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Interpretation and knowledge of 12 lead ECGs and thrombolytic therapy of paramedics in Gauteng and North west provinces in South Africa

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INTERPRETATION AND KNOWLEDGE OF 12 LEAD ECGs AND THROMBOLYTIC THERAPY OF PARAMEDICS IN GAUTENG AND NORTH WEST PROVINCES IN SOUTH AFRICA

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfillment of the requirements for the degree

of

Master of Science in Medicine

in

Emergency Medicine.

Johannesburg, 2015

DECLARATION

I, Nicolaas Everhardus Louw, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Medicine in Emergency Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

_____

08th day of November 2015

DEDICATION

If it was not for the support and prayers of my loving wife Riana and my family, this work would not have been possible.

I am forever grateful.

ABSTRACT

Introduction

Pre-hospital Thrombolytic Therapy (TT) has been proven beneficial and widely practiced in many countries, yet only since November 2009 has it been introduced in South Africa (SA) as part of the scope of practice of the Advanced Life Support (ALS) paramedics with a Bachelor's degree (BTech) qualification. Other ALS qualified paramedics in SA, with either a National Diploma (NDip) or Critical Care Assistant (CCA) qualification, who also treat patients with Acute Coronary Syndromes (ACS), are not mandated by the Health Professions Council of South Africa (HPCSA) to administer TT. As the 12 lead ECG is one of the important variables to determine if a patient is a candidate for TT, this exploratory study analysed the ability of the different qualifications of paramedics to interpret 12 lead ECGs, and to decide whether a patient is a candidate for TT, The performance of the paramedics were compared against the various demographical information of the participating paramedics.

Methods

An exploratory prospective study was conducted over a two month period during which contact sessions with paramedics from two provinces in South Africa were held – Gauteng, being predominantly urban and North West, a rural province. Participants completed a demographic questionnaire with information related to their working experience and educational background. Thereafter, they interpreted six 12 lead ECGs, all being cases of ACS, according to 13 specific questions. The questions were divided

into 3 categories namely 1) Accuracy of interpreting the 12 lead ECG; 2) Knowledge on the anatomy of the heart; and 3) Making the decision if the patient is a candidate for TT. The paramedics did not have time to prepare for the questionnaire as the aim was to test their current knowledge. Once completed, the questionnaires were marked and analysed using Statistica® and the results were compared against the three qualifications (BTech, NDip and CCA) as well as eight other demographic variables. These were 1) the sector in which the paramedics worked; 2) The province the paramedics were working in; 3) Their primary daily responsibility; 4) Operational hours worked per month; 5) Exposure to ACS patients per month; 6) Extra hours worked in the Emergency Department; 7) Exposure to 12 lead ECGs per month and 8) The role of the ACLS® courses on their performance.

Results

A total of 75 paramedics participated in the study, and 444 completed 12 lead ECG interpretations were collected. Of the 75 participants, 60 were from Gauteng, and 15 from North West, of which 16 were BTech, 21 were NDip, and 38 were CCA qualified. The BTech paramedics performed the best in all three categories of questions concluding with an average score of 75.7% (95% CI 65.0% - 86.42%), yet in category 2, which related to the anatomy of the heart, the average performance was 50.4% and in category 3, related to the decision if the patient is a candidate for TT, the average performance was 62.9%. The one way ANOVA test showed no statistically significant difference ($p = 0.4723$) between the performance of the different qualifications nor did

any of the eight other variables render any significant difference. The overall performance of all the paramedics was 72.6% (95% CI 61.35% - 83.93%).

Conclusion

Participating paramedics indicated their minimal exposure to patients experiencing ACS or to 12 lead ECGs. The average performance of all qualifications of paramedics was above 70%, even in the absence of any preparation for this study. Yet their knowledge on the anatomy of the heart and knowing whether a patient is a candidate for TT was concerning low. Although the BTech paramedics performed the best, there was no significant difference between the performances of the different qualifications of paramedics. It remains a necessity to have continuous training programmes, quality assurance mechanisms, together with appropriate support systems, to ensure that all three qualifications of paramedics, from the two respective provinces in SA, may perform on an adequate level and be mandated to administer pre-hospital TT.

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NOMENCLATURE

HPCSA: Health Professions Council of South Africa - the statutory body regulating the practice of medical and healthcare professions in South Africa.

ALS paramedic: An Advanced Life Support paramedic is registered at the HPCSA as an independent practitioner who has done extensive training and is permitted according to a specific scope of practice to perform certain procedures on patients that are generally of an advanced or invasive and technically complex nature. These paramedics may administer a wide variety of emergency medications, perform advanced airway manoeuvres (such as endotracheal intubation and surgical airway techniques such as cricothyroidotomy), use a defibrillator (for defibrillation, cardioversion and transcutaneous pacing) and perform advanced vascular access techniques (such as femoral, central or intra-osseous). Although used frequently in a way that would suggest a uniform definition, clinical procedures defining this term vary in South Africa according to the specific qualification and to some extent throughout the world. For the sake of this report, the word “paramedic” refers to an Advanced Life Support paramedic.

ECT paramedic: Emergency Care Technician. A National Certificate qualification consisting of two years of full-time training at a government or private (Further

Education and Training) Emergency Care College. This qualification leads to registration at the HPCSA as an ALS paramedic.[2]

CCA paramedic: Critical Care Assistant. CCA paramedics undergo a more vocational type of training at government and private (Further Education and Training) Emergency Care Colleges. The pathway to becoming a CCA paramedic entails the initial completion of a one month Basic Life Support course followed by a three month Intermediate Life Support course and finally doing a nine to twelve month Advanced Life Support course – the Critical Care Assistant course. Between all of these courses the individual has to work a certain amount of hours. This qualification leads to registration at the HPCSA as an ALS paramedic

NDip paramedic: National Diploma in Emergency Medical Care. A three-year full-time qualification obtained at one of four universities in South Africa. The scope of practice associated with the NDip paramedic is narrower than that associated with the BTech paramedic (definition below). This qualification allows registration at the HPCSA as an ALS paramedic.[3]

BTech paramedic: Bachelors of Technology degree in Emergency Medical Care. The BTech degree programme is offered as a two-year part-time programme for individuals already holding the NDip qualification. This programme prepares graduates for work at an ALS level in the pre-hospital environment in South

Africa. These paramedics have the widest scope of practice in South Africa. Their scope permits them to perform the same procedures as the CCA and NDip paramedics plus performing rapid sequence intubation and thrombolytic therapy. This qualification allows registration at the HPCSA as an ALS paramedic.[4]

NQF: National Qualification Framework. A framework regulated and maintained by the South African Qualifications Authority (SAQA) listing the hierarchical relationships and credit weightings of all SAQA-registered qualifications. The NQF is divided into basic education, further education and training, and higher education components.[5]

Cath Lab: A cardiac catheterisation laboratory is a procedural room in a hospital used for diagnostic and therapeutic imaging. A specialist cardiologist uses such a laboratory to perform angiograms on patients in order to visualise the inside of blood vessels.

PCI: Percutaneous Coronary Intervention is also commonly known as coronary angioplasty or simply angioplasty and is performed in a Cath Lab by a specialist cardiologist as a therapeutic procedure used to gain access to the coronary arteries of a patient via the femoral or radial artery and used to treat the stenotic (narrowed) coronary arteries of the heart found in coronary heart disease.[6]

Thrombolytic Therapy: Thrombolytic therapy is the use of specific drugs to break up or dissolve blood clots. It is administered intravenously.

ECG: An Electrocardiogram is used to view the electrical activity in the heart.

Pre-hospital: Relating to procedures performed or care provided prior to a patient's arrival at a hospital. This is mostly performed by emergency medical practitioners such as paramedics, either on the scene where the patient was found or en-route to the hospital.

In-hospital: Relating to procedures performed or care provided to a patient while inside the hospital.

Out-of-hospital: Relating to procedures performed or care provided to a patient while outside the hospital which does not follow with hospitalisation of the patient.

Chapter One: INTRODUCTION

This chapter will focus on the literature review and the justification for the research. It will clarify the aims and objectives that the researcher wishes to achieve from this study.

1.1 LITERATURE REVIEW

1.1.1 Coronary Heart Disease as a problem in South Africa

Coronary Heart Disease (CHD) is the term used to describe those conditions caused by the formation of atherosclerosis in the coronary arteries. Atherosclerosis is a chronic process in which a lipid-rich plaque forms in an arterial wall.[1, 7, 8] CHD remains the leading cause of death in the world despite the many recent advances in acute cardiac care. During 2008, 7.25 million people died due to CHD which accounted for 12.8% of all deaths worldwide.[9] In South Africa, even though CHD was rated the ninth leading cause of death during the turn of the century, accounting for 2.4% of all deaths per year, it was the most common cause of death among the White and Asian population.[10, 11] A more recent study conducted in 2008 among 1691 black South Africans indicated an increased prevalence of some of the major risk factors found among them for heart disease.[12] Overall, 78% of the participants had one or more major risk factors for heart disease, the most prevalent one being obesity, followed by hypertension, hypercholesterolaemia, and smoking. This might be indicative of the likelihood that the coming years will see a probable increase in

the incidence and prevalence of coronary heart disease in South Africa.[13] A more recent revision of the Burden of Disease estimates confirmed that the prevalence of CHD has increased and has become the second leading cause of deaths towards 2006.[14] This seems to still be the case as reported by Statistics South Africa during the census of 2011.[15] In addition, more than half the deaths caused by chronic diseases, including CHD, occur before the age of 65 years,[16] accounting for premature deaths which affect the workforce and have a major impact on the economy of a country.

1.1.2 An understanding of Acute Coronary Syndromes

1.1.2.1 Acute Coronary Syndrome defined

ACS is defined as the acute manifestation of CHD and occurs when a thrombus (a clot or solid mass consisting of fibrin or whole blood cells) forms over an atherosclerotic plaque within a coronary artery[7, 8] and comprises the following spectrum of potential life-threatening disorders:[7]

- Unstable angina: a worsening of ACS symptoms caused by the formation of a thrombus that does not completely occlude the coronary artery and does not cause myocardial damage or death.
- Non ST-Elevation Myocardial Infarction (NSTEMI): Acute myocardial infarction (AMI), similar to unstable angina, but with signs and symptoms that appear to be more prolonged and severe. The severity of the ischaemia is sufficient to

produce elevated serum cardiac enzymes due to the injured myocardium. The ST-segment on an ECG (Figure 1.1) is that part of the ECG between the end of the S-wave and the beginning of the T-wave. In the case of a NSTEMI, this segment appears to be deflected downwards or is depressed.

- ST-elevation Myocardial Infarction (STEMI): AMI characteristic of complete thrombotic occlusion of a coronary artery, characteristic of continuous severe substernal pain, coupled with visible ST-segment deflection upwards or elevation (Figure 1.1).[7]

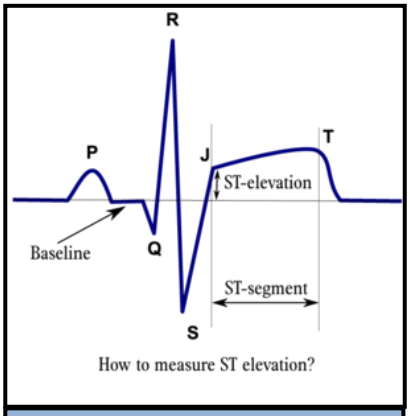

Figure 1.1: QRS complex with ST-Segment changes. [1]

1.1.2.2 Time is of the essence

The patient presenting with a STEMI needs speedy and effective emergency treatment as irreversible damage to the myocardium can occur within two to four hours.[1] Re-establishing blood flow through the infarct-related coronary artery is the main aim of emergency treatment as this will ensure a reduced infarct, preservation of ventricular function, and therefore reduced mortality. This can be achieved by either the administration of thrombolytic drugs or the insertion of a balloon in the coronary artery (also known as percutaneous coronary intervention or PCI) by a cardiologist in a catheterization laboratory (cath lab).[17] Thrombolytic therapy (TT) seeks to dissolve the offending blood clot in the coronary artery to improve

myocardial blood flow. This treatment has become common in the pre-hospital environment internationally, since it effectively reduces the time from the onset of pain to definitive therapy, especially in those areas where PCI is not easily accessible.[18, 19]

The benefit of early administration of TT has been proven by various research studies.[19-23] Although primary PCI has increasingly been advocated as the preferred approach to treat the STEMI patient, this is not always possible in areas where a cath lab is not available.[20, 24] Even though patients could be transferred from the initial admitting hospital to the appropriate hospital, any prolonged transfer and delay in treatment may be detrimental. Hence, the alternative treatment, in the form of TT, becomes the next best option.

Unfortunately, too many patients still hesitate to immediately seek medical attention. Somatic and emotional awareness towards chest pain or discomfort varies with every patient and contributes to the time delay prior to calling for help or traveling to the nearest hospital or doctor.[25] Two of the time intervals that are particularly essential are firstly, the time delay between the onset of symptoms and the first medical contact (FMC), and secondly, the time delay between FMC and the beginning of reperfusion. The time delay between the onset of symptoms and FMC depends on the patient's response to the symptoms as well as on the organisation of the Emergency Medical Service (EMS) if being called upon.[26] A study by Rawles[27] found that each minute of delay in reperfusion treatment resulted in a loss of 11 days

of life for the patient. Similarly, another study by De Luca[25] found that delays in primary PCI significantly increased the one-year mortality of patients with AMI. The international recommendation is that TT should be administered to patients in all systems that cannot ensure PCI within 90 minutes after FMC.[18, 26, 28-30] In South Africa, that certainly places the administration of TT in the pre-hospital domain as PCI is mostly limited to the developed urban areas. Patients seeking medical attention in rural areas may find such help with the local EMS or the closest doctor – either at the local hospital Emergency Department (ED) or at a doctor's consultation rooms. With the vast distances in rural areas in South Africa, the admission of a patient to a cath lab could be well beyond 90 minutes.

1.1.3 Making the decision to administer Thrombolytic Therapy

The definitive diagnosis of a STEMI is not only based on the changes seen on an ECG, but also by considering the elevated serum levels of cardiac enzymes such as Creatine Kinase MB (CKMB) or Troponin (T) as well as one of the following criteria:[31, 32]

1. The patient has the typical complaints associated with an AMI such as substernal chest pain, which radiates to the left shoulder and mandible, dyspnoea, nausea and/or vomiting, and a cold and clammy skin.

