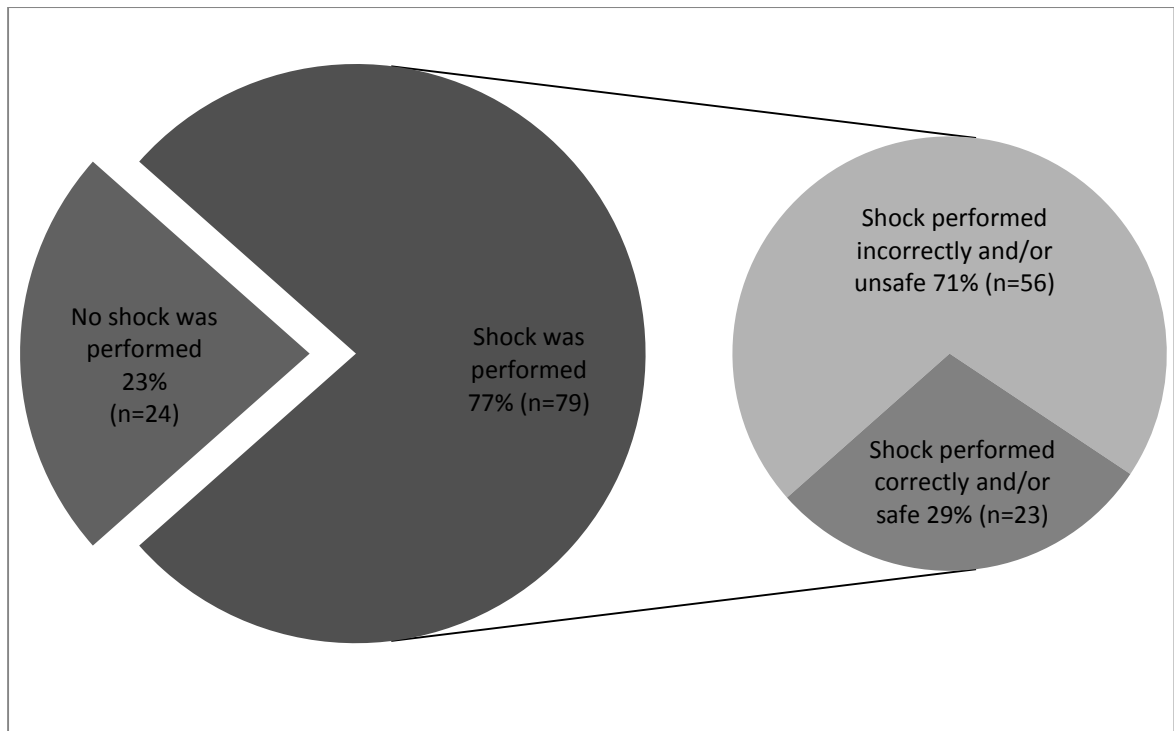
in Chapter 5. Figure 5 depicts the six characteristics used in assessing the quality of chest compressions performed in the skills assessment.



**Figure 5: Summary of the characteristics that constitute high quality chest compressions in the psychomotor skills assessment.**

The only characteristics where more than 50% of participants performed the skills correctly were under ‘correct hand position” (61 and 56%) and the initial pulse check (52%). Characteristics where participants performed considerably poorly were: following defibrillation immediately with chest compressions (8%), hands-off chest time (7%), and stopping CPR to analyse the rhythm as soon as the defibrillator arrived (5%).

Regarding manual defibrillation performed by the participants, 31% (n = 35) did not deliver a shock at all throughout their assessment. For those that did defibrillate, the median time from arrival on scene was 4 minutes 12 seconds (IQR: 3 minutes 2 seconds to 5 minutes 14 seconds). According to the skills sheet used that was adopted from the AHA ACLS one-rescuer BLS CPR skills sheet, it requires that the shock with an AED be delivered within 45 seconds from arriving at the ventricular fibrillation cardiac arrest victims’ side. While 10% of participants never switched on the monitor to analyse the cardiac rhythm, only 5% of participants stopped CPR as soon as the defibrillator was ready to analyse the rhythm. Figure 6 shows the action taken and outcome once the monitor was switched on.



**Figure 6: Action taken and outcome if the monitor was switched on (n = 103).**

Of the 90% (n = 103) of participants that did switch on the monitor to analyse the rhythm, 23% did not deliver a shock. Of the total number of shocks delivered only 29% were performed in a safe and/or correct manner. For the total number of participants only 23 (20%) of the 114 switched the monitor on and performed the shock correctly and in a safe manner. Psychomotor skills in the area of rescue breaths delivered during CPR were assessed using two items and the median score of the participants was 31% and 29%. Psychomotor skills in the area of rescue breaths delivered following return of spontaneous circulation (ROSC) were also assessed in two items and the median score of the participants was 24% and 13%.

During the initial assessment following arrival on scene, 39% assessed responsiveness and breathing correctly, whilst only 18% activated the emergency response system. When assessing the pulse, 52% of participants assessed the pulse correctly for between 5 and 10 seconds.

#### **4.5 Comparison between the theoretical knowledge and psychomotor skills results**

In the following section the theoretical knowledge of the participants were compared to the equivalent psychomotor skill performed. It aims to investigate whether there is a

significant level of agreement between theoretical knowledge and psychomotor skills of BLS CPR in this population group, and to test the research question of 'if they knew it, does it mean they did it?'

Tables 7 and Table 8 summarize the comparisons made between theoretical knowledge and the equivalent skill performed in CPR. The results used in the tables were taken from the 12 steps of the original skills sheet, as well as the additional 11 steps which were added as the modified skills sheet. Together this made up 23 steps/items which were viewed as one skills sheet and used in this way throughout this study, as seen in Table 7 and Table 8.

**Table 7: Comparison between theoretical knowledge and skill performance for the general CPR categories.**

General CPR categories	Item description	Theory Results % (n = 115)	Skills Results % (n = 114)	Both correct % (n = 114)	Kappa Statistic	p-value
Initial assessment	Pulse check	49	52	19	- 0.1926	0.7218
Rescue breaths during CPR	1 <sup>st</sup> delivery of rescue breaths	50	31	16	0.0175	0.0033*
	2 <sup>nd</sup> delivery of rescue breaths	50	32	19	0.1228	0.0027*
Rhythm analysis and defibrillation	After the defib. arrives, when should the rhythm be analysed	68	5	4	0.0152	< 0.0001*
	Correct placement of the defib. paddles	48	38	18	0.0615	0.1088
ROSC treatment	Correct timing of re-analysing the rhythm following defibrillation and CPR	15	10	3	0.1100	0.2008
	Recognizing inadequate breathing following ROSC	60	24	16	0.0156	< 0.0001*
	Delivery of rescue breaths	62	13	11	0.1439	< 0.0001*

Note: \* = p-values are significant; CPR = Cardiopulmonary Resuscitation, ROSC = return of spontaneous circulation, Defib. = defibrillator

Table 7 lists and compares the theoretical knowledge to the equivalent psychomotor skill performed. These have also been grouped into the appropriate categories for

general CPR. Table 8 contains the high quality chest compression characteristics. A summary on the results of both Tables 7 and 8 follows.

**Table 8: Comparison between theoretical knowledge and skill performance for the quality of chest compression characteristics.**

High quality chest compression characteristics	Item description	Theory Results (n = 115)	Skills Results (n = 114)	Both correct (n = 114)	Kappa Statistic	p-value
Depth	1 <sup>st</sup> chest compression depth	63	34	25	0.1866	< 0.0001*
	2 <sup>nd</sup> chest compression depth	52	34	19	0.0673	0.0046*
	3 <sup>rd</sup> chest compression depth	59	34	22	0.0710	< 0.0001*
Rate	1 <sup>st</sup> chest compression rate	26	31	8	0.0768	0.4658
	2 <sup>nd</sup> chest compression rate	74	31	25	0.1249	< 0.0001*
Recoil	Chest compression recoil	83	34	28	0.0005	< 0.0001*
Hand position	1 <sup>st</sup> hand position	26	61	13	- 0.0198	< 0.0001*
	2 <sup>nd</sup> hand position	23	56	15	0.0958	< 0.0001*
After defibrillation	Next immediate action following defibrillation – CC's	26	8	5	0.2120	< 0.0001*
Hands-off chest time	1 <sup>st</sup> hands-off chest time	15	7	0	- 0.1032	0.1025
	2 <sup>nd</sup> hands-off chest time	50	7	4	- 0.0024	< 0.0001*

Note: \* = p-values are significant, CCs = chest compressions

For five (26%) of the 19 items, the theoretical knowledge item did not differ significantly ( $p > 0.05$ ) from the equivalent skill performance assessed. This implies that in only 26% of the items tested, the participants applied the relevant knowledge to the skill performance required. The level of agreement, that is where both the knowledge and skill assessed was correct, appears to be poor since all the Kappa statistics were less than 0.25.