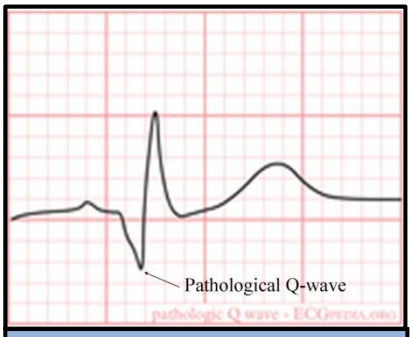

Figure 1.2: Pathological Q-wave after an AMI.[1]

2. The ECG indicates abnormalities in the ST-segment, mainly being elevated (Figure 1.1).

3. Pathological Q waves developing on the ECG (Figure 1.2).
4. Development of a new left bundle branch block (Figure 1.3).
5. A coronary intervention which had previously been performed.[31, 33]

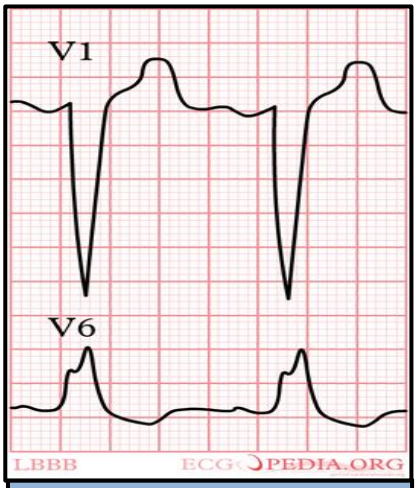

Figure 1.3: Typical pattern for a Left Bundle Branch Block.[1]

Detection of elevated serum cardiac enzymes is a more accurate indicator of a STEMI than ECG changes.[33] However, the cardiac enzymes can only be detected in the serum 2-12 hours after the onset of a myocardial infarction. The early diagnosis of a STEMI can be achieved by rapid ECG recording and interpretation at FMC, wherever this contact takes place – in a hospital, at home or in an ambulance. Tele-transmission of the ECG for immediate interpretation by experienced cardiologists or emergency physicians is considered as the optimal choice and should be the recommended practice.[33, 34]

Once a diagnosis of a STEMI has been confirmed, TT should be considered as early as possible if PCI is not available, even if it is in the pre-hospital setting.[35] As part of TT, contra-indications must be ruled out to prevent major and potentially life-threatening complications. The major toxicity effect of all thrombolytic agents is haemorrhage which results from two factors: firstly, the lysis of fibrin in thrombi at sites of vascular injury; and secondly, the systemic lytic state that results from systemic formation of plasmin, which breaks down fibrin and destroys other

coagulation factors – especially factor V and VIII. Using a checklist that details all the conditions and instances that contraindicate administration of a thrombolytic can be used effectively. Examples of these are the “Houston Fire Department Emergency Medical Service Acute Myocardial Infarction Therapy Checklist,” the “North Coast Emergency Medical Services Thrombolytic Therapy Pre-alert Checklist,” or the “Joint Royal College Ambulance Liaison Committee Checklist”.[36-38] However, for this study, the assumption was made that there were no contra-indications for TT and the decision to administer TT was only based on the accurate interpretation of the 12-lead ECG.

1.1.4 Pre-hospital Thrombolytic Therapy internationally

The use of TT following STEMI is well documented, and a major advantage of this treatment is its ease of administration. In Norway, the geographical conditions limit the possibility of transferring all patients to a centre with a cath lab within an acceptable time. In the absence of contraindications and if primary PCI cannot be performed within 90 minutes by an experienced team, TT has been developed in the pre-hospital setting in order to initiate treatment as soon as possible.[39] In Sweden, pre-hospital TT has been studied since 1997 and in 1999, the Swedish Board of Health and Welfare approved paramedic administered TT.[40] By 2000, the country had 75 hospitals establishing a system of ECG transmission from the ambulance on scene. Of these hospitals, approximately 50 implemented a system in support of pre-hospital paramedic administered TT which lead to an average reduction in “pain

to needle” time of 45 minutes. The feasibility of TT in Turkey was also considered.[41] According to a study in 2007, it was found that although PCI was preferred in patients with STEMI, it was acknowledged that bolus dose TT in the pre-hospital stage provided an early therapeutic option that was as good as primary PCI. In Germany, one study focused on two critical time intervals: the time between the onset of symptoms and the FMC, and the time between the FMC and the beginning of reperfusion. If primary PCI was not possible within 90 minutes after FMC, TT was initiated within 30 minutes after FMC – either in the EMS ambulance or in a nearby non-PCI hospital. Once TT was administered, even if "successful", it was not considered as the final therapy and the patient was then transferred, within 24 hours (but not before three hours), to a cath lab to receive PCI.[42]

CHD is also a major cause of mortality in India. Indeed, patients in India, who showed symptoms of ACS, showed a higher rate of STEMI than did patients in developed countries. Since most of these patients lived in poor socio-economic circumstances, they were less likely to receive evidence-based treatments, and had a greater 30-day mortality rate.[43] Reduction of delays in access to a hospital and provision of affordable treatments was suggested to reduce the mortality. The study recommended that treatment regimens for STEMI should aim to open the coronary artery as soon as possible. The author of the study acknowledged that patients suitable for TT should receive it as soon as possible, as time was the critical factor. Furthermore, pre-hospital TT was considered significantly superior to in-hospital TT in those regions where PCI was not an option as it resulted in the treatment being given much earlier.[43]

In a study conducted in the Kapiti Coastal Region of New Zealand, where the closest appropriate hospital with a PCI facility was more than an hour's drive away, a programme was developed in 2003 to initiate pre-hospital TT. After a four-year review, it was concluded that pre-hospital TT administered by paramedics was safe, reduced the time to treatment, and was associated with a reduction in heart failure. [44]

Moreover, in a large North American Medical Centre study, pre-hospital TT had a reduced time to treatment of 1 hour and 43 minutes compared to 2 hours and 38 minutes with in-hospital TT – a difference of 55 minutes. Due to the significant reduction in time to treatment with pre-hospital TT, patients showed improved peak CKMB levels, smaller pathological Q-waves at discharge, less occurrence of intracranial haemorrhage, and lower in-hospital mortality, compared to in-hospital TT.[45]

A number of studies in the United Kingdom (UK) also indicated the increased advantages of administering TT as early as possible, even if it was conducted by paramedics in the pre-hospital environment.[37, 46, 47]

Although not all countries permit their paramedics to administer TT in the pre-hospital environment, some countries have implemented a system where paramedics, at various levels of qualification, would be able to perform a 12 lead ECG in the pre-hospital environment and transmit the ECG to the receiving hospital, thereby alerting the receiving facility to the condition of the patient. Alternatively, in EMS systems where data transmission was not possible, a different practice was to

rely on the capability of the paramedics to correctly interpret the 12 lead ECG, diagnose a STEMI, and reroute the patient to an appropriate facility with a Coronary Care Unit (CCU).[48] Indeed, a study from the UK revealed that the accuracy of the paramedics to correctly diagnose STEMI in the pre-hospital environment was sufficient to cause a reduction in the “Door to Needle” time from 97 to 37 minutes.[49]

Conclusively, it is clear that a worthy alternative to PCI is TT as it can be administered substantially earlier than PCI and establishes reperfusion to the compromised artery much quicker. This can be achieved by implementing a well-functioning system in the pre-hospital environment which includes the recording of a 12 lead ECG at FMC, or as an alternative, to transmit the 12 lead ECG to the receiving facility thereby ensuring that the patient receives prompt treatment upon arrival.[50]

1.1.5 Pre-hospital 12 lead ECGs interpreted by paramedics

In South Africa the 12 lead ECG machine was predominantly reserved for the in-hospital setting or the medical practitioner’s consulting rooms. However, more ECG machines, specifically designed for the pre-hospital environment, are currently available.[51] As mentioned earlier, many studies have shown that the use of these ECG machines by paramedics in the pre-hospital environment has reduced the time from the onset of ACS symptoms to the time that the patient receives definitive care – whether pre-hospital or in-hospital, whether by means of TT or PCI. [52-58]

In an American study conducted on 103 paramedics, who had to interpret five 12 lead ECGs, revealed a high diagnosis accuracy by having a sensitivity of 92.6%(95% CI.88.9-95.1) and specificity of 85.4% (95% CI.79.7-89.8).[59] The participants in this study were full-time operational staff and received an hour's training on 12 lead ECG interpretation, focusing on STEMI. A Canadian study also concluded that paramedics, nurses, and doctors working in the pre-hospital environment, even with minimal training, are capable of accurately interpreting ECGs and diagnosing STEMIs comparable to control ECGs obtained from physicians.[60] Another American study examined the ability of a mixed group of ALS paramedics and nurses to diagnose STEMI based on the pre-hospital 12 lead ECG.[54] Of the 21 patients with STEMI, the paramedics correctly diagnosed 17 (81%). The other four patients did not have pre-hospital 12 lead ECG evidence of STEMI and hence were not incorrectly diagnosed. No false-positive diagnoses were made. A study involving British paramedics achieved an 87.5% accuracy with pre-hospital 12 lead ECG interpretation for STEMI patients during the initial "training" phase of the study, diagnosing 64 patients with STEMI. During the "active" phase of the study, diagnosing 72 patients with STEMI, an accuracy of 92% were achieved.[49] A study from the United Kingdom involved seven paramedics who had completed a two day course in pre-hospital 12 lead ECG interpretation.[48] A paper-based testing of 12 lead ECGs one year later, revealed an overall accuracy for diagnosing STEMI of 95% (95% CI.88–98), prompting the authors of the study to conclude that transmission of the pre-hospital 12 lead ECG to a physician for interpretation may not be necessary. A more recent study from the Boston EMS system began with a

six hour training session for all paramedics, followed by an eight month trial of real-time field interpretation of pre-hospital 12 lead ECGs.[61] Of the 151 patients enrolled, 25 had STEMI, and the paramedics correctly diagnosed 20 (80%) of them. The paramedics also categorized four patients as having STEMI who did not actually have STEMI, two of whom the control physicians felt had mimics of STEMI. The overall specificity was 97%, reflecting a low false-positive rate.

With the 12 lead ECG machine being more available, it could be assumed that paramedics with varying types of ALS qualifications (CCA, NDip or BTech) could have gained experience in the use of these machines and therefore may have increased their knowledge in the interpretation of 12 lead ECGs. Further to this, an array of courses are being developed across the world and offered via all possible routes of education on the topic of 12 lead ECG interpretation and paramedics therefore have easier access to opportunities that may increase their knowledge.

Therefore, this study was based on the premise that the value of pre-hospital TT has been well established and the capability of 12 lead ECG interpretation was not only limited to BTech paramedics, but indeed should fall within the ambit and ability of all paramedic qualifications.

1.1.6 Pre-hospital Thrombolytic Therapy in South Africa

Although TT in the pre-hospital setting has been practiced in other countries since the 1980s,[62] it was only introduced by the Health Professions Council of South Africa (HPCSA) as part of the scope of practice of BTech qualified paramedics in November 2009 even though, as eluded to earlier, the prevalence of CHD in South Africa has increased. While paramedics in South Africa can qualify via different routes, the HPCSA determined that this form of therapy should only be performed by paramedics with the BTech qualification.[29]

In South Africa there are currently four different educational pathways which an individual can follow to qualify as a paramedic. All pathways are distinctly different in format and duration and render the individual with a unique title that is used in the South African EMS context to distinguish one paramedic qualification from another. Firstly, the Emergency Care Technician (ECT) pathway consists of two years of full-time study at designated Emergency Care Colleges based on a curriculum that is classified as a National Certificate level. According to the National Qualification Framework (NQF), it is rated on level 5.[2, 5] Among the four qualifications to be mentioned, the ECT paramedic has the narrowest scope of practice.[63] Apart from cardiac arrest and ACS patients, the ECT paramedic is not trained to deal with a wide variety of other cardiac related emergencies. They also have a very basic knowledge regarding the interpretations of ECGs. Hence, the ECT paramedics have been excluded from this study.

Secondly, the Critical Care Assistant (CCA) paramedic undergoes a more vocational type of education. The training focusses on acquiring practical skills and competencies needed in the workplace. For the CCA paramedic, this process consists of three different short courses that successively build upon one another. Between these courses the individual has to gain a minimum of 1000 hours in the work place before advancing to the next course.[64] This pathway will usually take a minimum of three years to complete and each of the short courses is presented at Emergency Care Colleges. This qualification is not aligned with a NQF level. The scope of practice of the CCA paramedic is more comprehensive than the ECT, even though the educational foundation of the CCA is not considered to be on a higher educational level.[63]

Thirdly, the National Diploma (NDip) paramedic performs on the same scope of practice as the CCA paramedic, yet the educational pathway is markedly different.[63] The NDip paramedic studies a three year full-time National Diploma in Emergency Medical Care (EMC) at one of four universities in South Africa and is on a NQF level 6.[3, 4] The qualification is on a tertiary level and includes a proper foundation in basic sciences as well as all rescue related disciplines.

Forthly, the NDip qualification has been supplanted by the BTech qualification. The Bachelors of Technology (BTech) qualification requires as entry level the National Diploma qualification, and could be completed in one year as full time study or 2 years as part time studies. The BTech qualification is on a NQF level 7 and is presented at the same universities offering the NDip qualification.[4] More recently

the NDip and BTech qualifications have been replaced with a 4 year full time Bachelor's degree qualification in EMC on NQF level 8 also presented at the same universities. Both the BTech and Bachelor's qualifications allows for graduates to register with the HPCSA as Emergency Care Practitioners or ECPs.[60, 65] These paramedics have two additional lifesaving skills in their regulated scope of practice, namely Rapid Sequence Intubation and Thrombolytic Therapy.[29, 66, 67]

Currently, it appears that there are only a few BTech paramedics working operationally. It can be speculated that the reasons for this are twofold: firstly, this may be due to there being only 181 paramedics registered with the HPCSA who have the BTech degree qualification compared with the 1912 paramedics with the CCA- and NDip paramedic qualifications; [68] secondly, ostensibly many of these paramedics tend to move into managerial or training positions and thus spend less time treating patients on a daily basis. This implies that, although collectively the operational paramedics in South Africa may be called to respond to patients experiencing ACS, many patients do not benefit from possible TT because only a few operational BTech paramedics are available to provide the therapy.

1.2 AIM OF THE STUDY

The aim of this exploratory study was to determine and compare the current knowledge of the varying types of Advanced Life Support paramedic qualifications,

from Gauteng and North West Provinces in South Africa, on the interpretation of ACS related 12 lead ECGs and whether they could identify, based on their interpretation, if a patient is a candidate for TT. Furthermore, the aim was to determine if there was any correlation between the various demographic characteristics of the paramedics and their performance.

1.3 STUDY OBJECTIVES

With the aim of the study divided into two categories, three objectives were identified and established the focus for the research. The specific objectives were to determine:

1. The general trends observed in the demographic information of the three different paramedic qualifications.
2. If there is a significant difference in the performance of the different qualification paramedics in terms of their ability to correctly interpret 12 lead ECGs, based on 13 specific questions for each ECG, and to identify common problems with the interpretation of a 12 lead ECG.
3. Whether any correlations exist between the various demographic information of the paramedics, and:
    a. Their knowledge in interpreting the simulated 12 lead ECGs.
    b. Their understanding of the location of the pathology in the heart based on the abnormalities found on the different 12 lead ECGs.

c. Whether they know when a patient is a possible candidate for TT based only on their interpretation of the ECG and the brief clinical history of the patient.

1.4 CONCLUSION

In this chapter, the rationale for the study, as it pertains to the South African environment, was considered which led to the identification of the aim and objectives that would drive the research. The literature review has shown that CHD is a major problem, not only in the rest of the world, but also in South Africa. This section of the study also further elaborated on the merit of having TT in the pre-hospital setting as it is beneficial to the patient. Finally the importance of the 12 lead ECG, in identifying a STEMI as soon as possible, was accentuated.

The varying types of ALS paramedic qualifications (CCA, NDip, BTech) were also discussed together with the recent introduction of TT, by the HPCSA, to the scope of practice of only the BTech paramedics. This was compared with the practice in other countries and lead to the justification for inviting paramedics of all qualifications to partake in this study. Thus, data relating to the demographics and working environment of the different qualified paramedics was collected, and the participating paramedics' knowledge on the interpretation of 12 lead ECGs was explored.

Chapter Two: MATERIALS AND METHODS

2.1 INTRODUCTION

After considering the justification for this study in the previous chapter, this chapter focuses on the design of the study, the methodology used to collect and process the data, and the study population. The inclusion and exclusion criteria for participating paramedics will be discussed as well as the justification for the sample size used. The data analysis and ethical considerations of the study will also be discussed.

2.2 STUDY DESIGN

The design of this exploratory study was to collect quantitative data prospectively, over a two-month period, from a transverse group of participants. The results are described and analysed as they were recorded.

2.3 METHODOLOGY

Direct contact sessions with the paramedics were conducted to collect the necessary data. These sessions were arranged in one of three ways:

1. It was determined when a group of paramedics, working for the same organisation or under the same supervisor, would gather together for a pre-arranged meeting. This could include monthly meetings, clinical reviews,

workshops, etc. The researcher liaised with the convenor of the meeting and requested permission to address the paramedics at the beginning or end of the meeting and invite their participation.

2. A contact session was set up by the researcher and various paramedics from the same geographical area were invited to attend.
3. Paramedics were contacted on an individual basis and arrangements were made to meet them at a venue and time that suited them. In such a case, the researcher also attempted to group paramedics from the same area together in order to meet with as many as possible at a time.

A diverse range of venues were used for the contact sessions dependant on what was most convenient for the participants. Most of the sessions were conducted at the paramedic's place of work with the exception of three sessions which were held in restaurants. In these cases, the researcher paid for any refreshments ordered by the participants as a token of appreciation. Other direct expenses incurred due to this study were the travelling costs to all the paramedics and the cell phone costs to arrange all the contact sessions.

Communication to arrange these contact sessions was made mainly via cell phone communication. Email communication was also used to further support the request for a contact session by providing the convenors of meetings with the necessary information so that the researcher could obtain permission. For some of the contact sessions, the researcher used SMS communication to remind the participants of the date, time, and venue of the session. The researcher did observe that paramedics,

who were invited to participate in this study via SMS communication alone, did not respond or participate in the study at all.

Whenever these contact sessions were arranged, the researcher only informed the potential participants of the general concepts of the study. Mention was only made of the involvement of 12 lead ECGs in the study, but not the final reason behind the study. This was to ensure that the paramedics would not prepare in any way for the session as this could create an unrealistic reflection of their current knowledge. For those companies who employed a large number of paramedics, the researcher followed the necessary channels to obtain the permission from the employer before arranging the contact sessions with the employed paramedics.

Each contact session started with the researcher handing out the Participant Information Leaflet (Appendix 1) to each participant followed by a brief explanation of the aims and objectives of the study. The participants were informed that ethical clearance for this study was obtained from the Human Ethics Research Committee of the Faculty of Health Science of the University of the Witwatersrand (Clearance Certificate no M110121 – Appendix 5) and that their participation was voluntary. They were reassured that the results of the study would be handled in a strictly confidential manner and that the research report would not be written in such a way as to expose any individual. An opportunity was given to the participants to ask any questions before they completed the consent form.

A name list was then compiled of all the participants to ensure that no one participated more than once in the study. Only the researcher had access to the name list and no names were recorded on the participant's questionnaires (Appendix 2 and 3). All participants were asked to refrain from sharing the topic of the study with other paramedics until the end of the data collection period.

A demographic questionnaire (Appendix 2) was completed by each paramedic with questions regarding their qualification, working experience, their current working environment, and their educational background. The demographic questionnaire had no direct questions indicative of the paramedic's identity.

Each participant was then given a pack of ten 12 lead ECGs from which they had to select six that they felt most comfortable with to analyse. These 12 lead ECGs were obtained from the book "The ECG Made Easy" by John R. Hampton.[69] Each 12 lead ECG differed from the other, yet they were all related to an ACS problem, and contained a short clinical history. A questionnaire (Appendix 3), consisting of 13 questions, had to be completed by the participants for each of the six ECGs they chose. The first ten questions were related to the basic analysis of the ECG. Question 11 and 12 referred to the anatomical vascular supply of the heart that might produce the abnormalities noticed on the ECG and the 13th question asked whether they would consider TT for the patient. Participants were allowed sufficient time to complete the six questionnaires after which they handed them in. Four of the questions were open ended questions where the participants had to write the correct

answer in their own words whereas the remaining nine questions were a choice between 3 possible answers: The right answer, the wrong answer and the option “I am not sure”. The latter option was added as a possible answer to give the participants the option of rather being honest when they don’t know the right answer than to merely guess an answer and have a 50% chance of being correct. However, nothing stopped them from still guessing an answer and take the chance even if they were “not sure”.

The researcher marked the questionnaires according to a memorandum (Appendix 4) that was compiled from the accompanying notes of each ECG as described in the book “The ECG Made Easy”. The inputs of an experienced Emergency Medicine doctor, who analysed each of the ten ECGs, further assisted in compiling the memorandum accurately.

The marking of the questionnaires was done by giving 1 mark per correct answer. Adding up all the correct answers the final score was calculated as a percentage to the total of 13 questions asked. Whenever the option “I am not sure” was chosen, it was marked as incorrect.

2.4 DATA ANALYSIS

For this study an analysis was conducted to determine if there were any statistically significant differences in the performance of the paramedics based on the three types of ALS qualifications (CCA, NDip, or BTech) and eight other demographic

variables. Even though the sample size was not statistically representative of the population size, and a convenient sample of only 75 participants were collected, it was decided to use inferential statistical techniques to analyse the data in support of the descriptive interpretations. The 75 participants represented 15% of the population as, at the time of the study, the population size, according to the iRegister of the HPCSA, was 496 ALS paramedics (26 for North West Province and 470 for Gauteng). Analysis of variance (ANOVA) was used and a confidence level of 95% was used in all cases. The null hypothesis was considered to be “No significant difference in the performance of the paramedics based on the variable used”. Should the analysis reveal a p-value of less than 0.05, the null hypothesis would be rejected and the performance of the paramedics, based on the specific variable, would be statistically significantly different. Given the relatively small convenience sample, the possibility of a Type II error is acknowledged.

If any significant difference was detected, the effect size would be measured by calculating the Cohen’s-d value and thereby estimating the practical implication of the finding.

The independent variables used were firstly the different paramedic qualifications and thereafter the 8 paramedic demographics. Those were 1) the province in which the paramedics were working, 2) the sector in which the paramedics were working in, 3) the primary daily responsibility of the paramedics, 4) operational hours worked per month, 5) exposure to ACS patients per month, 6) extra hours worked in the ED, 7) exposure to 12 Lead ECGs per month, and 8) attendance of the Advanced

Cardiac Life Support® (ACLS®) courses. Dependant variables used were the percentages that the paramedics scored in the 13 question test.

All data was entered and stored in a Microsoft Excel® (Microsoft Office 2010, Microsoft Corporation) spread sheet. All analyses were conducted with the assistance of a statistician using StatSoft, Inc. (2013) STATISTICA® (data analysis software system), version 11.

2.5 STUDY POPULATION AND SETTING

2.5.1 Inclusion criteria

- All BTech, NDip, and CCA paramedics working in the North West and Gauteng Provinces in South Africa could participate in the study.

2.5.2 Exclusion criteria

- Paramedics who were part of a research committee of a given company, from whom the researcher had to obtain permission first before proceeding with the data collection, were excluded.
- Paramedics who were not currently registered with the HPCSA. The author conducted a registration check by using the iRegister website of the HPCSA.
- Paramedics living outside the two applicable provinces.

- ECT paramedics, due to their educational background and scope of practice, which excludes the interpretation of 12 lead ECGs and treatment of patients with a variety of cardiac abnormalities, were excluded from this study.

Only 3 paramedics were excluded from this study based on criteria 1 – being part of a research committee.

2.5.3 Sample size

The aim was to collect as much data as logistically possible over the period of July and August 2012, which concluded with a total of 75 participants who interpreted 444 ECGs. A statistical sample size representative of the population of participants was not determined for this study.

2.6 ETHICAL CONSIDERATIONS

Due to the prospective design of this study all recorded data was obtained by having contact sessions with the participating paramedics. It often happened that a group of paramedics attended a session. It was therefore known among paramedics who participated in the study. Yet, due to the sensitivity of the questionnaire, which assessed the competence of the participants, the results of the marked questionnaires were kept confidential. All data from the questionnaires were entered into a Microsoft Excel® spread sheet by the researcher that served as the platform from which the descriptive analyses were made. For the sake of confidentiality, the access to this file was restricted by making it password protected

with only the researcher knowing the password. Furthermore, all hard copies of the completed questionnaires were kept in a locked safety cabinet in an office with limited access to people other than the researcher, yet no questionnaire recorded the name of the participating paramedics. An undertaking was made by the researcher not to disclose any of the information that could be indicative of the performance of an individual person. An Ethical Clearance certificate was obtained from the Human Ethics Research Committee of the Faculty of Health Science of the University of the Witwatersrand (Clearance Certificate no M110121 - Appendix 5).

The necessary gatekeeper permission was obtained from the employers of paramedics before an attempt was made to recruit paramedics to participate. In some instances, the details of the study had to be disclosed to a panel of managers to make an informed decision. No person with any prior detailed knowledge of the study participated in this study.

2.7 CONCLUSION

This chapter has provided a description of the study design, the methodology used, with reference to all the appendices used below, to collect data from all paramedics that met the inclusion criteria. The next chapter will elaborate on the results of the data collected from the 75 participants.

Chapter Three: RESULTS

3.1 INTRODUCTION

As discussed earlier, the objectives of this study were to firstly investigate the demographics of paramedics from the Gauteng and North West Provinces, and secondly to determine their understanding and knowledge in the interpretation of 12 Lead ECGs, as it relates to TT, in simulated patients presenting with clinical ACS and thirdly to determine if there existed any correlation between their demographical information their performance.

A total number of 75 paramedics participated in this study during the two months of July and August 2012. Of these, 16 (21%) were BTech paramedics, 21 (28%) were NDip paramedics, and 38 (51%) were CCA paramedics. The majority of paramedics were from the Gauteng Province, contributing 60 participants as opposed to the North West with only 15.

3.2 PARAMEDIC DEMOGRAPHICS

Paramedics who participated in the study were employed in both the public and the private sectors. The public sector refers to the sector where the government is the employer and uses tax-payer's money to fund the organisation. The aim of this sector is to serve the population in a non-profit business model. The private sector, on the other hand, refers to the corporate environment where the primary aim of the

business is to render a service to the patient who has a form of medical insurance. The business model is profit driven and the funds generated from the service are essential for the survival of the business. The distribution of participants per sector and per province is indicated in Table 3.1. In the North West province, 11 (73%) of the paramedics were employed by the private sector with the most prevalent qualification being CCA. No BTech paramedic in the North West province participated in the study. At the time of the study the researcher was the only BTech paramedic in North West. In Gauteng, the results were similar with most of the paramedics being CCA qualified and employed by the private sector. All BTech paramedics participating in this study were from Gauteng.

Table 3.1: Current working sector and province

	Total	North West			Gauteng		
		Public	Private	Total	Public	Private	Total
BTech	16	0	0	0	5	11	16
NDip	21	3	3	6	8	7	15
CCA	38	1	8	9	3	26	29
Total	75	4	11	15	16	44	60

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

In terms of gender distribution, Table 3.2 indicates that 76% of all participants were male and the BTech paramedic group had the highest percentage of females (31.3%) compared to the female NDip and CCA paramedics. On average, the CCA paramedics were the oldest at 34.6 years of age while the BTech paramedics were

the youngest with an average age of 30.6 years. Across all qualifications the female paramedics were younger than the male paramedics.

Table 3.2: Gender and age distribution.

	Total	Male			Female			Average age[β]
		Qty	Percentage of total*	Average age	Qty	Percentage of total	Average age	
BTech	16	11	68.7%	31.0	5	31.3%	29.6	30.6
NDip	21	16	76.2%	34.8	5	23.8%	27.4	33.0
CCA	38	30	78.9%	34.9	8	21.1%	33.1	34.6
Total	75	57	76.0%		18	24.0%		32.6

*** Percentage of paramedics being male compared to the total number of paramedics with same qualification.**
[β] Average age of all paramedics per qualification.
BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

Figure 3.1 indicates the age distribution of paramedics sampled. The average age of all participants is 32.6 years with the mode age being 30 years. The standard deviation is six years with the youngest person being 22 years and the oldest 49.