A significant weak positive correlation of  $r = 0.40$  was observed between the two variables ( $p < 0.0001$ ). Using the original skills performance percentage as the

dependent variable and the theory percentage as the independent variable, the regression model was significant ( $p < 0.0001$ ) and the coefficient of determination ( $r^2$ ) was 0.157. Thus 15.7% of the change in the original skills percentage was due to the change in the theory percentage and 84.3% was due to other variables.

A significant moderate positive correlation of  $r = 0.53$  was observed between the overall theoretical knowledge and modified skill performance ( $p < 0.0001$ ). With further investigation, a simple linear regression analysis revealed that the modified skills percentage was significantly associated with theory percentage ( $p < 0.0001$ ,  $F = 43.05$ ) with 27.8% of variability in modified skills percentage explained by the change in the theory percentage and 72.2% was due to other variables.

The results above show that the theoretical knowledge of the participants does play some role in their skills performance. Other possible factors that could influence the theoretical knowledge and skill performance are investigated in the next section.

#### **4.6 Theoretical knowledge and psychomotor skills results by demographic variables**

The effect of each of the demographic variables on the overall theoretical knowledge and psychomotor skills results was also investigated. Table 9 depicts a summary of the descriptive results for each of the categorical demographic variables.

**Table 9: Descriptive statistics of the theoretical knowledge and psychomotor skills results for the different categorical demographic variables.**

Demographic Variables		Theoretical Knowledge		Original Psychomotor Skills		Modified Psychomotor Skills	
	N	Median % (IQR)	P value*	Median % (IQR)	P value*	Median % (IQR)	P value*
<b>Gender</b>							
Male	90	50 (35 - 65)		33 (16 - 58)		22 (13 - 44)	
Female	24	40 (35 - 65)	0.392	29 (13 - 50)	0.4125	20 (89 - 37)	0.5233
<b>Sector employed</b>							
Public	104	45 (35 - 55)		25 (17 - 58)		22 (13 - 39)	
Private	11	70 (65 - 75)	<0.0001*	58 (25 - 50)	0.6287	35 (26 - 48)	0.0559
<b>Place of training</b>							
Local Govt. Coll.	87	45 (35 - 55)		25 (17 - 58)		22 (13 - 39)	
Outside Govt. Coll.	15	40 (30 - 55)		17 (8 - 50)		20 (4 - 48)	
Local Private Coll.	7	65 (55 - 75)		58 (42 - 67)		35 (26 - 44)	
Outside Private Coll.	6	73 (70 - 75)	0.0011*	33 (25 - 42)	0.0876	35 (26 - 44)	0.2131
<b>Most recent type of CPR training</b>							
AEA course	63	45 (30 - 60)		25 (17 - 50)		22 (9 - 39)	
AEA refresher course	37	45 (40 - 65)		42 (25 - 67)		28 (13 - 48)	
CPR update	10	63 (50 - 80)		46 (25 - 58)		35 (26 - 48)	
Other	2	53 (50 - 55)		21 (8 - 33)		11 (4 - 17)	
Unknown	3	50 (20 - 65)	0.0817	8 (8 - 25)	0.0188*	13 (4 - 13)	0.0072*
<b>Guidelines trained according to</b>							
2010 AHA	11	75 (45 - 75)		58 (50 - 67)		44 (35 - 57)	
2005 AHA	13	50 (45 - 55)		33 (17 - 50)		22 (17 - 39)	
Relevant guidelines	8	70 (60 - 75)		38 (25 - 58)		39 (30 - 50)	
Unrecognizable	49	50 (35 - 60)		25 (17 - 50)		17 (9 - 35)	
Unknown	34	38 (30 - 55)	<0.0001*	25 (17 - 42)	0.0248*	17 (13 - 30)	0.0048*
<b>Number of times CPR was performed in last year</b>							
0	41	40 (35 - 55)		25 (8 - 42)		17 (9 - 35)	
1	32	45 (30 - 55)		42 (17 - 58)		26 (13 - 44)	
2	20	50 (38 - 70)		33 (25 - 58)		26 (17 - 44)	
3	5	45 (40 - 55)		25 (17 - 25)		13 (13 - 17)	
>3	16	60 (50 - 73)	0.1407	46 (25 - 67)	0.0769	41 (20 - 48)	0.0766
<b>Area employed</b>							
Urban	54	50 (35 - 65)		38 (25 - 58)		26 (13 - 44)	
Rural	61	45 (35 - 55)	0.2073	25 (17 - 54)	0.2063	17 (11 - 39)	0.0824

Note: The Kruskal Wallis test was used to calculate the p-value to test for significant median differences, \* = p-values are significant. AEA = Ambulance Emergency Assistant, AHA = American Heart Association, Coll = College, CPR = Cardiopulmonary Resuscitation, Govt = government, IQR = Inter-quartile range

Table 9 indicates that the demographic variables that have a significant effect ( $p < 0.05$ ) on theoretical knowledge are the sector, the place of training, and the type of guidelines they were last trained according to.

The demographic variables that have a significant effect ( $p < 0.05$ ) on psychomotor skills, were the most recent type of CPR training (original and modified skills

performance) and the type of guidelines they were last trained according to (original and modified skills performance).

In addition to the information from Table 9, the participants were also asked whether they continued to follow the guidelines they were originally taught. Only two participants who were trained with outdated guidelines stated that they updated their practice to current guidelines. This had no significant effect on the theoretical knowledge or the skills performance ( $p > 0.05$ ).

Table 10 depicts a summary of the descriptive results for each of the numerical demographic variables.

**Table 10: Analytical statistics of the theoretical knowledge and psychomotor skills results for the different numerical demographic variables.**

Demographic variables	Assessment	Correlation Analysis	Regression analysis	
			p-value	r <sup>2</sup>
<b>Age</b>	Theory	$r = -0.46$ ( $p < 0.0001^*$ )	$<0.0001^*$	0.2120
	Original Skills	$r = -0.24$ ( $p = 0.0004$ )	0.0089*	0.0596
	Modified Skills	$r = -0.26$ ( $p = 0.0002$ )	0.0050*	0.0683
<b>Years since BAA qualification</b>	Theory	$r = -0.33$ ( $p = 0.0005$ )	0.0005*	0.1120
	Original Skills	$r = -0.18$ ( $p = 0.0614$ )	0.0614	0.0332
	Modified Skills	$r = -0.17$ ( $p = 0.0794$ )	0.0794	0.0293
<b>Years since AEA qualification</b>	Theory	$r = -0.33$ ( $p = 0.0004$ )	0.0005*	0.1045
	Original Skills	$r = -0.18$ ( $p = 0.0614$ )	0.0144*	0.0522
	Modified Skills	$r = -0.17$ ( $p = 0.0794$ )	0.0608	0.0310
<b>Last time trained in CPR</b>	Theory	$r = -0.35$ ( $p = 0.0002$ )	0.0002*	0.1227
	Original Skills	$r = -0.39$ ( $p < 0.0001$ )	$<0.0001^*$	0.1546
	Modified Skills	$r = -0.37$ ( $p < 0.0001$ )	$<0.0001^*$	0.1338

Note: \* = p-values are significant. AEA = Ambulance Emergency Assistant, BAA = Basic Ambulance Assistant, CPR = Cardiopulmonary Resuscitation.

The results in Table 10 indicate that all the numerical variables had a significant negative effect ( $p < 0.05$ ) on the theoretical knowledge of the participants. They include greater age, greater number of years since qualified as BAA, greater number of years since qualified as an AEA, and greater number of years since last trained in CPR.

The variables that have a significant negative effect ( $p < 0.05$ ) on the psychomotor skills performance of the participants include greater age (original and modified skills

performance), greater number of years since qualified as an AEA (original skills performance), and greater number of years since last trained in CPR (original and modified skills performance).

The summary of results above taken from Table 10 show the demographic variables that have a statistically significant effect on both theoretical knowledge and psychomotor skills. The summary that can be taken from Tables 9 and 10 reveal the demographic variables that contribute to better and worse performance of both knowledge and skills. These will be further discussed in the next chapter.

# Chapter 5 - Discussion

## Introduction

This chapter discusses the findings of this study in the context of other similar studies conducted on this topic. Attention is given to demographic variables of the participants and the effects that this has on CPR competency, including training and experience. The theory and skills results of the participants' performances as compared to the effects that their performance would have on survival rates (Figure 7) is also looked at, i.e. for every minute there is a delay in defibrillation, survival decreases by 10%. The influence that theoretical knowledge has on psychomotor skills is discussed and compared to similar studies. The findings of the main research questions are discussed and interpreted by integrating the quantitative results.

### 5.1 CPR training and experience among AEA qualified EMS workers

Survival rates are commonly poor for both the in-hospital and OHCA victim and ranges from 0%-16% when BLS CPR is provided by HCPs (19, 31). It has been shown that when high quality CPR is performed, survival rates can approach 50% following witnessed OH VF cardiac arrest (23). The AHA state that early CPR and rapid defibrillation are 2 of the 5 vital links that make up the chain of survival that saves lives following cardiac arrest. These 2 links are directly impacted by EMS, and our participants' performance is compared and discussed against the several components that make up these two links. With such variations of survival in mind, it is important to remember that rescuer characteristics also play a role and influence the optimal application of the various components of these links. The components that make up these links and their application depend on the rescuer's training, experience and confidence (29).

There is a paucity of evidence surrounding the competency level at which BLS CPR is provided by EMS personnel in SA. Quality assurance mechanisms are scarce or do not exist in the majority of EMS settings. There is no requirement in SA for HCPs to recertify their CPR training in order to maintain their registration. This is unusual considering the statistics of cardiovascular disease and the associated high mortality rates previously mentioned. Thus, the lack of ongoing training has the potential to adversely impact the quality of CPR performance. And with no mandate in place to

ensure that EMS HCPs remain competent at BLS CPR, there is a high probability that these HCPs use no point of reference to guide their practice or to ensure they perform CPR to internationally best standards. This is evidenced by the two largest groups of participants either not recognising (43%) or not knowing (30%) the guidelines they were trained to, as displayed in Table 9. The remaining participants knew that they were trained to AHA guidelines, whether it was the outdated guidelines (17%), or the most recent guidelines (10%). This shows that the minority of these HCPs were exposed to the AHA guidelines at some point during their training or practice. This is concerning as they should all have been exposed to and trained to these guidelines which are considered to be international best practice. The HPCSA require all HCPs to keep themselves current with their practice by earning 30 CPD points per year. They specify that these points should be acquired through courses that relate to the profession of the HCP, but do not include any courses of priority, e.g. CPR. It is also the duty of the employer to ensure that their employees remain current with relevant competencies to their core business. The adherence to this however, is not specified and varies from service to service. The only recommendation for CPR recertification that exists in SA is the AHA BLS for HCPs course. The promotion and attendance of this course among EMS HCPs is generally quite low. It is likely that the majority of staff have not attended this course after 2010, especially since only 10% reported having being trained to the latest 2010 guidelines.

## **5.2 Theoretical knowledge of BLS CPR**

A HCP must first demonstrate proficiency in theoretical knowledge of BLS CPR in order to perform the skill of BLS CPR correctly. The AHA test this knowledge on the BLS for HCP's course, and if the HCP scores below 84% it is considered to be sub-optimal and a fail (49). The AHA states that only high-quality CPR has been proven to save lives (24). What the AHA consider to be a fail theoretically, is likely to result in the skill of BLS CPR being applied poorly. This would translate into very low survival rates. The participants in this study (n = 115) achieved a median score of 50% (IQR: 35 – 65%). Only one person achieved an acceptable score that met the AHAs requirements for acceptable theoretical knowledge. This means that less than one percent of our participants was on par with the standard set out by the AHA to theoretically know how to apply BLS CPR correctly. Even this does not mean that this participant necessarily knows how to perform the skill of BLS CPR correctly. This is an alarming result, meaning that the impact of BLS CPR combatting cardiac arrest is negligible. We will need to further explore the impact that the application of the skill of BLS CPR is having

on survival rates, based on theory having only a small influence on skill. This will be discussed in the 'Psychomotor skills of BLS CPR' section below.

The 20 theoretical knowledge questions that were asked were summarized into five general CPR categories (Table 3) and six high-quality chest compression characteristics (Table 4). Less than half ( $n = 48$ , 42%) of participants knew the correct sequence of actions for CPR as defined by the CAB approach, or Circulation, Airway, Breathing approach. The CAB approach was first mentioned in the 2010 guidelines (27). This approach ensures that chest compressions are the first action that the rescuer performs, and was a novel change to CPR at the time. Even though significance was placed on early chest compressions in the previous 2005 guidelines, the ABC approach, or Airway, Breathing, Circulation approach, appeared to delay chest compressions. This was because several assessments and actions were performed after the arrival of the rescuer at the victim's side which delayed chest compression initiation. The CAB approach mitigates these delays. Considering that only 10% of participants mentioned they were trained to the most recent guidelines, a result of 42% for correct sequence achieved in theory is rather high considering their generally outdated training. This could suggest that participants have heard of the updated guidelines, but have not actually attended the updated training and thus not having the opportunity to put these rumours into practice.

Early CPR and chest compressions are a fundamental aspect of BLS CPR and a vital link in the Chain of Survival. The AHA 2010 guidelines place a great deal of emphasis on the topic of high-quality chest compressions. The AHA has pointed out several characteristics that contribute to high-quality chest compressions that was previously mentioned, and have elsewhere included additional characteristics including correct hand position and following defibrillation immediately with chest compressions. The theoretical knowledge tested on these characteristics of high quality chest compressions among participants was especially poor, where they scored under 30% in four out of these six characteristics. If the HCP does not know the theory of how to deliver chest compressions correctly, this translates into the skill of chest compressions being performed incorrectly and thus poorer survival rates. Similar studies conducted among EMS HCPs in other countries also showed that the decay in theoretical knowledge on chest compression delivery was poorly retained over time, however the decay of the skill delivery appeared to decay even more rapidly (72). This is true, even despite knowledge having a small, but positive effect on skills (52). In the remaining two characteristics depth and recoil, participants scored above 50%.

Defibrillation was included in the general CPR categories which were mentioned in Table 3. Rapid defibrillation is one of the five links in the Chain of Survival, and according to the skills sheet, demands that a shock is delivered within 45 seconds after the practitioner arrives on scene. 68% of our participants knew to correctly attach the monitor, and less than half (48%) knew where to correctly place the paddles to perform defibrillation. Rapid defibrillation is a powerful predictor of successful resuscitation following VF SCA when used correctly (93, 94). It is important to note that the majority of participants did not know how to correctly place the paddles which would influence the efficacy of the shock that they delivered. Improper defibrillation can also be disastrous and dangerous to both the victim (95, 96) and the rescuer (97).

In summary, the theoretical knowledge results achieved by our participants in BLS CPR falls short of the standards outlined by the AHA and the evidence that supports them. It is clear that this lack of knowledge on the fundamental aspects of BLS CPR compromises the Chain of Survival. EMS has a direct impact on two links in the chain of survival, namely 'early CPR' and 'rapid defibrillation'. It is critical that all links remain intact in order to save lives following OHCA (23).