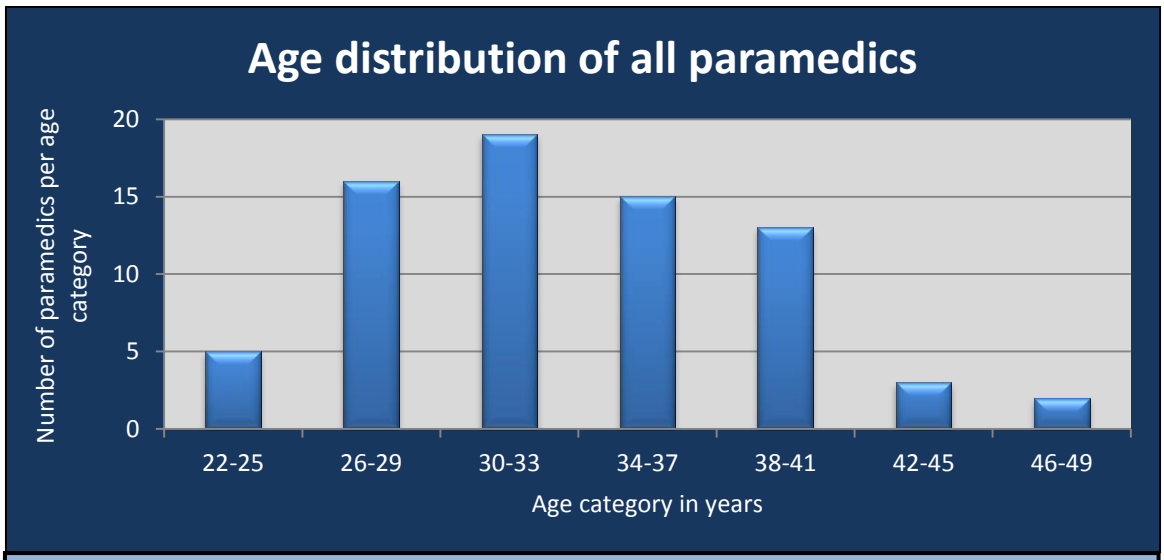

Figure 3.1: Age distribution of all paramedics

Participating paramedics indicated in the questionnaire their years of experience working in the public and private sector since their first entry into the EMS. Table 3.3a demonstrates that all participating paramedics have more experience working in the public sector than in the private sector. The CCA paramedics have the most years of experience in both sectors. The CCA paramedics also had the most years of experience since their first entry into EMS while the BTech paramedics had the least.

Table 3.3a: Years of experience in EMS

	Average years of experience in the Public sector	Average years of experience in the Private sector	Average years of experience since first entry into EMS†
BTech	7.5	5.7	9.0
NDip	7.9	6.0	12.1
CCA	8.8	7.1	13.0
Averages	8.1	6.3	11.9

† Paramedics could have worked in the EMS with a lower qualification before they obtained their current ALS qualification
EMS: Emergency Medical Services
BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

The participating paramedics indicated in the questionnaire the year that they qualified with their current ALS qualification. A calculation was made to determine the years of experience between the year of qualification and the year 2012. Table 3.3b illustrates the average years of experience of the paramedics for the different qualifications since they qualified with their current ALS qualification.

Table 3.3b: Years of experience with current ALS qualification

	Average years of experience with current ALS qualification
BTech	2.4
NDip	8.4
CCA	7.6
Average	6.1

ALS: Advanced Life Support
BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

The primary daily responsibilities refer to what the paramedics were mainly occupied with on a daily basis. The three selected categories were Operational, Training, or Management. Each paramedic had to rate these three responsibilities in a sequence of one to three with one being the most dominant responsibility and three the lowest. Table 3.4 indicates that the CCA paramedics rated their main responsibility as operational (65.8%), while NDip paramedics had the highest percentage (38.1%) working in management.

Table 3.4: Primary daily responsibilities

	Total	Primary daily responsibility					
		Operational		Training		Management	
BTech	16	4	25.0%	7	43.8%	5	31.2%
NDip	21	5	23.8%	8	38.1%	8	38.1%
CCA	38	25	65.8%	5	13.2%	8	21.0%
Total	75	34	45.3%	20	26.7%	21	28%

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

BTech paramedics rated their main responsibility as training (43.8%) which is also the highest percentage compared to the other qualifications. Conversely, the lowest responsibility of CCA paramedics was training (13.2%), while for the BTech paramedics this was operational work (25.0%). The NDip paramedics, however, was the category of qualification working the least operationally (23.8%), compared to the others. Figure 3.2 displays the data of Table 3.4.

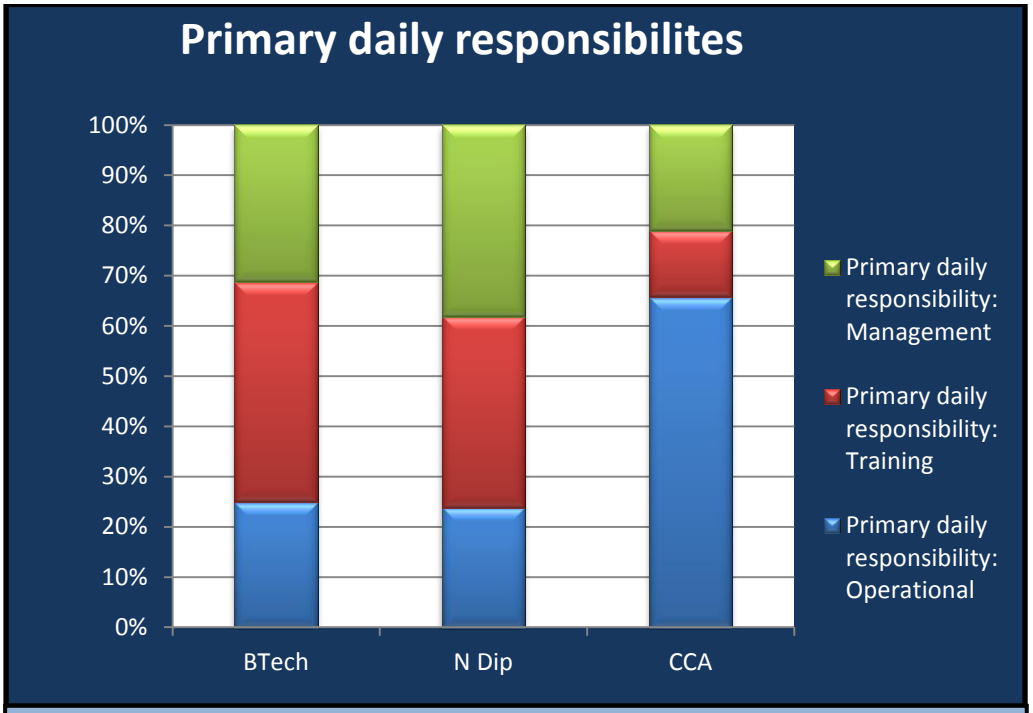

Figure 3.2: Primary daily responsibility of paramedics

Many paramedics cited their primary daily responsibility as working in an operational environment; yet those who had their primary responsibility in training or management also indicated that they did spend some time working operationally per month. This may be done after hours or on weekends, or as the secondary call-out

paramedic when the primary paramedic was occupied with another incident. Table 3.5 illustrates the amount of operational hours that paramedics, per qualification, spent working operationally. There were a few paramedics, who mentioned that they did not spend any operational hours per month; yet this was not specifically recorded and hence those paramedics selected the lowest category.

Table 3.5: Operational hours per month

	Total	Hours spent working operationally per month			
		40 hours or less		More than 40hours	
BTech	16	10	62.5%	6	37.5%
NDip	21	16	76.2%	5	23.8%
CCA	38	13	34.2%	25	65.8%
Total	75	39	52.0%	36	48.0%

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

Table 3.6 reflects the perceived number of ACS patients treated per month, for each of the paramedic qualifications. Each paramedic estimated how many patients he/she dealt with per month and did not base this figure on a monthly statistic. This perceived value is thus prone to major inaccuracy, yet accurate figures were not available at the time of data collection.

The first category indicates how many paramedics attended to virtually no ACS patients per month. The NDip paramedics had the highest occurrence in this category with 66.7% attending to less than two ACS patients per month. The second category indicated how many paramedics dealt with two or more ACS patients per

month. In this category, the CCA paramedics had the highest occurrence of 76.3%. Considering all participating paramedics, 40.0% indicated that they treat less than two patients presenting with ACS per month.

Table 3.6: Exposure to patients experiencing ACS per month

	Total	Number of ACS patients treated per month			
		Less than 2		2 or more	
BTech	16	7	43.8%	9	56.2%
NDip	21	14	66.7%	7	33.3%
CCA	38	9	23.7%	29	76.3%
Total	75	30	40.0%	45	60.0%

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

Considering another variable that might influence the competence of the paramedics, their monthly exposure to 12 lead ECGs was recorded. Table 3.7 illustrates how many paramedics have exposure to different quantities of 12 lead ECGs on a monthly basis. The majority of paramedics had exposure to less than eight 12 lead ECGs per month, no matter what the qualification. The CCA paramedics had the highest occurrence of 12 lead ECG interpretations per month (21.1%).

Table 3.7: Interpretation of 12 Lead ECGs per month

	Total	Number of 12 lead ECGs interpreted per month			
		Less than 8		8 or more	
BTech	16	14	87.5%	2	12.5%
NDip	21	19	90.5%	2	9.5%
CCA	38	30	78.9%	8	21.1%
Total	75	63	84.0%	12	16.0%

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

Furthermore, the paramedics were asked what cardiac related short courses they had done over and above their original ALS qualification. This was done to determine what other courses existed that could aid in the ACS related knowledge of paramedics. The most common short courses that the paramedics referred to were the Advanced Cardiac Life Support (ACLS®) courses from the American Heart Association (AHA). These are two-day continuing professional development courses that address the management of the most common cardiac emergencies.[70, 71] Other courses that the paramedics referred to were firstly, a one-day ECG interpretation course which five of the paramedics (7%) had done, and secondly, the 4th year Emergency Medical Care subject that forms part of the BTech curriculum which three NDip paramedics had done. This specific subject deals with TT and 12 lead ECG-interpretation.

Table 3.8: Cardiac related courses attended

	Total	**ACLS® related training**									
		None or Expired		ACLS®		ACLS EP®		ACLS® Instructor[β]		ACLS EP® Instructor[*]	
BTech	16	6	37.5 %	10	62.5 %	6	37.5 %	1	6.3%	0	0.0%
NDip	21	7	33.3 %	14	66.7 %	5	23.8 %	1	4.8%	0	0%
CCA	38	15	39.5 %	23	60.5 %	10	26.3 %	3	7.9%	1	2.6%
Total	75	28	37.3 %	47	62.7 %	21	28.0 %	5	6.7%	1	1.3%

ACLS: Advanced Cardiac Life Support
ACLS EP: Advanced Cardiac Life Support for Experienced Providers.
[β] Referring to paramedics who can present the ACLS® course
[*] Referring to paramedics who can present the ACLS EP® course
BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

More than a third of the paramedics (28; 37.3%) had done the entry level ACLS® course but, being only valid for two years, some had already expired. The majority of the paramedics (47; 62.7%) completed the course less than two years ago and are therefore still current with their ACLS® certificate. The BTech paramedics had the highest percentage (37.5%) of paramedics who had completed the more advanced ACLS for Experienced Provider® (ACLS EP®) course.

In summary, demographic data was obtained to determine the background and current working environments of paramedics in the two provinces. Table 3.9 displays the summary.

Table 3.9: Summary of the trends noticed regarding the demographic information of the different qualification of paramedics

No	Variable	QUALIFICATION		
		BTech	NDip	CCA
1	Participants	16	21	38
2	Average age	30.6	33.0	34.6
3	Dominant gender	Male	Male	Male
4	Years of experience in EMS	9.0	12.1	13.0
5	Primary daily responsibility	Training	Management	Operational
6	Working more than fourty operational hours per month	37.5%	23.8%	65.8%
7	Treating more than two patients with ACS per month	56.2%	33.3%	76.3%
8	Interpreting more than eight 12 lead ECGs per month	12.5%	9.5%	21.1%
9	Most common cardiac related short course attended	ACLS®	ACLS®	ACLS®

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic
EMS: Emergency Medical Services
ACS: Acute Coronary Syndromes

3.3 PARAMEDIC 12 LEAD ECG INTERPRETATION

The ten 12 lead ECGs that the participating paramedics could choose from were a selection of different ACS conditions. Each case also contained a short description of the patient's history and based on these two sources of data, the paramedics had to decide whether a patient was a candidate for TT. From these ten ECGs, the paramedics had to choose six to interpret.

Due to some paramedics being on duty at the time of the contact sessions, a few had to leave the session and respond to a call, resulting in two paramedics only completing four ECGs and another two paramedics only completing five. Hence, the total number of ECGs being interpreted was 444. For these four participants, the calculations were modified in Microsoft Excel® to determine their average performances according to the four or five ECGs submitted. Table 3.10 demonstrates the different diagnoses of the ECGs together with the number of paramedics that chose to interpret them. A further breakdown per paramedic qualification is shown. There seems to be a trend among the qualifications to choose the same ECGs. ECGs number one and two were popular among all the qualifications. Similarly, ECGs number eight and ten were the least popular among all the qualifications.

Table 3.10: Diagnoses of the ten 12 lead ECGs, as well as the quantity of interpretations chosen by the different paramedic qualifications, for each diagnosis

Diagnosis of 12 lead ECG	Qty	BTech (16)		NDip (21)		CCA (38)	
		Qty	%*	Qty	%*	Qty	%*
1. **Acute anterior MI**	63	14	87.5%	19	90.5%	30	78.9%
2. **Acute inferior MI**	67	13	81.3%	20	95.2%	34	89.5%
3. **Normal sinus rhythm with T-wave abnormalities**	38	9	56.3%	7	33.3%	22	57.9%
4. **Old inferior MI with acute anteriolateral MI**	66	15	93.8%	19	90.5%	32	84.2%
5. **1st degree AV block with T-wave abnormalities**	28	8	50.0%	8	38.1%	12	31.6%
6. **Acute inferior MI**	56	12	75.0%	12	57.1%	32	84.2%
7. **Severe anteriolateral ischaemia**	30	8	50.0%	7	33.3%	15	39.5%
8. **Acute anteriolateral MI**	25	3	18.8%	10	47.6%	12	31.6%
9. **Acute inferior MI with 1st degree block and possible posterior involvement**	47	8	50.0%	15	71.4%	24	63.2%
10. **Incomplete Left Bundle Branch Block with PVCs**	24	6	37.5%	8	38.1%	10	26.3%
Total number of 12 lead ECGs interpreted:	**444**	**96**		**125**		**223**	

MI: Myocardial Infarction.
AV: Atrioventricular.
PVC: Premature Ventricular Contraction
*** Calculated as a percentage of the total amount of paramedics per qualification**
BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

Table 3.11 indicates the average performance of each of the paramedic qualifications for each of the ten ECGs. Comparing Table 3.10 and Table 3.11, the popular choices of ECGs also rendered higher performance from the participants. ECGs number one and two scored relatively high among all the qualifications. Similarly, ECGs number eight and ten rendered low performances from all the

qualifications with the only exception being the BTech paramedics who scored a relatively high percentage of 71.8% for ECG number eight. The ANOVA test was used to compare the results of the three qualifications, rendering p-values as presented in the last column. Although the BTech paramedics scored the highest in most of the cases, none of the comparisons had a statistically significant difference.