### **5.3 Psychomotor skills of BLS CPR performance**

EMS directly impacts the second link in the Chain of Survival, namely "early CPR with emphasis on chest compressions" (27). Meaney *et al* add that survival from cardiac arrest critically depends on the quality of CPR delivered (24). The two facets that make up this link are early initiation of CPR by bystanders and EMS personnel, and an emphasis on high quality of chest compressions. Our participants' median time to initiating chest compressions from arrival on scene was 61 seconds (IQR: 30 to 93 seconds) for the 96% of participants who did actually perform chest compressions during the scenario. The AHA specifies that chest compressions should be initiated within 20 seconds from arrival on scene after the response breathing and pulse check have occurred (27). Our participants took three times longer to initiate chest compressions than the 20 seconds prescribed by the AHA. This delay in initiating chest compressions early negatively impacts mortality rates as described in Figure 7.

Early defibrillation when indicated is the third link in the Chain of Survival that is critical to survival from VF SCA (27). Survival rates from witnessed VF SCA decrease by 7 – 10% every minute from initial collapse to defibrillation if no CPR is provided (44). The

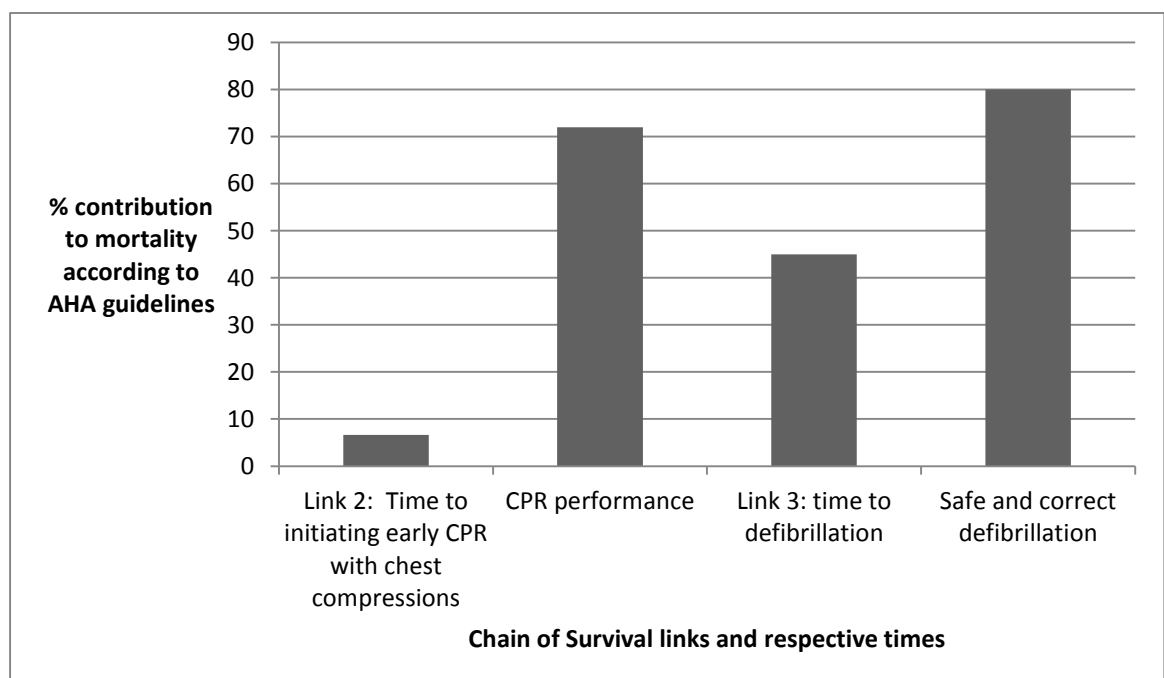
AHA also state elsewhere that “*the victim’s chance of survival decreases with an increasing interval between arrest and defibrillation*” (94). The AHA skills sheet mentions that the shock should be delivered within 45 seconds from the time of arrival of the rescuer on scene. This information tells us that the victim cannot afford unnecessary delays to defibrillation, as any delay increases mortality. The effect on mortality based on our participants’ performance is described in Figure 7.

The BLS for HCP’s skills sheet also contains steps regarding the safe use of the defibrillator by the rescuer on the victim, as there is danger of causing electrocution or fire hazards to both the victim as well as those surrounding the victim with improper use of this device (28). From the above information about the third link in the Chain of Survival, rapid defibrillation, we see that its effective delivery requires both safe and rapid use by the HCP.

In the scenario given to our participants, a defibrillator was used instead of an AED as all our participants were trained to use a manual defibrillator, and very few have been trained with, or even exposed to the use of an AED. Whilst a manual defibrillator does take more time to use and requires rhythm analysis by the rescuer, we aimed to eliminate this loss of time by attaching the ECG cables prior to the scenario beginning. This means that the participant merely had to arrive on scene, turn on the monitor, rapidly determine that the rhythm was shockable and deliver the shock within the specified time. A manual defibrillator in a competent practitioners’ hands for this process would be the same, if not quicker to use than an AED, as the pads of the AED would still need to be attached initially upon arrival of the rescuer. The victim in this scenario was experiencing VF cardiac arrest throughout the simulation and would revert to a normal sinus rhythm if a shock was delivered, as may typically happen on a true OHCA victim. A total of 10% of participants did not switch on the monitor at any point during the scenario. The exact reason for this is unknown. One explanation for this could be due to a lack of knowledge of using this device since less than half of the participants (48%) knew where to correctly place the paddles of the defibrillator. Of the 90% of participants that did switch on the monitor to analyse the rhythm, 23% did not deliver a shock. Of the total number of shocks delivered only 29% were performed in a safe and/or correct manner, leaving the majority, 71% to deliver the shock incorrectly and/or in an unsafe manner.

Only 23 of the 114 (20%) participants switched the monitor on and performed the shock correctly and in a safe manner. When the shock was delivered, the median time to delivering the shock was 4 minutes and 12 seconds (IQR: 3 minutes 2 seconds – 5

minutes 14 seconds). Thus the majority of our participants neither performed defibrillation rapidly nor safely when compared to the standards the AHA have set out. The AHA states that early defibrillation is critical to survival from sudden cardiac arrest. In the skills sheet that they designed and which we used to measure psychomotor skills, they state that the shock must be delivered within 45 seconds from the time it arrives on scene (28). In our scenario, the monitor was already attached, and so the participants merely had to switch it on as soon as they arrived on scene. Whilst the monitor takes approximately 10-15 seconds to switch on and display the rhythm, this time should have been used to perform chest compressions. For the 69% of participants who did deliver the shock (not all safely), it took them almost six times longer than what the skills sheet required. The negative impact on mortality that this delay in defibrillation had when translated into real-world practice is displayed in Figure 7. Figure 7 provides a summary and illustrates a point of discussion for our participants' performance and the effects they would have on mortality rates when delays or improper performance occurs when measured against the links in the chain of survival.



**Figure 7: Participants' contribution to mortality according to the Chain of Survival that EMS impact**

We measured our participant's performance against the two links in the chain of survival that they impact according to the evidence that these links have on mortality rates. The median time to initiating chest compressions was 61 seconds [IQR: 30 to 93 seconds]. If this was performed in the real-world, and we know that mortality rates

increase by up to 10% every minute delay in CPR for VF SCA, the mortality rates of victims treated by this group would increase by almost 7%. We summarized the performance of CPR based on the seven categories that constitute high quality CPR. The average of the medians scored by participants with correct high-quality CPR performance would only be 28%. Thus the remaining 72% of victims would receive poor quality CPR which as some say, is as good as no CPR at all (37).

Participants took 4 minutes and 12 seconds (IQR: 3 minutes 2 seconds – 5 minutes 14 seconds) to perform defibrillation. If survival rates decrease by up to 10% every minute whilst poor CPR is provided before defibrillation occurs, we can calculate that based on their performance that mortality rates would increase by 42% due to unnecessary delays in performing defibrillation. We also calculated that only 20% of our participants performed defibrillation safely. The remaining 80% consisted of participants who did not switch on the monitor at all, no shock delivered at all if the monitor was switched on, incorrect placement of the paddles whereby the PI had to intervene during the scenario before the shock was delivered so as to avoid harm to the participant, and attempts made at defibrillation where only one discharge button was pressed and not both, simultaneously placing further harm to the participant. Hence this is graphically represented (Figure 7) as an 80% contribution to mortality as a patient in VF must be defibrillated correctly in order to gain ROSC (28).