Table 3.11: Average performance of the different paramedic qualifications for each of the ten ACS cases

ACS case	Qty	Average performance			ANOVA test
		BTech	NDip	CCA	p-Value
1. **Acute anterior MI**	63	86.3%	76.9%	73.8%	0.0749
2. **Acute inferior MI**	67	82.2%	81.9%	81.0%	0.9329
3. **Normal sinus rhythm with T-wave abnormalities**	38	68.4%	62.6%	65.0%	0.8470
4. **Old inferior MI with acute anteriolateral MI**	66	78.5%	74.5%	77.4%	0.7180
5. **1st degree AV block with T-wave abnormalities**	28	66.3%	62.5%	69.2%	0.7562
6. **Acute inferior MI**	56	80.8%	76.3%	79.6%	0.6674
7. **Severe anteriolateral ischaemia**	30	72.1%	78.0%	65.6%	0.2396
8. **Acute anteriolateral MI**	25	71.8%	59.2%	59.6%	0.6976
9. **Acute inferior MI with 1st degree block and possible posterior involvement**	47	81.7%	75.9%	69.9%	0.1702
10. **Incomplete Left Bundle Branch Block with PVCs**	24	42.3%	44.2%	40.0%	0.8733
Average performance:		**73.0%**	**69.4%**	**68.7%**	**0.4723**

MI: Myocardial Infarction.
AV: Atrioventricular.
PVC: Premature Ventricular Contraction
BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic

As mentioned earlier, the ECG interpretations were recorded on Appendix 3 and assessed by the researcher according to three categories: 1) the accuracy of interpreting the 12 lead ECG (Question 1 – 10); 2) knowledge of the anatomy of the heart experiencing the pathology (Question 11 and 12); and 3) concluding whether the patient is a candidate for TT (Question 13).

All categories were marked separately and also added together to reflect an average performance. The average performance of all the paramedics on each of the 13 questions was calculated and is presented in Table 3.12 and reveals that the BTech paramedics had the best average score in all three categories and concluded with the best average final score of 75.7%. The average performance of the entire sample (n=75) was 72.6% (95% CI 61.35% - 83.93%).

The one way ANOVA test was used to compare the performance of the different qualifications of paramedics (independent variable) against their average score in all of the three categories (dependant variable). Table 3.13 indicates that none of the comparisons had a statistically significant difference.

Table 3.12: Average performance of paramedics on each of the 13 questions in the participants' questionnaire

No	Questions asked	BTech	NDip	CCA	Average score
Question 1 – 10 related to the interpretation of the 12 Lead ECG					
1	**Rate:** Beats / minute	64.6%	65.1%	66.7%	**65.8%**
2	**Rhythm:** Regular or Irregular	95.8%	82.4%	87.9%	**88.1%**
3	**P-Wave:** Normal or abnormal	76.0%	73.2%	71.0%	**72.6%**
4	**PR-Interval:** Normal or Abnormal	82.3%	79.7%	83.8%	**82.2%**
5	**QRS Complex:** Narrow or Wide	89.6%	90.5%	89.9%	**90.0%**
6	**ST-Segment:** All normal or some abnormal	84.4%	85.7%	85.9%	**85.5%**
7	**T-Wave:** All normal or some abnormal	74.0%	68.1%	60.4%	**65.5%**
8	**Diagnosis** of the patient's condition	68.8%	66.5%	66.4%	**67.0%**
9	**Any leads suggestive** of ischaemia or infarction: Yes / No	84.4%	84.9%	84.7%	**84.7%**
10	**Which leads** suggests abnormalities	80.2%	74.6%	81.6%	**79.4%**
Average performance of all paramedics based on the first 10 questions		80.0%	77.1%	77.8%	**78.1%**
Question 11 – 12 related to the part of the heart experiencing the pathology					
11	**Which part of the heart** is experiencing the pathology	74.0%	57.9%	55.4%	**60.1%**
12	**Which coronary artery** are involved: Right or Left	38.5%	43.2%	40.4%	**40.9%**
Average performance of all paramedics based on questions 11 and 12		56.3%	50.6%	47.9%	**50.4%**
Question 13 related to the decision if the patient is a candidate for TT					
13	In the absence of any contra-indications is the **patient a candidate for TT**	71.9%	64.8%	57.9%	**62.9%**
Average performance of all paramedics based on all 13 questions		75.7%	72.0%	71.7%	**72.6%**

BTech: Bachelors of Technology Paramedic
NDip: National Diploma Paramedic
CCA: Critical Care Assistant Paramedic
TT: Thrombolytic Therapy

Table 3.13: Summary of the influence of the different qualifications on the average performance of the paramedics

Variable	Qualification performing best	p-Value	Significant difference*
Performance per ACS case (From Table 3.11)	BTech	0.4723	No
Analysis of 12 lead ECG (Question 1-10)	BTech	0.6628	No
Knowledge of heart anatomy (Question 11-12)	BTech	0.6046	No
Indications for TT (Question 13)	BTech	0.2238	No
Average Performance	BTech	0.4723	No

*** Significant difference between the performance of the 3 paramedic qualifications**
BTech: Bachelors of Technology Paramedic
ACS: Acute Coronary Syndrome
TT: Thrombolytic Therapy

3.4 CORRELATIONS BETWEEN DEMOGRAPHICS AND PERFORMANCE

As part of the third objective of the study, the researcher attempted to establish if there were any other correlations between some of the demographic variables and the ability of the paramedics to correctly interpret a 12 lead ECG. In this section, these variables will be presented in Table 3.14 to Table 3.23.

The first of the variables considered the sector in which the paramedics worked. All paramedics either worked in the private or public sector. Table 3.14 illustrates that paramedics in the private sector had more frequent interactions with patients presenting with ACS. In the private sector, 41 (74.5%) paramedics dealt with more

than two ACS patients per month, whereas 16 (80.0%) paramedics in the public sector hardly dealt with any ACS patients at all.

Table 3.14: Number of ACS patients treated per month by the paramedics working in the private and public sector

	Total	Number of ACS patients treated per month			
		Less than two		Two or more	
Private sector	55	14	25.5%	41	74.5%
Public sector	20	16	80.0%	4	20.0%
ACS: Acute Coronary Syndrome					

In Table 3.15, the performances of the paramedics working in the private versus public sectors are compared. The paramedics in the private sector performed slightly better in all but one category, and concluded with an average performance of 73.1% versus 71.3% in favour of those paramedics working in the private sector. However, this small difference was not statistically significant using the one way ANOVA test on the two groups showed $p = 0.5522$ and $F = 0.36$.

Table 3.15: Accuracy of interpretation of the ECGs according to the different sectors in which the paramedics work

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
Private sector	55	78.7%	50.7%	62.8%	73.1%
Public sector	20	76.3%	49.8%	65.5%	71.3%
TT: Thrombolytic Therapy					

This study was conducted in two distinctly different provinces - the North West being a rural province, and Gauteng being predominantly urban. Therefore, the second variable that might influence the knowledge of paramedics was the effect of working in a rural province versus an urban province. Table 3.16 demonstrates the average performance of the two groups. Using the one way ANOVA test on the two groups showed p = 0.9979 and F = 0.00. Hence, there was no significant difference between the groups.

Table 3.16: Accuracy of interpretation of the ECGs according to the province in which the paramedics were working

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
Gauteng	60	77.9%	50.6%	64.4%	72.7%
North West	15	78.8%	50.0%	56.7%	72.6%
TT: Thrombolytic Therapy					

The primary daily responsibility of the paramedics was the third variable taken into consideration. Each paramedic indicated their primary daily responsibility, which could either be working operationally, in training, or in management. Regarding the average performances, Table 3.17 indicates that those paramedics working primarily in a training environment performed the best in all categories. The one way ANOVA

test on the three groups showed p = 0.3560 and F = 1.05. Hence, there was no significant difference between the groups.

Table 3.17: Accuracy of interpretation of the ECGs according to the primary daily responsibility of paramedics

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
Operational	34	79.5%	50.0%	62.5%	73.6%
Training	20	77.7%	61.7%	64.2%	74.2%
Management	21	76.2%	40.6%	62.2%	69.9%
TT: Thrombolytic Therapy					

The fourth variable taken into consideration was the number of operational hours worked per month. The paramedics were grouped into categories of 40 hours or less, or more than 40 hours per month. Table 3.18 indicates that those paramedics who worked more than 40 hours per month rendered a better performance. Using the one way ANOVA test on the two groups showed p = 0.3592 and F = 0.85. Hence, there was no significant difference between the groups.

Table 3.18: Accuracy of interpretation of the ECGs according to the amount of operational hours worked per month

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
40 hours or less	39	76.7%	49.1%	63.7%	71.5%
More than 40 hours	36	79.5%	51.9%	61.8%	73.9%
TT: Thrombolytic Therapy					

A fifth variable that was considered was the number of patients with signs and symptoms of ACS that each paramedic dealt with on a monthly basis. As illustrated in Table 3.19, the group of paramedics that dealt with two or more patients per month had a better average performance of 73.5%. Using the one way ANOVA test on the two groups showed p = 0.4067 and F = 0.70. Hence, there was no significant difference between the groups.

Table 3.19: Accuracy of interpretation of the ECGs according to the amount of exposure per month to patients experiencing ACS

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
Less than 2 per month	30	77.0%	47.1%	63.6%	71.4%
2 or more per month	45	78.8%	52.8%	50.0%	73.5%

ACS: Acute Coronary Syndrome
TT: Thrombolytic Therapy

A sixth variable that was considered, that might play a role in the performance of the paramedics, was the effect of paramedics spending extra time working or helping in a hospital ED. As the amount of pre-hospital 12 lead ECGs seems to be very scarce, the easiest place for paramedics to gain more exposure to 12 lead ECGs would be in the ED. As illustrated in Table 3.20, only 20 (26.7%) paramedics indicated that they spend regular extra time in an ED. The only improved performance notable was their knowledge of the anatomy of the heart. Based on the statistics, all the other categories showed a lower score than those not working in an

ED. Using the one way ANOVA test on the two groups showed p = 0.8781 and F = 0.02. Hence, there was no significant difference between the groups.

Table 3.20: Accuracy of interpretation of the ECGs according to extra hours worked in the ED

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
Extra time in ED	20	77.3%	53.3%	60.4%	72.3%
No extra time in ED	55	78.4%	49.5%	63.8%	72.5%
TT: Thrombolytic Therapy **ED: Emergency Department**					

A seventh variable that was considered was the paramedics' exposure to 12 lead ECGs on a monthly basis. As presented in Table 3.21, the largest portion of

Table 3.21: Accuracy of interpretation of the ECGs according to the amount of 12 lead ECGs seen per month

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
Less than 8 ECGs	63	77.5%	49.4%	60.7%	72.0%
8 or more ECGs	12	81.3%	55.6%	66.7%	75.9%
TT: Thrombolytic Therapy					

paramedics (63; 84.0%), who had exposure to less than eight 12 lead ECGs, consistently performed worse than the other group (72.0% versus 75.9%). Those paramedics who dealt with more than eight ECGs per month had a higher performance in all three categories. The one way ANOVA test on the two groups showed p = 0.2853 and F = 1.16. Hence, there was no significant difference between the groups.

An eighth variable that was considered was the difference in performance of the paramedics based on their completion of the ACLS® courses. Three groups were considered: firstly, those who had not done any ACLS® course or whose certificate had expired (more than two years old); secondly, those who had done ACLS® less than two years ago; and thirdly, those who had done the ACLS EP® course or higher (i.e. having done the instructor's courses).

Table 3.22: Accuracy of interpretation of the ECGs according to the ACLS® courses done by paramedics

	Total	Accurate ECG interpretation	Correct Heart Anatomy	Correct decision to TT	Average performance
No or expired ACLS®	28	77.3%	44.0%	53.9%	70.4%
Current ACLS®	26	76.7%	48.0%	62.8%	71.2%
Current ACLS EP® or higher	21	80.8%	61.9%	74.6%	77.4%

TT: Thrombolytic Therapy
ACLS®: Advanced Cardiac Life Support
ACLS EP®: Advanced Cardiac Life Support for Experienced Providers.

Table 3.22 demonstrates that the paramedics in the third group performed the best in all three categories and conclusively had the highest average performance of 77.4%. Using the one way ANOVA test on the three groups showed $p = 0.0695$ and $F = 2.77$. Hence, there was no significant difference between the groups, yet this is the lowest p-value obtained among all the tests and this variable was the closest to achieving a significant difference.

Another variable that was considered was the influence of any other short courses that dealt with 12 lead ECG interpretation. Only six paramedics indicated that they had done such a course, which can be considered insignificant and small compared to the total sample size of this study.

In summary, there were a number of variables that were analysed to identify any influence on the performance of the paramedics. Considering the average performance of the paramedics, based on the different qualifications and the eight demographic variables that were considered, Table 3.23 shows which group within each variable rendered the best results yet it also shows that there was no significant difference between the different groups within each variable.

Table 3.23: Summary of the influence of different variables on the average performance of paramedics

Variables		Best group	p-Value	Significant difference*
1	**Different sector in which paramedics are working**	Private sector	0.5522	No
2	**Province in which paramedics are working**	Gauteng province	0.9979	No
3	**Primary Daily Responsibility**	Training	0.3560	No
4	**Operational hours worked per month**	More than 40 hours per month	0.3592	No
5	**Exposure per month to patients experiencing ACS**	2 or more patients treated per month	0.4067	No
6	**Extra hours worked in ED**	No extra time in ED	0.8781	No
7	**Amount of 12 lead ECGs seen per month**	8 or more ECGs interpreted per month	0.2853	No
8	**The role of the ACLS® courses**	ACLS EP® course or higher	0.0695	No

*** Significant difference between the performance of the different groups within each variable**
BTech: Bachelors of Technology Paramedic
ACS: Acute Coronary Syndrome
ED: Emergency Department
ACLS®: Advanced Cardiac Life Support
ACLS EP®: Advanced Cardiac Life Support for Experienced Providers

3.5 CONCLUSION

This chapter has provided a detailed account of the study results, which were described as they pertain to the 75 participating paramedics, who were either from the North West or Gauteng provinces.

The first part of the chapter addressed the results related to the demographics of the paramedics. These included their working sector and province, gender and age distribution, years of experience in EMS, primary daily responsibilities, operational

hours worked per month, exposure to patients experiencing ACS per month, exposure to 12 lead ECGs per month, and finally any cardiac related short courses they had done.

Thereafter, the knowledge of the different qualifications of paramedics regarding the interpretation of six conveniently selected 12 lead ECGs, was reported.

The third part of this chapter reported on the correlation between eight demographic variables and their effect on the performance of the paramedics.

Chapter Four: DISCUSSION

4.1 INTRODUCTION

This chapter presents a discussion of the results of the study as they relate to the three objectives set forth in Chapter One.

4.2 Objective One: TRENDS IN PARAMEDIC DEMOGRAPHICS

The first part of the discussion will focus on the general trends observed with the paramedic demographics as they were recorded on the questionnaire. Each demographic variable will be considered as they stand in relation to the different paramedic qualifications.

Distribution per province

A period of two months was allocated for the collection of data. As many participants as possible were recruited during that time. The biggest challenge was locating a time and venue that would suit as many paramedics as possible at a given time. The communication channels among paramedics in the private sector appeared to be more effective since 55 (73,3%) paramedics were sourced to participate from the private sector compared to only 20 (26.7%) from the public sector. Only 15 participants from the North West province contributed to the study. These paramedics operated in only three towns of the province, illustrating the poor distribution of paramedics throughout the North West province. The North West

province covers a surface area of 104 882km^2 and is the sixth largest of the nine provinces in South Africa with a population of 3.2 million people.[72] According to the iRegister of the HPCSA, there is a total of 26 paramedics in the North West province.[68] Hence, the paramedic to public ratio is approximately 1:123077, covering a wide outstretched space. Comparatively, 470 paramedics live in the Gauteng province which serve a population of 11.3 million people over an area of 18178km^2, rendering a paramedic to public ratio of 1:24043.[73]

Age and gender

Male paramedics were in the majority in all three qualifications. An average ratio for male versus female of 3:1 was observed. The BTech paramedics had the highest percentage of females (31.3%), which is similar to the gender distribution of emergency personnel in America with the male paramedics constituting 69% and females 31%.[74] This is still in line with the male dominant military origins of the profession dating as far back as the American Civil War in the 19th century.[75] It is only in recent years, where gender equality became the norm in the workplace, that the prevalence of female paramedics has increased. Hence, the female paramedics were also younger in all qualifications of paramedics. The CCA paramedics were found to be the oldest in both male and female categories, perhaps due the CCA qualification being the oldest in South Africa, dating back to the mid-1980s. The majority of paramedics were between the ages of 30 and 33 with the mode age being 30 years old and the average age being 32.6 years old. Considering the standard deviation of six years, 95% of the paramedics in this study were between

the ages of 26 and 37 years old. Only 13 (17.3%) of the paramedics were older than 40 years. With the high incidence of burnout among paramedics in South Africa and internationally,[76-78] it is not surprising to have so few paramedics older than 40 years of age, let alone paramedics being more than 50 years old.

Years of experience

Even though there were a few paramedics who haven't worked in both the public and private sectors, on average, all three qualifications showed that their years of experience in the public sector exceeded their years of experience in the private sector. On average, there was a difference of 1.8 years (6.3 versus 8.1) between the experiences in the public sector versus the private sector. In South Africa, the private ambulance sector is a development of the mid-1990s with the formation of the Private Ambulance Association, whereas the public sector has been involved with providing emergency medical care since the 1970s.[64, 67]

Considering the different paramedic qualifications, each with its unique educational pathway, it takes a different length of time to complete each of the different ALS qualifications. It is clear that the CCA paramedics had the most years of experience (13 years) since their first entry into the Emergency Medical Services. The educational pathway of CCA paramedics is of such nature that they enter the EMS as a Basic Ambulance Assistant with a very basic qualification and have to gain sufficient hours of experience before proceeding to the intermediate and advanced levels of qualification. Coupled with the fact that the CCA qualification is the oldest, as mentioned earlier, it is not surprising that the CCA paramedics have the most

years of experience in the EMS. Also notable is the few years of experience in the EMS among the BTech paramedics (9 years). This makes sense due to the fact that this is the youngest registered qualification with the HPCSA. Furthermore, the BTech and NDip qualifications are pathways where an individual can enter into the EMS as an ALS paramedic with no previous experience in the EMS at a lower qualification level – unlike the CCA qualification. Yet, this seemed to be the exception as both the BTech and NDip paramedics had more years of experience in the EMS than the years they've had their current ALS qualifications. Of the 16 BTech paramedics, only three qualified directly as BTech paramedics while the other 13 were initially qualified as NDip paramedics before furthering their education to the BTech qualification. On average, these BTech paramedics had an average of 7.5 years of experience as ALS paramedics (NDip and BTech qualifications combined) compared to the 2.4 years as BTech paramedics only, which is more comparable with the other two qualifications.

Primary daily responsibility

Most of the participating paramedics (34; 45.3%) worked operationally as part of their primary daily responsibility, yet when considered per qualification, it was clear that the CCA paramedics were the most dominant group working operationally with 25 of the 38 CCA paramedics (65.8%) working operationally. Regarding the BTech and NDip paramedics, it was noticeable that their primary daily responsibility was training and management. This could be ascribed to the content of the different educational curricula and the effect thereof on promotional opportunities. The NDip

and BTech curriculum offer subjects on law and administration while the BTech curriculum covers subjects such as management, educational techniques and research. Moreover, both the NDip and BTech qualifications are formal tertiary qualifications, and renders paramedics with these qualifications to more rapidly progress into managerial and training positions. This is further supported by the HPCSA who prescribes that paramedics in training positions, or employed as managers at training institutions, must hold an NDip or BTech qualification.[14]

Operational hours worked per month

Even though the BTech and NDip paramedics' primary daily responsibilities consisted of training or management, as discussed earlier, 37.5% of BTech paramedics did spend more than 40 operational hours per month. The majority of NDip paramedics (16; 76.2%) spent less than 40 hours working operationally per month making them the qualification of paramedics spending the least amount of time operationally. In contrast, more than half (25; 65.8%) of CCA paramedics spent more than 40 hours per month working operationally. This is in alignment with what was discussed earlier where the majority of CCA paramedics indicated that their main daily responsibility was working operationally. Although the BTech and NDip paramedics worked primarily in training or management, it seemed as though they still found the time to attend to operational needs. It could be argued that the amount of hours spent operationally could play a role in the ability of paramedics to deal with patients suffering from ACS. This is explored as part of objective 3 later in the chapter.

Exposure to patients experiencing ACS

As mentioned in Chapter One, many people in South Africa suffer from ACS. Surprisingly, many of the paramedics (30; 40.0%), irrespective of qualification, claimed to have dealt with less than two ACS patients per month. Most of the CCA paramedics (29; 76.3%) treated more than two patients per month, making them the qualification of paramedics dealing most frequently with patients presenting with ACS. Furthermore, NDip paramedics constituted the largest group (66.7%) that dealt with less than two ACS patients per month. This is in alignment with what was earlier observed regarding CCA paramedics working primarily operationally and NDip paramedics working primarily in management. For a country where CHD contributes to a large percentage of deaths, it is surprising that the paramedics had such limited exposure to ACS cases and especially since the practitioners who could affect the greatest change had even lower numerical exposure.

Exposure to 12 lead ECGs

Despite the increasing availability of 12 lead ECG machines in the pre-hospital environment, it appeared that most paramedics had very little exposure to 12 lead ECGs. The majority (63; 84.0%) of paramedics indicated that they hardly deal with 12 lead ECGs on a monthly basis (less than eight per month). The researcher explained to the participants that they should not only indicate how many 12 lead ECGs they interpreted in the pre-hospital environment, but also from any other hospital environments such as the ED, Intensive Care Units (ICU), doctor's rooms, etc. For those that interpreted more than eight ECGs per month, the CCA

paramedics had the most exposure (21.1%), followed by the BTech paramedics (12.5%), and lastly the NDip paramedics (9.5%). On average, only 12 paramedics (16.0%) had exposure to eight or more ECGs per month. This implies that only 16% of paramedics interpreted two or more ECGs per week. The limited exposure to 12 lead ECGs is surprising as the literature review has clearly indicated the important role of the 12 lead ECG in the early diagnosis of ACS. It raises the question whether the BTech paramedics receive sufficient exposure to 12 lead ECGs in order to keep their knowledge up to date and constitute a valid topic for further research. The literature also revealed that even if TT is not administered in the pre-hospital environment, the 12 lead ECG can be effectively used by paramedics to transmit their findings on scene to the receiving facility, thereby alerting the receiving team. However, with the necessary training, this could possibly be done by all qualifications of paramedics, yet it should first be trialled and tested.

Cardiac related short courses

Paramedics can undertake a variety of short courses on an array of topics. The participants were asked to list those short courses that they had done that were related to cardiac emergencies or ECG interpretation. As these short courses could have an influence on their knowledge of 12 lead ECGs, this occurrence was recorded. Only three different types of courses were mentioned, of which the first one, the ACLS® range of courses from the American Heart Association (AHA), was the most popular. These courses are presented by many providers and are internationally recognised. On varying levels, these courses deal with 12 lead ECG

interpretation and address the indications for TT. As different levels of these courses exist, the paramedics indicated which level they had completed. These included the first level ACLS® course, followed by the ACLS EP® (for Experienced Providers) course, which is followed by the ACLS® instructor course, and finally the ACLS EP® instructor course. It was noted that 21 paramedics did the ACLS EP® course whereas six paramedics qualified as ACLS® or ACLS EP® instructors. Although most paramedics had done the ACLS® course, it was noted earlier that as many as 40% of paramedics hardly ever treat any ACS patients on a monthly basis. It is therefore questionable why so many paramedics pursue this course. It could be due to the course being internationally recognised and possibly often forming part of the requirements for vacant posts. It could also be ascribed to the fact that this course earns the participants 34 Continuing Professional Development (CPD) points and therefore services the minimum ALS requirement of 30 points per annum in South Africa.[15] Yet, the reason why paramedics attended these courses was not explored as part of this study.

The second course mentioned was a course that dealt specifically with the interpretation of 12 lead ECGs, yet only nine paramedics have done such a course.

Lastly, there were three NDip paramedics who had completed the subject on the BTech curriculum that deals with 12 lead ECGs and TT, which is a small amount compared to the total number of participants.

All categories mentioned above have been considered to create an understanding of the trends in the demographics of the paramedics researched. These demographics were specifically considered as they might have an influence on the paramedics' knowledge on interpreting 12 lead ECGs. A discussion of these correlations will form part of Objective Three, later in the chapter.

4.3 Objective Two: PARAMEDIC 12 LEAD ECG INTERPRETATION

The second objective of the study was to establish if there was a significant difference in the performance of the three qualifications among the paramedics. This difference referred directly to their ability to correctly interpret 12 lead ECGs, based on the 13 specific questions for each ECG, and to identify common problems with the interpretation of a 12 lead ECG.

There were ten different ECGs which the participants could choose from, each uniquely different from the others, but all depicted a form of ACS emergency. The researcher explained to the participants that they could browse through the ECGs before selecting their preferred six ECGs. A trend was noticed across all three qualifications that the same ECGs were considered more popular and conversely less popular. Furthermore, it was observed that the performance of the different qualifications of paramedics correlated with the choice of ECG. ECGs number one and two, which were simulated cases of an acute anterior myocardial infarction and acute inferior myocardial infarction, were popular choices among all three

qualifications and the respective average performances, based on the marking of the 13 questions, were all above 73%. Similarly, the two least popular choices of ECGs were number eight and ten, which were simulated cases of an acute anteriolateral myocardial infarction and an incomplete left bundle branch block with premature ventricular contractions. Although ECG number eight was an unpopular choice among all qualifications, with their average performance correspondingly poor, the BTech paramedics rendered a performance of 71.8% as opposed to the weaker results of the NDip and CCA paramedics with 59.2% and 59.6% respectively. ECG number ten was consistently unpopular and rendered the lowest score across all three qualifications. The best performances among the three qualifications, for each of the different ECGs, rendered the following results: The CCA paramedics scored the best in only one ECG which was ECG number five. The NDip paramedics scored the best in two ECGs. These were ECGs number seven and ten. Although the NDip paramedics scored the best in ECG number ten, this case rendered the worst performance ECG of all the NDip paramedic results. The BTech paramedics rendered the best performance in the remaining seven ECGs and were accordingly the best performing qualification among all three qualifications scoring 73.0%, as opposed to 69.4% and 68.7% for the NDip and CCA paramedics respectively. Although the BTech paramedics performed the best overall, the difference in performance among the three qualifications was not statistically significant ($p = 0.4723$).

Considering the performance of the different qualifications on each of the 13 questions, the following is worth discussing:

Question 1 to 10 in the questionnaire dealt with the analysis of the 12 lead ECGs. It was noted that the largest difference between the average performances of the three qualifications was only 2.9% - the BTech paramedics scored the highest at 80.0% versus the NDip paramedics who scored the lowest with 77.1% yet the difference between the three qualifications was statistically insignificant ($p = 0.6628$). Combined, the final average score, for all three qualifications, was 78.1%. In fact, all paramedics scored more than 75% in six of the ten questions. This is lower than the performance of the international studies where the accuracy of interpreting 12 lead ECGs were all higher than 80%. It was however noticed that with each of the international studies the paramedics received some form of training on the interpretation of 12 lead ECG specifically pertaining to STEMI cases before the study was conducted, which is contrary to the methodology followed in this study. The training varied from a few hours to a few days.[48, 49, 54, 59-61]

Similar trends across the three qualifications were also noted in terms of the worst performances. Calculating the heart rate from a 12 Lead ECG, making an accurate diagnosis, and identifying abnormalities in the T-wave, scored between 60% and 70% across all qualifications.