#### **5.4 The nature and strength of the relationship between BLS CPR theoretical knowledge and BLS CPR psychomotor skills performance**

The overall competency of BLS CPR provision is poor, and when participants' performances translate directly into factors affecting mortality rates, the results are even more alarming. To understand the factors that contribute to worse performance among our participants, the section to follow will explore the nature and relationship of theoretical knowledge affecting psychomotor skills among our participants. The next section will explore the demographic variables that have an effect on theoretical knowledge and psychomotor skills.

The psychomotor skills of BLS CPR require prior cognitive knowledge. This is especially important in the earlier developmental stages of psychomotor skill development (50). It has been shown that when the rescuer knows the guidelines theoretically they perform BLS CPR better (52). Thus, we can see that the relationship between the knowledge and skill of BLS CPR is important. One factor that affects this

relationship is HCPs undergoing prolonged periods of time without attending CPR refresher/training courses, which leads to skill decay (64). Basic skills have also been shown to deteriorate when assessed at 1 - 6 months (54, 75, 78, 98, 99) and 7 – 12 months (100, 101) following training. Studies investigating the effect of theoretical knowledge on BLS skill performance among EMS personnel show conflicting results. In two separate studies, Latman and Deliere found that guideline knowledge had little impact on the performance of BLS CPR skills, and that motor skill decay is more responsible for poor performance (102, 103). Contrary to this, a study performed by Brown *et al* concluded that better knowledge of the guidelines translated into better quality of some elements of CPR performance (52).

Tables 7 and 8 show the comparison between theory and the equivalent skill performed, in order to reveal whether knowing translates into doing. Our results show vastly different scores between psychomotor skills and the equivalent theoretical knowledge result, with theoretical knowledge showing a higher score in all categories. There were 19 items where the theory component could be compared to the equivalent skill performed. The results from our study showed that for only five (26%) of the 19 items, the theoretical knowledge item did not differ significantly ( $p > 0.05$ ) from the relevant skill performed. This implies that in only 26% of the items tested did the participants apply the relevant knowledge to the equivalent skill performed. The level of agreement, that is where both the knowledge and skill performed was correct, appears to be poor since all the Kappa statistics were less than 0.25. A significant weak positive correlation of  $r = 0.40$  was observed between the two variables of theoretical knowledge and original skills performance ( $p < 0.0001$ ). This appears to be in agreement with several other studies which show that knowledge appears to have a positive influence on skills, but this effect is small (52). Our results resemble the results of other studies, as 15.7% of the change from the original skills percentage was due to the change in the theory percentage, and 84.3% was due to some other variables. Similarly, it appears that only 27.8% of variability in modified skills percentage was explained by the change in the theory percentage and 72.2% was due to some other variables.

It can thus be concluded that the theoretical knowledge of the participants only plays a small role in their skills performance, whilst other factors have a much greater influence on skill performance. The other more significant variables will be explored when comparing demographic variables to the knowledge and skills in the next section.

## **5.5 An investigation into demographic variables that have a significant effect on theoretical knowledge and psychomotor skills of BLS CPR**

Apart from knowledge being a factor that affects the skills and performance of BLS CPR, other factors affecting CPR have been mentioned in the literature. The AHA states that *“CPR skills and their application depend on the rescuer’s training, experience, and confidence”* (29). We investigated these as well as other factors among our participants to see whether these demographic variables had a significant effect ( $p < 0.05$ ) on knowledge and skills. Our study investigated various demographic variables of our participants and the effects of these variables on knowledge and skills. The factors we investigated included gender, sector employed, place of training, type of most recent CPR training, guidelines most recently trained according to, number of times CPR was performed in the last year, and whether they worked in the rural or urban setting. We also looked at age, years of experience, and time since last trained in CPR.

### **5.5.1 Demographic variables that had a significant effect on theoretical knowledge**

In our study the demographic variables that were categorical showed a significant difference ( $p < 0.05$ ) in theoretical knowledge were; the sector of employment, the place where they were trained, and the guidelines they were last trained according to. The sector of employment in the setting of our participants appears to make a difference to their theoretical knowledge. The reason for this is currently unknown, but could be due to the private entities being smaller which results in a greater level of accountability for the employees practice. No literature was found that reported on public versus private theoretical knowledge. The place where participants’ received their initial training and qualification also appears to have an impact on theoretical knowledge in the EMSs. This may be due to the limited research done in the EMSs in SA. The literature agrees with this by also stating that CPR competency relies upon the quality at which the CPR instruction was delivered (53, 54). Similarly, we also noted that only 10% of our participants were trained according to the AHA 2010 guidelines, and thus we found that the guidelines that they were trained according to were associated with a significant difference and higher score in theoretical knowledge performance, but scores overall still remained poor. Poor CPR performance has been attributed to HCPs undergoing prolonged periods of time without attending refresher training courses (24).

Other demographic variables that were numerical and contributed to statistically significant worse theoretical knowledge were greater age, greater the experience, and greater number of years since last trained in CPR. We could not find literature on theoretical knowledge worsening with advancing age. It is often assumed in the medical field that the greater the experience of the HCP, the better their BLS CPR competency. The literature however seems to reveal evidence contrary to this broad assumption. Brown noted in their study of EMTs when considering experience, worse performance was found with the greater the experience of the EMT (52). The time since last trained in CPR does appear to have an impact on knowledge and skill retention. Traditionally, the time-intervals for CPR training are 2 years for AHA BLS CPR courses. But the optimal time for maintaining CPR competence is not known. It has been well documented that basic skills have been shown to deteriorate when assessed at 1 to 6 months and 7 to 12 months (72). Verplancke also reports that HCPs' undergoing prolonged periods of time without attending CPR refresher or training courses is a common barrier that leads to poor CPR performance (64). Our results are similar and also showed that theoretical knowledge got worse the greater the number of years since participants in this study last attended CPR training. The median number of years since our participants were last trained in CPR was 4 years (IQR: 1 to 9 years) ago. This appears to be a significantly contributing factor to our participants' general poor performance, as it quite clearly states in the literature that basic skills have been shown to deteriorate when assessed at 1 to 6 months or 7 to 12 months following training (72). Based on this evidence, our participants' knowledge and skills retention clearly reflects the time since they were last trained or updated.

With these variables identified as having a significant effect on knowledge, the respective EMS sectors can develop methods based on these factors that contribute to better knowledge performance. EMSs can use these results to prioritize the ongoing training and updating of their HCPs if they wish ensure competent HCPs who provide quality BLS CPR to OHCA victims. HCPs should be aware of advancing age and experience and the associated skill decay. Together with their EMS, they should ensure that they attend frequent, short duration, refresher courses of CPR skills. This has been shown to prevent skill decay and improve acquisition and retention of CPR knowledge and skills.

### **5.5.2 Demographic variables and their effect on psychomotor skills**

In our study, the demographic variables that showed a significant difference in psychomotor skills were the type of most recent CPR training and the guidelines they were last trained according to. Other demographic variables that contributed to statistically significant worse psychomotor skill performance were greater age, greater the number of years qualified, and the longer it has been since last receiving CPR training.

The results of our study show that the type of CPR training has a significant effect on psychomotor skills. A simple BLS CPR update course as the most recent type of training appeared to show better results with skill performance, although the results for this particular type of training were not significantly better than other types of training. This agrees with other studies that emphasize the quality of training depends on the quality of the CPR instruction given, and that any form of ongoing training is necessary to minimize skill decay (53, 54). The guidelines that participants were trained according to also appear to have an understandably significant effect on skill performance.

Other demographic variables that contributed to statistically significant worse psychomotor skills performance were increased age. Our hypothesis was opposite to this, where we expected that increased age would result in improved BLS CPR skill performance, as it is understandable that HCPs generally get better at performing skills the older they are. Similarly to knowledge above, no other literature was found to support this. Similar to knowledge in the previous section, the greater the number of years qualified and experience has been shown in previous literature (52) to be associated with worse skill performance. This is in agreement with our results of worse psychomotor skill performance with the greater the number of years of experience. The longer the time since last receiving CPR training is another variable that is associated with worse skill performance. Similarly as mentioned in knowledge above, CPR skills acquired on training programs deteriorate rapidly if not used frequently (24).