To calculate the heart rate, a few paramedics wanted to use a heart rate ruler that they carried with them, yet its use was denied for the sake of consistency among all participants. In a real life situation, however, the use of such aids is recommended as they are light and compact to carry. Many other paramedics mentioned that it is not necessary for them to rely on a method to calculate the heart rate as the ECG

machine always has some mechanism of indicating the heart rate and it can conveniently be read off the screen or from the printout.

Describing the diagnoses of the 12 Lead ECGs varied among the paramedics. Some would state that the most likely diagnosis of the patient was, for example "Anterior Myocardial Infarction" while others would diagnose the same ECG by the abnormalities they saw on the 12 Lead ECG, for example, "Normal Sinus Rhythm with ST-Elevation". Although the latter might be technically correct in terms of the abnormality noticed on the ECG, it was not marked as a correct diagnosis as it was not addressing the pathology in the heart. Consequently the score for this question was consistently low among the qualifications.

Question 11 and 12 focused on the anatomical area of the heart experiencing the pathology. This section produced the lowest score among all qualifications, especially Question 12 which enquired which main coronary artery – left or right – was most likely experiencing the pathology. Knowing which part of the heart is suffering from an occluded artery is important as it has an influence on determining the appropriate treatment for the patient. All scores were below 50% and concluded with an average score of 40.9%. Yet again, even though the BTech paramedics performed the best in this section, the difference in the scores were not statistically significant ($p = 0.6046$).

Question 13 was the concluding question, incorporating the information from the previous questions, and making a decision whether the patient was a candidate for TT. The scores for this question had the largest range of difference between the

best and worst groups of paramedics; the BTech paramedics scored 71.9%, the NDip paramedics 64.8% and the CCA paramedics 57.9% (14% difference), yet the difference was still statistically insignificant ($p = 0.2238$). The BTech paramedics were the only group that has received formal training and could be the contributing factor why they were the best performing group. With a performance of 71.9% it is still questionable if this is of an adequate level when it comes to making a decision about a critical procedure such as TT. It does raise a concern and warrants the further investigation of instilling mechanisms that would ensure paramedics to stay abreast within this field of clinical practise. A formal educational programme should serve as the minimum requirement for the NDip and CCA paramedics before starting to practise TT, while regular updates, case reviews and workshops would most likely help with maintaining the necessary knowledge and performance of all paramedics.

Fortunately there are mitigating factors that do play a role before a final decision is made whether or not to perform TT. From the literature review is was clear that a paramedic should preferably consult with a receiving facility before a decision is made to thrombolyse a patient. This may reduce the risk of making a wrong decision and thrombolysing the patient incorrectly. The common practice of using an acceptable checklist to rule out the contra-indications of TT forms part of the consultation process and further reduces the risk of a wrong decision.

The performance of the different paramedic qualifications should be viewed in light of their demographic occurrences. As discussed earlier, even though most of the paramedics who participated in this study, regardless of their primary daily

responsibility, did spend time operationally, the average exposure among all qualifications to patients suffering from ACS, and furthermore to 12 Lead ECGs, were negligible. Hence, it is not surprising that the average performance of all paramedic qualifications was not what one would expect.

4.4 Objective Three: CORRELATION BETWEEN VARIOUS DEMOGRAPHICS AND PERFORMANCE OF PARAMEDICS

In addition to the different qualifications of the paramedics, eight demographic variables were considered to determine what influence they had on the performance of the paramedics. All the variables were selected based on the assumption that each variable might logically have an effect on the performance of the paramedics.

The majority of the participating paramedics (55 versus 20) were working for the private sector at the time of the study. It was clear that paramedics in the private sector had more exposure to patients experiencing ACS than those in the public sector (74.5% versus 20% of paramedics were exposed to more than two ACS patients per month). Considering the general profile of patients attended to by the private sector, where the majority of patients can afford medical insurance, the prevalence of CHD, and specifically ACS, is more common.[9, 11] Even though the exposure of the paramedics to these patients was different in the two sectors, their performance was not significantly different ($p = 0.5522$).

In a rural province like the North West, where definitive care for a patient experiencing ACS might be hours away, paramedics frequently spend a long period of time with a patient prior to handing over to the receiving hospital. Hence, the possibility of a patient arriving in a cath lab and receiving PCI in less than 90 minutes in the North West is minimal. Conversely, the paramedics in Gauteng might need to treat more patients in a shorter space of time, but the treatment and transport time is much less. In the North West Province, at the time of the study, the only BTech paramedic was the researcher of this study, therefore implying that the possibility of a patient receiving pre-hospital TT throughout the province is minimal. As the general profile of calls attended to by paramedics in these two provinces may vary in certain aspects, it should render the paramedics with specific experiences and knowledge unique to the province. In terms of the performance of the paramedics, based on the province they were working in, the biggest difference was noted in category three of the questionnaire where the paramedics had to decide if the patient was a candidate for TT (64.4% correct for Gauteng versus 56.7% for North West). The urban paramedics were more accurate in making a correct decision regarding TT even though the average performance was not significantly different ($p = 0.9979$).

It could be argued that the urban paramedics treat more patients during a normal shift and therefore gain more experience in dealing with the ACS patient. Furthermore, the likelihood of the urban paramedic interacting with a wider variety of medical specialists such as emergency physicians or cardiologists is also higher compared to the rural paramedics. In a rural setting, it is more important that the paramedic be able to confidently interpret a 12 lead ECG and determine the best

early treatment for the patient as the paramedic is compelled to treat the patient for longer periods of time before handover to the hospital staff.

In terms of primary daily responsibilities, it was noticed that those paramedics working primarily operationally or in training performed better in all three categories of the questionnaire. Both these areas of responsibilities deal with clinical matters as it relates to patient care, whereas the paramedic in a management position would be much less exposed to clinical knowledge of patient care. Considering the fact that most paramedics indicated that they did manage to spend some time working operationally, it surely has contributed to preventing a dismal performance of those paramedics working primarily in management. Hence, the difference in performance, based on the primary daily responsibility of the paramedics, was not significantly different ($p = 0.3560$). Even for those paramedics who indicated that they worked more than 40 hours operationally per month; their performance was only marginally higher (73.9% versus 71.5%) than those spending 40 hours or less operationally per month. These results still rendered an insignificant difference ($p = 0.3592$).

Another variable that was considered was the exposure paramedics had with patients suffering from ACS. It might be a logical assumption that more exposure to such patients would improve the experiential knowledge of paramedics. As discussed earlier, only 60% of paramedics claimed to treat two or more ACS patients per month. Every patient experiencing ACS should receive a 12 lead ECG, yet similarly, the majority of paramedics did not even interpret eight 12 lead ECGs per

month. Comparing the performances of paramedics to their exposure to ACS patients, as well as to 12 lead ECGs, still rendered no significant difference ($p = 0.4067$ and $p = 0.2853$ respectively). Paramedics cannot proactively do much to increase their exposure to ACS patients, other than educating the public to contact the EMS when symptoms of ACS are experienced. However, it is much easier for paramedics to proactively increase their exposure and knowledge on 12 lead ECG interpretation. This will naturally happen in a system where 12 lead ECG machines are more readily available in the pre-hospital environment, especially if the machine can transmit the ECG to the receiving facility and the diagnosis can be discussed with a cardiologist or emergency physician. An analysis was made to determine if the 20 paramedics who indicated that they spent extra time working in an ED, performed better than those paramedics who did not. Again, the variance in performance was dismal and not significantly different ($p = 0.8781$). It should be noted that even though so few paramedics indicated that they worked extra official shifts in the ED, all paramedics deliver their patients to the ED, and therefore do spend some extra time there. It is a common occurrence that paramedics will spend some time in the ED after a call to finish paperwork or clean equipment in preparation for the next call. General informal discussions do occur among medical personnel even though it cannot be quantified or measured.

The ACLS® courses from the AHA were well attended by all qualifications of paramedics. These were analysed in three categories: Firstly, those paramedics who had never done the course or whose certificate had expired; secondly, those who had done the ACLS® course less than two years ago – hence it is still current;

and thirdly, those who had pursued the more advanced courses like the ACLS EP® or had even qualified themselves as instructors. Comparing the performance of the paramedics against these three groups rendered the lowest p value ($p = 0.0695$) among all the variables considered. Even though it could still be said that the difference was not statistically significant, it is worth considering this variable as the one that rendered the lowest p value. It seems as though those paramedics who had done the advanced ACLS® courses achieved a difference in performance that was the closest to a significant difference. Indeed, a difference of 7% (77.4% versus 70.4%) in the average performance was found between the 1st and the 3rd group.

Considering the influence of all the variables, none of the groups within each variable produced a statistically significant difference in the knowledge of paramedics to interpret 12 lead ECGs.

Chapter Five: CONCLUSION

As has been noted, the CCA paramedics in this study were the ones who spent the most time working operationally. The recommendation from this study is that the skill of TT may be extended to all paramedics as the benefits of pre-hospital TT have been well established, while the performance among the different qualifications of paramedics was proven to be statistically insignificant, yet lower than the performance of paramedics in similar studies. However, it needs to emphasised that the literature made it clear that TT should not be conducted in isolation without any form of consultation.[29, 67] TT further requires activities that precede the final decision to thrombolyse a patient.[50] Among these activities the following are highlighted:

1. Appropriate and adequately focused training on the knowledge of TT. A training curriculum can be developed that focuses on TT. Individuals can undertake this training once the skill of TT is extended to NDip and CCA paramedics, and must be mandatory before a paramedic start practising the skill. This should also be driven from the needs of the work environment of the paramedic. This study has shown that very few paramedics find themselves in a situation where they need to deal with cases of ACS and might opt not to pursue the improvement of their knowledge in the field of TT.
2. The availability of the 12 lead ECG machine with telemetry capability in the pre-hospital environment is vital. As being prescribed by the HPCSA, TT cannot be performed without the proper interpretation of the 12 lead ECG.[67] Even if

paramedics are permitted to perform TT independently, the final decision should preferably be done after consultation with a cardiologist who has received a transmitted copy of the ECG. Evident from the data collected was the lack of exposure paramedics had to 12 lead ECGs. This study did not record whether each paramedic was equipped with a 12 lead ECG and neither enquired what the reason was for the minimal exposure. The literature review has however shown that even if TT is not performed pre-hospital, the patient does benefit from the early alert of the hospital ED staff due to decisions being made based on an early interpretation of the 12 lead ECG. Hence, the priority should be to increase the prevalence of 12 lead ECG machines in the pre-hospital setting and ensure the competent usage of them.

Finally, it can be concluded that paramedics with varying types of ALS qualifications (CCA, NDip and BTech) from the two provinces in South Africa performed surprisingly well considering the absence of any formal training for the NDip and CCA paramedics, coupled with no specific training in preparation for this study either. Yet the performance was not as good as one would expect from paramedics who have to make a challenging decision regarding a life-saving, yet very risky procedure. With the performances of the different qualifications being insignificantly different from each other the recommendation would be that the different qualifications of paramedics could possibly function on the same level provided that the conditions mentioned above are met.

BIASES

1. It could be speculated that, during the contact sessions with the paramedics, the possibility exists that the participants could have felt pressured to participate. This could be possible in those instances where they received a directive from their managers to participate or where their attendance was purely due to the fact that they had to attend the meeting that was scheduled before or after the data collection session. In such cases, some individuals might have felt obliged to participate due to the instruction they received or due to the peer pressure from colleagues around them who participated. This could have caused the participant to complete the questionnaires just for the sake of getting it done, instead of applying their best performance, and thus could have skewed the results.
2. The mere existence of three different ALS qualifications in South Africa, with their different scopes of practice, could have also caused the participants to consider their participation in this study as a form of competition or challenge. This could have either caused the paramedics to be more motivated to participate or, on the contrary, they might have felt exposed and unwilling to have their knowledge "assessed". As this study did not allow to be conducted as a randomised control study, these underlying factors might have skewed the willingness of paramedics to participate.
3. It should also be mentioned that the researcher did put in extra effort to recruit the participation of BTech paramedics, as they were part of the smallest contingent of paramedics. At the time of the data collection, there was not one

BTech paramedic (other than the researcher) in the North West province and very few operational BTech paramedics in Gauteng that could participate. Specific phone calls to these individuals were made in order to request their participation.

4. As 3 (4%) of the participating paramedics had to interrupt their participation in the study, due of them being on duty, and only interpreting 4 or 5 of the ECGs, this might have skewed the data slightly as it is not sure if they started with the "easier" ECGs and leaving the possible "more difficult" ones for last. However, the missing 4 ECG's were very small compared to the total number of 444 ECG collected.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. Knowledge of the interpretation of 12 lead ECGs is only one component in the approach to treating patients with possible ACS. Comparing the ability of paramedics to comprehensively treat a patient with ACS will need a much more comprehensive assessment than merely the comparison of their interpretation of a 12 lead ECG. Hence the limitation of this study lies within the fact that it only compared the knowledge of paramedics related to the 12 lead ECG and not the holistic treatment of patients experiencing ACS. The conclusion that the performance of the 3 different qualifications is insignificantly different does not imply the same for their ability to treat the patient holistically. This needs further investigation.

2. TT should preferably not be performed in isolation based on an independent decision of a paramedic. From the literature, and as prescribed by the HPCSA, it is strongly suggested that the paramedic should first consult with the receiving facility and especially the cardiologist.[19, 67] Furthermore, the cardiologist cannot make a decision or any recommendations if the 12 lead ECG cannot be transmitted. This places the emphasis on the development and implementation of the necessary logistical support that will enable effective transmission and communication between the paramedic and cardiologist, thus ensuring a prompt and accurate decision for the benefit of the patient. Even if TT is not administered in the pre-hospital setting, sufficient studies have indicated the benefits of patients receiving earlier definitive treatment when the receiving facility was alerted by the paramedic prior to the arrival of the patient in the ED. Future research can be aimed at establishing such systems and evaluating the effectiveness of different systems relative to patient outcomes.
3. With CHD becoming one of the leading causes of death in South Africa, it was surprising that paramedics only treated a few patients per month experiencing ACS. This raises questions regarding the access routes followed by the public towards receiving definitive medical care. Thus, it would be worthwhile to research the access routes used by the public, and subsequently, why the EMS system is not optimally used, such as doing an assessment of what proportion of ACS patients are treated only by Intermediate Life Support providers and where ALS is not being requested for assistance.