The variables that significantly affect skills are similar to the above variables that affect knowledge. The participants in this study and their respective EMS should include continuous maintenance of competency programs that employ frequent short duration interactions with content and skills after an initial course, or they may include guided debriefings after real-life events that focus on response improvement. AEA HCPs in this province currently face a massive crisis with ongoing training and staying up to

date with the latest set of BLS CPR guidelines, and this needs to be rectified through mass training and updating in order to provide this skill safely and effectively to victims of OHCA.

## **5.6 Limitations**

Limitations of this study include not being able to use the most advanced equipment to measure exact performance of some components of CPR. A skills reporter manikin that records each facet of chest compressions and ventilations is more accurate than a dial manikin. A dial manikin was used in this study and relied on the IRs assessment for each intricate component of the skill by category. A reporter manikin could add further insight into the intricate quality of chest compressions and ventilations administered by the sample. However, for the purposes of this study, the aim was to evaluate competency based on two factors: knowledge of current guidelines and the adherence thereof; as well as the correct sequence and skill of BLS CPR. The assessment of correct sequence of skills performance was achieved as this aspect requires observational assessments by IRs to accurately measure this element.

Another limitation to this study involved discrepancy in scores given by the three IRs. IR 2's score was statistically significantly different from the other two IRs, whose were otherwise similar to each other. This carries the potential to threaten the reliability of the psychomotor skills scores. However with this being said, we suggest that the scoring given by IR 2 was more stringent than the other two IRs. The reasons for this are unknown, but could show variation between professions and their perspective on BLS CPR. We would however need to include more IRs from the three professions in order to validate this statement. With this being said, all scores are exceptionally low, as scores given by the two agreeing IRs (1 and 3) were well below 50%, whilst IR 2's scores were well below 30%. When considering the pass requirement for the skills assessment is 100%, these scores are extremely low regardless of the IR who scored them.

Another limitation within this study is that participants had the voluntary option of participating or not. Thus, the likelihood exists that willing participants may have been more confident with their knowledge and performance of CPR, which may have introduced a bias into this sample of participants who were more likely to perform better or were more experienced than unwilling, less experienced, or candidates with low

confidence. However, participants who were aware of a prolonged period without CPR training may have been more eager to attend.

A further limitation with this study is that the choice of participants was done through convenience sampling, which may not be representative of the study population. We had aimed to enrol an equal number of 20 participants from each of the seven districts throughout the province in order to gain a representative sample of EMS personnel and their competency at BLS CPR provision. Whilst we were not able to obtain the initial number that we aimed for, we were still able to obtain high numbers of participants which was closely, but not fully representative. These staff members were not able to attend due to personal reasons. We were still able to meet the objectives of the study.

A final limitation of this study is that it was carried out over a period of time that may have allowed participants to communicate with potential participants prior to the assessment dates. This had the potential to introduce a bias with a more prepared sample group than the initial participants. It is not believed that this had an effect to any measurable degree, as the study timeline was relatively short, and all participants seemed genuinely surprised that they would be taking a CPR competency assessment on the day of the study and course. This would have produced bias towards better performance, so the results are a best case scenario. These results are the first to be published and therefore there is no previous baseline to compare our results to.

# Chapter 6 - Conclusion

## 6.1 Conclusion

This study revealed overall poor competency in BLS CPR performance. We investigated and identified the reasons that contributed to this poor performance in CPR in this particular setting. Our results showed that knowledge of CPR contributes only a small percentage to actual correct skill performance. Other variables were identified in our study as having a larger impact on correct skill performance and should also be included in improving the quality at which BLS CPR is delivered.

Factors that significantly affected these AEA personnel in their knowledge and skill of BLS CPR were unacceptably long periods of time since they were last trained and some were never updated to the latest CPR guidelines. Each EMS system and hospital should have an ongoing CPR continuous quality improvement program and measure survival rates and deficiencies, and enable corrective actions to be monitored.

## 6.2 Recommendations

On the basis of the research conducted in this study, it is possible to make recommendations which will have important implications for the future practice of EMS personnel and the quality of care that they provide their patients with. We know that quality CPR provision by HCP's depends on having excellent theoretical knowledge and frequently practiced psychomotor skills in order to deliver high-quality BLS CPR. However, before fixing these more obvious issues we need to first start with the issues that plague this EMS, which are not uncommon in other EMS settings. Relevant stakeholders within the healthcare system, and particularly EMS, need to be consulted and take responsibility for turning this issue around. Based on our results, it is important to note that specific areas need to be focussed on when addressing this problem. This includes:

- First, to ensure that EMS staff attend more frequent updates in BLS CPR training on the latest CPR guidelines;
- Second, to ensure that more experienced and older EMS HCP's are prioritized with regards to the previous point mentioned;

- Third, track the number of times that EMS personnel perform CPR in a year and ensure that those who have performed it less frequently are re-sent on training;
- Fourth, to ensure that training focusses on theoretical knowledge, but significantly more so on practical skills, since our results show theory has limited influence on skill performance, similar to results from other studies.

These focus points can be used to change the way that EMS currently deliver BLS CPR to the OHCA victim, which will lead to thousands of lives saved.

Future studies that can further add value to this area of EMS BLS CPR provision are comparing different strategies that can be implemented within EMS to ensure that high-quality CPR is delivered among EMS HCPs. Areas to be focussed on would be:

- The amount of time between training sessions and the impact that this has on the skill decay curve;
- Different training strategies that can be used to reduce the level of skill decay among EMS personnel;
- CQI systems that can monitor the outcome of OHCA victims and the effect of implemented strategies that improve BLS CPR delivery.

***ANNEXURES: Data Collection Tools/Instruments***

Annexure A: Theoretical Knowledge Assessment on Adult BLS CPR

Annexure B: OSCE Scenario and OSCE Assessment Sheet on Adult BLS CPR

Annexure C: Demographics/Background data

Annexure D: UCT HREC Approval Form

Annexure E: UCT HREC Re-Approval Form

## Annexure A: Knowledge on adult BLS CPR guidelines

Answer Questions 1-20: Circle the correct letter

1. **You respond with your partner to a collapsed patient. Upon arrival you find a patient who is unconscious and unresponsive. The rescuer will perform several assessments before initiating treatment/actions. Which is the first critical action the rescuer should perform on this patient once it is determined that the patient is in cardiac arrest? (Item 1)**
  - a. Airway – clear the airway, perform a head tilt chin lift, and insert an OPA
  - b. Breathing/Ventilations – administer 2 breaths with BVM
  - c. Compressions – initiate chest compressions
  - d. Defibrillation
2. **The 2010 AHA Guidelines for CPR and ECC recommend that to identify cardiac arrest in an unresponsive victim with no breathing (or no normal breathing), a healthcare provider should check a pulse for no more than (Item 3)**
  - a. As long as the rescuer needs to be sure
  - b. 10 seconds
  - c. 2 seconds
  - d. 5 seconds
3. **Where should the hands be placed to perform chest compression on an adult? (Item 4)**
  - a. On the lower half of the sternum
  - b. On the upper portion of the abdomen
  - c. In the centre of the sternum
  - d. On the upper half of the sternum
4. **The recommended rate for performing chest compressions for victims of all ages is? (Item 5)**
  - a. At least 40 compressions per minute
  - b. At least 60 compressions per minute
  - c. At least 80 compressions per minute
  - d. At least 100 compressions per minute
5. **Why is it important to compress to the appropriate depth during CPR? (Item 13)**
  - a. Adequate depth of compression is needed to create blood flow during compressions
  - b. Adequate depth of compression is needed to create air flow into the lungs and adequate oxygenation
  - c. Adequate depth of compression is needed to prolong asystole
  - d. Adequate depth of compression is needed to stimulate spontaneous respirations
6. **Complete chest recoil contributes to CPR success by (Item 13)**
  - a. reducing the fatigue of the rescuer.
  - b. allowing the heart to refill with blood between compressions.
  - c. reducing the risk of rib fractures.
  - d. increasing the rate of chest compressions.
7. **Which of the following is a characteristic of high-quality CPR in adults? (Item 13)**
  - a. Minimizing recoil
  - b. Compressing at a depth of about 2.5 cm
  - c. Compressing at a depth of at least 5 cm
  - d. Checking for a pulse every minute

- 8. How long should it take to deliver 1 set of breaths between cycles of compressions? (Item 7)**
- Less than or equal to 2 seconds
  - Less than or equal to 5 seconds
  - Less than or equal to 10 seconds
  - Less than or equal to 15 seconds
- 9. Gastric inflation is more likely to occur if the rescuer (Item 15)**
- does not make a good seal between the face and the mask.
  - gives breaths too quickly or with too much force.
  - gives each breath over 1 second.
  - gives volume just sufficient to see the chest rise.
- 10. Ideally, interruptions in chest compressions should be (Item 12)**
- limited to less than 10 seconds.
  - performed as often as needed to assess the victim.
  - longer than 10 seconds.
  - performed every 5 minutes.
- 11. Where should the paddles/pads of the defibrillator/AED be placed on the patient? (Item 9)**
- Directly below the left and right clavicle in line with each other
  - Upper left chest and to the side of right nipple a few inches below the armpit
  - Upper right chest and to the side of left nipple a few inches below the armpit
  - Directly over the sternum, and over the apex of the lung
- 12. As soon as an AED/defibrillator becomes available, when should the rescuer attach the pads/electrodes and analyse the rhythm: (Item 8)**
- Immediately
  - Only after the 5 cycles of CPR have been completed
  - Only once the 2<sup>nd</sup> cycle of CPR has been completed
  - Only after 2 sets of 5 cycles of CPR have been completed
- 13. What is the next immediate action the rescuer should perform after a shock has been delivered: (Item 13)**
- breathing/ventilations – administer 2 breaths
  - analyse the pulse and ECG
  - chest compressions
  - deliver a 2<sup>nd</sup> shock immediately if the 1<sup>st</sup> shock was unsuccessful, and repeat a 3<sup>rd</sup> time if the 2<sup>nd</sup> shock was also unsuccessful
- 14. The depth of chest compressions for an adult victim should be at least (Item 16)**
- 2.5 cm
  - 5 cm
  - 7.5 cm
  - 10 cm
- 15. The latest guidelines for CPR recommended BLS sequence of steps are:**
- Chest compressions, Airway, Breathing
  - Airway, Breathing, Check pulse
  - Airway, Breathing, Chest compressions
  - None of the above

- 16. The compression-ventilation ratio for 1-rescuer adult CPR is**
- 5: 1
  - 15: 2
  - 30: 1
  - 30: 2
- 17. According to the options below, when should the rescuer reassess the patients pulse and ECG rhythm after initiating CPR?**  
(Item 17, 18)
- Immediately after defibrillating the patient
  - Immediately after delivering the final cycle of compressions
  - Immediately after delivering the final cycle of ventilations
  - Immediately when the rescuer notices a change on the ECG monitor during the 5 cycles of CPR
- 18. To reduce rescuer fatigue during team CPR, compressor roles should be switched about every**
- 1 cycle.
  - 3 cycles.
  - 5 cycles.
  - 8 cycles.
- 19. Once the patients pulse rate is adequate whereby CPR is no longer required, which respiratory rate is considered the most inadequate whereby the rescuer will be required to initiate rescue breaths?** (Item 20)
- 8
  - 10
  - 12
  - 14
- 20. At which rate should the rescuer deliver rescue breaths/ventilations to a patient who is breathing inadequately (too slowly)?**  
(Item 21)
- 1 breath per second
  - 1 breath per 2 seconds
  - 1 breath per 5 seconds
  - 1 breath per 8 seconds

## Annexure B: Demographics/Background data

1. How old are you? \_\_\_\_\_yrs
2. Circle your gender Male Female
3. Which sector are you currently employed (circle)? Public Private
4. Are you (circle) BAA AEA/ILS Paramedic/Advanced  
Other (Specify) \_\_\_\_\_
5. Which year did you qualify as a BAA? \_\_\_\_\_
6. Which year did you qualify as an AEA? \_\_\_\_\_
7. Where did you receive your AEA training (City & institution)? \_\_\_\_\_
8. Which year and month did you receive your last CPR training? \_\_\_\_\_; \_\_\_\_\_
9. Please specify which type of training you received for CPR most recently (circle)
  - a. On your actual AEA Course
  - b. Attended an AEA Refresher Course
  - c. Attended a CPR Update
  - d. If other, please specify .....
10. According to the above mentioned answer, which CPR guidelines were you trained according to? Please include the year they were published.  
Name: .....  
Year: .....
11. Do you still follow these guidelines (circle)? Yes No
12. If your last answer was no, please provide the name of the guidelines you currently follow and the reason why you follow the guidelines now  
Name & Year: .....  
Reason for change:  
.....  
.....  
.....

13. How many times have you performed CPR (chest compressions), in the field or in the hospital, on a patient in the last 1 year?

- a. 1
- b. 2
- c. 3
- d. More than 3

14. Would you consider the area you work to be:

- a. Urban
- b. Rural

15. How important do you rate and view CPR as an essential skill to your practice?

- a. Very important
- b. Not very important. There are other more important skills for me to focus on

16. If your answer above was "b", please explain

.....

## **Annexure C: Observed Simulated Clinical Examination (OSCE)**

### ***2<sup>nd</sup> Assessment: OSCE - Standard scenario***

1. We are assessing SINGLE RESCUER CPR. You may be used to doing multiple rescuers CPR in the field, but for this simulation please perform single rescuer CPR.
2. Please use the Bag-valve-mask for all ventilations. Do not do mouth-to-mouth. Please do not assume the manikin is ventilated unless you see actual chest rise.
3. You do not need to speak to the researchers or the camera, although you may do so if you wish. Please pretend that the researchers and the camera are not present.
4. Finally, this is NOT a test. Your performance is confidential, and the results of this study will be used to help understand how CPR can be improved to save more lives. Do you have any questions?

### **Scenario**

Upon responding to a call, you see an adult lying still on the floor. There was no traumatic injury. Please demonstrate how you would address this situation.

I will not offer advice or feedback. If you feel a pulse on the manikin, assume there is a pulse. If you do not feel a pulse on the manikin, assume there is no pulse.

Likewise, if you ventilate the manikin and there is no chest rise, behave as you would for a patient in the field.

Please continue for 3 min; I will inform you when the time is up.

Do you have any questions?

Begin now.

## Objective Structured Clinical Examination (OSCE) Skills Sheet

CPR and AED Skills Test			
1-Rescuer Adult CPR and AED Checklist			
Student Name/Code:	CA no.	Test Date:	/ / 2013
Skill Step	Critical Performance Steps	X if done correctly	Item Code
<b>BLS Survey and Interventions</b>			
1	Checks for responsiveness: Taps and shouts, "Are you all right?" and scans the chest for movement (5-10 seconds)	*	1
2	Tells someone to activate the emergency response system and get an AED	*	2
3	Checks carotid pulse (minimum 5 seconds; maximum 10 seconds)	*	3
4	Bares patient's chest and locates CPR hand position	*	4
5	Delivers first cycle of compressions at correct rate (acceptable: 18 seconds or less for 30 compressions)	*	5
	<i>TIME:</i> * : :		
	Avoids hands-off chest time between cycles (no more than 10 sec)	*	6
	Head-tilt chin-lift and inserts OPA	*	7
6	Gives 2 breaths (1 second each)	*	8
<b>AED Arrives/ECG Arrives</b>			
	Stops CPR immediately to analyze rhythm as soon as AED/ECG arrives/is ready	*	9
AED 1	Turns AED on, selects proper pads, and places pads correctly/ECG	*	10
AED 2	Clears patient to analyze (must be visible and verbal check)	*	11
	Correctly and safely operates defibrillation paddles	*	12
	Selects the correct energy dose for defibrillation	*	13
AED 3	Clears patient to shock/presses shock button (must be visible and verbal check; maximum time from AED arrival less than 45 seconds)	*	14
	<i>TIME:</i> * : :		
<b>Student Continues CPR</b>			
	Immediately initiates chest compression (does not analyze pulse/ECG)	*	15
7	Delivers second cycle of compressions at correct hand position (acceptable: greater than 23 of 30 compressions)	*	16
8	Gives 2 breaths (1 second each) with visible chest rise	*	17
The next step is performed only if the manikin is equipped with a feedback device, such as a clicker or light. If there is no feedback device, STOP THE TEST.			
9	Delivers third cycle of compressions of adequate depth with complete chest recoil (acceptable: greater than 23 compressions)	*	18
	Delivers a total of 5 cycles of compressions before analyzing pulse/ECG	*	19
	Analyzes rhythm following final breaths at the end of the 5th cycle of CPR	*	20
<b>Post ROSC Management</b>			
	Correctly identifies that there is ROSC and stops CPR	*	21
	Correctly identifies that the patient's breaths are inadequate	*	22
	Initiates rescue breaths at a rate of 1 breath every 5-6 seconds for 2 minutes	*	23
<b>STOP TEST</b>			
Test Results	Circle P or NR to Indicate Pass or Needs Remediation: *	P	NR
Instructor signature affirms that skills tests were done according to AHA Guidelines.	Instructor Signature:	*	
	Print Instructor Name:	*	
Save this sheet with course record.	Date:	*	
<b>Overall Impression of Participants Performance: *</b>		<b>DO NOT FILL IN BOX/RESEARCHER USE ONLY</b>	
circle	1 Very Poor (Fail)	AHA SKILLS SHEET RATING	MODIFIED AHA SKILLS SHEET RATING
	2 Poor (Fail)	12	23
	3 Meets Minimum Standard (Pass)		
	4 Above Average (Pass)		
	5 Excellent (Pass)	%	%
Video Was Assessable (circle)	Yes	No	

## Annexure D: Human Research Ethics Committee Approval Form

UNIVERSITY OF CAPE TOWN



Faculty of Health Sciences  
Faculty of Health Sciences Human Research Ethics Committee  
Room E52-24 Groote Schuur Hospital Old Main Building  
Observatory 7925  
Telephone [021] 406 6338 • Facsimile [021] 406 6411  
e-mail: [sumayah.ariefdien@uct.ac.za](mailto:sumayah.ariefdien@uct.ac.za)  
[www.health.uct.ac.za/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms)

**25 September 2013**

**HREC REF: 575/2013**

**Mr JP Veronese**  
C/o R AllGaier  
Division of Emergency Medicine  
Department of Surgery  
J-floor  
OMB

Dear Mr Veronese

**PROJECT TITLE: AN ASSESSMENT OF THEORETICAL KNOWLEDGE AND PSYCHOMOTOR SKILLS OF BASIC LIFE SUPPORT CARDIO-PULMONARY RESUSCITATION PROVISION BY EMERGENCY MEDICAL SERVICES IN A PROVINCE IN SOUTH AFRICA**

Thank you for your letter dated 25 September 2013, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above mentioned study.

**Approval is granted for one year until the 30 September 2014.**

Please submit a progress form, using the standardised Annual Report Form, if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

Please note that the on-going ethical conduct of the study remains the responsibility of the principal investigator.

**Please quote the REC. REF in all your correspondence.**

Yours sincerely

**PROFESSOR M BLOCKMAN**  
**CHAIRPERSON, HSF HUMAN ETHICS**

Federal Wide Assurance Number: FWA00001637.  
Institutional Review Board (IRB) number: IRB00001938

sAriefdien

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

## Annexure E: UCT HREC Re-Approval Form



**FACULTY OF HEALTH SCIENCES**  
Human Research Ethics Committee



### FHS016: Annual Progress Report / Renewal

<b>HREC office use only (FWA00001637; IRB00001938)</b>			
<b>This serves as notification of annual approval, including any documentation described below.</b>			
<input checked="" type="checkbox"/> Approved	Annual progress report	Approved until/next renewal date	30 09 2015
<input type="checkbox"/> Not approved	See attached comments		
Signature Chairperson of the HREC		Date Signed	3/12/14

Comments to PI from the HREC	
------------------------------	--

**Principal Investigator to complete the following:**

**1. Protocol information**

Date (when submitting this form)	03 December 2014		
HREC REF Number	575/2013	Current Ethics Approval was granted until	30/09/2014
Protocol title	An assessment of theoretical knowledge and psychomotor skills of Basic Life Support Cardio-Pulmonary Resuscitation provision by an Emergency Medical Service in a province in South Africa		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		
If yes, could you please provide the HREC Ref's for all sub-studies? Note: A separate FHS016 must be submitted for each sub-study.			
Principal Investigator	Jean-Paul Tyrone Veronese		
Department / Office Internal Mail Address	jpveronese@gmail.com		

1.1 Does this protocol receive US Federal funding?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
1.2 If the study receives US Federal Funding, does the annual report require full committee approval?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
1.3 Has sponsorship of this study changed? If yes, please attach a revised summary of the budget.	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No



## 7. Progress of study

Please provide a brief summary of the research to date including the overall progress and the progress since the last annual report as well as any relevant comments/issues you would like to report to the HREC:

Proposal passed  
 Ethical Approval Granted  
 Data Collection completed  
 Data Analysis mostly completed  
 Currently busy with writing up the Results, Discussion and Conclusion sections

## 8. Protocol violations and exceptions (tick ✓ all that apply)

<input checked="" type="checkbox"/>	No prior violations or exceptions have occurred since the original approval
<input type="checkbox"/>	Prior violations or exceptions have been reported since the last review and have already been acknowledged or approved
<input type="checkbox"/>	Unreported minor violations that have occurred since the last review, as well as significant deviations not yet reported, are attached for review

## 9. Amendments (tick ✓ all that apply)

<input checked="" type="checkbox"/>	No prior amendments have been made since the original approval
<input type="checkbox"/>	Prior amendments have been reported since the last review and have already been approved
<input type="checkbox"/>	New protocol changes/ amendments are requested as part of this continuing review (See note below)

Note: If new protocol changes are being requested in this review, please complete an amendment form (FHS006).

Specific changes in the amended protocol and consent/assent forms must be **bolded**, *italicised* or tracked and all changes must include a rationale.



**10. Adverse events**

10.1 Please provide below or attach a narrative summary of serious adverse events and/ or unanticipated problems since the last progress report. Please indicate changes made to the protocol and informed consent document(s) as a result (if not already reported to the HREC). Please comment on whether causality to any study procedure or intervention could be established

N/A

10.2 Have participants received appropriate treatment/ follow-up/ referral when indicated (e.g. in the case of abnormal or incidental clinical findings, distress or anxiety)?

Yes                       No                       Not applicable

If yes, please describe:

**11. Summary of Monitoring and Audit Activities (tick ✓)**

11.1 Was this study monitored or audited by an external agency (e.g. MCC, FDA)?

Yes                       No                       Not applicable

11.2 Did a Data and Safety Monitoring Board publish a report?

Yes                       No                       Not applicable

11.3 If yes, please identify the agency and attach a summary of the findings.

Agency Name		Report attached	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> Not applicable
		DSMB report attached	<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> Not applicable

11.4 Has there been any agency, institutional or other inquiry into non-compliance in this study, or any finding of non-compliance concerning a member of the research team?

Yes                       No

If yes, please explain:



**12. Level of risk (tick ✓)**

12.1 In light of your experience of this research, please indicate whether the level of risk to participants has:	
<input type="checkbox"/>	Increased
<input type="checkbox"/>	Decreased
<input checked="" type="checkbox"/>	Shown no change
If there has been a change, please explain:	

12.2 Please provide a narrative summary of recent relevant literature that may have a bearing on the level of risk.
N/A

**13. Statement of conflict of interest**

Has there been any change in the conflict of interest status of this protocol since the original approval? (tick ✓)	
<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
If yes, please explain and if necessary attach a revised conflict of interest statement (Section #7 in the New Protocol Application Form FHS013):	

**14. Signature**

My signature certifies that the above is complete and correct.			
Signature of PI		Date	03 December 2014

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