LIMITATIONS OF THIS STUDY

1. As this study was only exploratory in nature, it was not the objective to determine the exact population of the various qualifications of paramedics within the 2 provinces, let alone the rest of South Africa. It can therefore not be concluded that the findings of this study are necessarily representative of the three different qualifications *per se*. This study only reported on what was recorded from the participants that could be found within the two provinces in South Africa. A more robust study, with a more statistically correct sample size, together with a more comprehensive data tool, could stem from this study and render more accurate inferential statistical analyses and diminish the possibility of a Type II error.
2. Paramedics in various parts of the country experience unique challenges in terms of geographic challenges, patient profiles, and EMS systems. To develop and roll out the skill of TT throughout South Africa, and among all paramedics, will need a system of focused research to determine the ideal solution for the specific needs of that part in the country.
3. It might be an unfair approach to expect that a paramedic, irrespective of qualification, who might have been in a managerial position for years, having very little experience treating patients due to his/her primary daily responsibility, to have adequate knowledge with regards to the interpretation of 12 lead ECGs. Even though the inclusion criteria of this study included all BTech, NDip and CCA paramedics, and the data analysis was conducted using all the data from these three groups, a more useful comparison would have been to compare the performance of only those paramedics working operationally. Unfortunately, for

this study, the sample size would have been inadequate to conduct proper analyses.

4. Although the methodology of this study was for the participating paramedics to interpret 12 lead ECGs in the comfort of a classroom setting, which is grossly different from the real life situation, a more realistic approach for a similar study would be to evaluate the performance of paramedics when they are dealing with real life scenarios. In such a case, all the nuances of a real life situation will be incorporated in the analysis of their performance and would render a more accurate result.

APPENDIX One: PARTICIPANT INFORMATION LEAFLET

DEPARTMENT OF EMERGENCY MEDICINE

FACULTY OF HEALTH SCIENCES

UNIVERSITY OF THE WITWATERSRAND

PARTICIPANT INFORMATION LEAFLET

INTERPRETATION AND KNOWLEDGE OF 12 LEAD ECGS AND THROMBOLYTIC THERAPY OF PARAMEDICS IN GAUTENG AND NORTH WEST PROVINCES IN SOUTH AFRICA

Dear Paramedic,

In partial fulfilment of the degree of Master of Science in Medicine in Emergency Medicine at The University of the Witwatersrand, please would you kindly consider participating in this important research study.

Background

As a registered paramedic, you will appreciate the importance of early and effective treatment of the patient who presents with an Acute Myocardial Infarction (AMI). Having access to reperfusion therapy, such as thrombolytic therapy, is the standard of treatment. As you are aware, on-site intravenous thrombolytic infusion therapy has been introduced by the Health Professions Council of South Africa (HPCSA) as being part of the scope of practice of Bachelor of Technology (BTech) paramedics, who constitute a very small percentage of operational paramedics in South Africa.

Therefore, I am doing a study on this topic involving the participation of all paramedics in this study.

Aim of the study

The aim of the study is to determine the current ability of all registered paramedics, irrespective of academic qualification, to interpret a number of 12 lead ECGs in order to determine whether thrombolytic therapy would be indicated for the particular patient.

This is based on the premise that some paramedics have undergone formal training on ECG interpretation while others might have undergone informal training or be self-taught.

The results of this study will aim at finding if there are any associations between the experience and qualification of the paramedic and the ability to correctly interpret the 12 lead ECGs and make a correct decision regarding thrombolytic therapy.

Methodology

You will be requested to interpret six 12 lead ECGs. You can choose 6 ECGs from 10 being handed to you. Each ECG will include a short case history of a patient that presents for management. Based on this information, you will be asked to complete the questionnaire for each case.

Please will you complete the demographical questionnaire regarding your educational and experiential background?

Ethical considerations

Ethical approval (Certificate No. M110121) has been obtained from the Human Research Ethics Committee (HREC) of the University of the Witwatersrand. Please note that you are under no obligation to participate and you may withdraw from the study at any time. Furthermore, your answer sheets will be handled confidential and no link will be made between your answer sheets and your name. The results of this study will not be disclosed to any employer and will not pose a threat to your employment.

Your participation in this study is greatly appreciated and should you wish to discuss anything else regarding this study you are welcome to contact me at Tel: 018 473 0324, Cell: 082 468 4326 or Email: nlouw@nwpg.gov.za.

To report any complaints of problems with this study you are welcome to contact the HREC administrator at Tel: 011 717 1234 or Fax 011 717 1265

Thank you kindly for your time and assistance.

Nico Louw

CONSENT FORM

INTERPRETATION AND KNOWLEDGE OF 12 LEAD ECGS AND THROMBOLYTIC THERAPY OF PARAMEDICS IN GAUTENG AND NORTH WEST PROVINCES IN SOUTH AFRICA

I have read and understood the information above and hereby acknowledge my participation in this study.

Name: _____

Date: _____

Signature: _____

APPENDIX Two: PARTICIPANT DEMOGRAPHIC QUESTIONNAIRE

Part A: Demographical questions

1. What paramedic qualifications do you hold?

	Year obtained	Institution obtained from
CCA		
Ndip		
Btech		

2. What is your age and gender?

Gender		Age
M	F	

3. How much working experience do you have in the following respective sectors?

	Years	Months
Public		
Private		

4 What daily responsibilities are you dealing with currently? You can select more than one. Rate them in order of time spend on each (1st, 2nd, 3rd - 1 being most time spent and 3 being least time spent on).

	Rating
Operational	
Training	
Management	

5. How much time do you spend operationally treating patients per month?

Less than 10 hours	
11 to 40 hours	
41 to 80 hours	
81 to 160 hours	
More than 160 hours	

6. How many patients with cardiac related complaints do you treat per month?

2 or less per month	
3 to 7 per month	
8 to 16 per month	
>16 per month	

7. Do you regularly work in departments other than pre-hospital?

Unit	Hours per month
Emergency Department	
ICU	
Primary Health Care clinic	
Operating Theatre	

8. How many 12 lead ECGs do you interpret per month?

2 or less per month	
3 to 7 per month	
8 to 16 per month	
>16 per month	

9. Have you had any specific ECG or cardiac related training (short courses)? Please list them.

Name of course and institution	Year obtained

10. What other formal cardiac related qualifications (i.e. diplomas and degrees) do you hold?

Name of qualification and institution	Year obtained

APPENDIX Three: ECG PAPER INTERPRETATION

Part B: ECG Paper Interpretation No.:

1. Rate _____beats / minute or I am not sure
2. Rhythm Regular or irregular or I am not sure
3. P Wave Normal or abnormal or I am not sure
4. PR interval Normal or abnormal or I am not sure
5. QRS Complex Narrow or wide or I am not sure
6. ST Segment All normal or some abnormal or I am not sure
7. T Wave All normal or some abnormal or I am not sure
8. Your diagnosis of the ECG _____
9. Are there any leads which have suggested signs of ischaemia or infarction? Yes/No
10. If yes, which leads indicate such changes?_____
11. Which part of the heart is experiencing this pathology? _____

    _____
12. Which coronary arteries are involved? Right Left I am not sure
13. In the absence of any contra-indications, do you think this patient is a candidate for thrombolytic therapy? Yes No I am not sure

APPENDIX Four: MEMORANDUM OF THE TEN 12 LEAD ECGs

No	Question	ECG 1	ECG 2	ECG 3	ECG 4	ECG 5	ECG 6	ECG 7	ECG 8	ECG 9	ECG 10
1	Rate	60-70	70-90	60-80	90-110	60-80	60-80	70-90	110-130	50-60	100-110
2	Rhythm	Regular	Regular	Regular	Regular	Regular	Regular	Regular	Regular	Irregular	Irregular
3	P Wave	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
4	PR Interval	Normal	Normal	Normal	Normal	Abnormal	Normal	Normal	Normal	Abnormal	Normal
5	QRS Complex	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow
6	ST Segment	Some abnormal	Some abnormal	All normal	Some abnormal	All normal	Some abnormal	Some abnormal	Some abnormal	Some abnormal	All normal
7	T Wave	Some abnormal	Some abnormal	Some abnormal	Some abnormal	Some abnormal	Some abnormal	Some abnormal	Some abnormal	Some abnormal	Some abnormal
8	Diagnosis	Acute anterior STEMI	Acute inferior / posterior STEMI	Sinus rhythm with T-wave abnormalities	Acute antero-lateral and old STEMI	1st Degree AV Block	Acute inferior STEMI	Acute antero-lateral NSTEMI	Acute antero-lateral STEMI	Acute inferior / posterior STEMI and 1st Degree AV Block	Incomplete LBBB with PVCs
9	Leads suggestive ischaemia	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No
10	Which leads	V2 – V4	II, III, aVF, V1-V3	None	V1-V6, III aVF	None	II, III, aVF	V1-V6, I, aVL	V2-V6, I, aVL	V1-V6, II, III, aVF	None
11	Which part of the heart	Anterior	Inferior	N/A	Antero-lateral	N/A	Inferior	Antero-lateral	Antero-lateral	Inferior	Septum
12	Which coronary artery involved	Left	Right	N/A	Left	N/A	Right	Left	Left	Right	Left
13	Candidate for TT	No	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes

APPENDIX Five: ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Mr Nico Louw

CLEARANCE CERTIFICATE	M110121
PROJECT	Interpretation and Knowledge of 12 Lead ECGs Thrombolytic Therapy of Paramedics in Provinces in South Gauteng and North West Africa (revised title)
INVESTIGATORS	Mr Nico Louw
DEPARTMENT	Department of Family Medicine
DATE CONSIDERED	28/01/2011
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 14/11/2012 **CHAIRPERSON** .....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Professor Efrain Kramer

DECLARATION OF INVESTIGATOR(S)

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

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

REFERENCE

1. Van der Bilt IAC. Myocardial Infarction: Cardio Networks.Org; [12 August 2012]. Available from: http://en.ecgpedia.org/wiki/Myocardial_Infarction.

2. South African Qualifications Authority: Registered Qualification: National Certificate: Emergency Care, SAQA identifier 86006; [cited 30 September 2012]. Available from: http://regqs.saqa.org.za/viewQualification.php?id=86006.

3. South African Qualifications Authority Registered qualification: National diploma: Emergency medical care, SAQA identifier 74077; [cited 30 September 2012]. Available from: http://regqs.saqa.org.za/viewQualification.php?id=74077

4. South African Qualifications Authority.: Registered qualification: Bachelor degree: Emergency medical care, SAQA identifier 71789; [cited 30 September 2012]. Available from: http://allqs.saqa.org.za/showQualification.php?id=71789.

5. Government Gazette. Republic of South Africa. Cape Town: Act No. 67 of 2008. National Qualifications Framework Act, 2008; 17 February 2009. p. 3.

6. Mayo Clinic. Definition of Coronoray Angioplasty [cited 10 December 2013]. Available from: http://www.mayoclinic.org/tests-procedures/angioplasty/basics/definition/prc-20014401.

7. Bassand JP, Hamm CW, Ardissino D, Boersma E, Budaj A, Fernández-Avilés F, et al. Guidelines for the diagnosis and treatment of non-ST-segment elevation acute coronary syndromes. Eur Heart J 2007;28(13):1598-660.

8. Fuster V, Moreno PR, Fayad ZA, Corti R, Badimon JJ. Atherothrombosis and high-risk plaque, Part I: Evolving concepts. J Am Coll Cardiol 2005;46(6):937-54.

9. The top ten causes of death. Fact Sheet No 310. November 2008: World Health Organisation; [12 August 2012]. Available from: http://www.who.int/mediacentre/factsheets/fs310/en/.

10. Bradshaw D, Groenewald P, Laubscher R, Nannan N, Nojilana B, Norman R, et al. Initial burden of disease estimates for South Africa, 2000. SAMJ. 2003;93(9):682-8.

11. Okrainec K, Banerjee DK, Eisenberg MJ. Coronary artery disease in the developing world. American heart journal. 2004;148(1):7-15.

12. Tibazarwa K, Ntyintyane L, Sliwa K, Gerntholtz T, Carrington M, Wilkinson D, et al. A time bomb of cardiovascular risk factors in South Africa: results from the Heart of Soweto Study "Heart Awareness Days". Int J Cardiol. 2009 Feb 20;132(2):233-9.

13. Gersh BJ, Sliwa K, Mayosi BM, Yusuf S. The epidemic of cardiovascular disease in the developing world: global implications. European Heart Journal. February 22, 2010.

14. Norman R, Bradshaw D, Schneider M, Pieterse D, Groenewald P. Revised Burden of Disease Estimates for the Comparative Risk Factor Assessment, South Africa 2000. Methological Note. Cape Town: South African Medical Research Council, 2006.

15. Mortality and causes of death in South Africa, 2011: Findings from death notification. Pretoria: Statistics South Africa, 2014.

16. Steyn K. The heart and stroke foundation South Africa. Heart disease in South Africa. Media data document. . Department of Medicine, University of Cape

Town & Chronic Diseases of Lifestyle Unit, at the Medical Research Council [Internet]. July 2007 23 September 2012:[2 p.].

17. Persse DE, McCarthy JJ, Vooletich M, Richter BK, Anderson HV, Denktas AE, et al. Prehospital Fibrinolysis in concert with rapid PCI. JEMS 2008 (March):74-88.

18. American Heart Association. Guidelines 2000 for cardiopulmonary resuscitation and emergency cardiovascular care - An international consensus on science. Resuscitation. 2000;46(1-3):1-448.

19. Danchin N, Durand E, Blanchard D. Pre-hospital thrombolysis in perspective. Eur Heart J. 2008 December 29(23):2835-42.

20. Moon JCC, Kalra PR, Coats AJS. DANAMI-2: Is primary angioplasty superior to thrombolysis in acute MI when the patient has to be transferred to an invasive centre? - In the Danish multi-centre randomized trial on thrombolytic therapy versus acute coronary angioplasty in acute myocardial infarction (DANAMI-2). Int J Cardiol. 2002;85:199-201.

21. Morrison LJ, Verbeek PR, McDonald AC, Sawadsky BV, Cook DJ. Prehospital thrombolysis for acute myocardial infarction: A meta-analysis. JAMA May 2000;283(20):2686-92.

22. Pinto DS, Kirtane AJ, Nallamothu BK, Murphy SA, Cohen DJ, Laham RJ, et al. Hospital Delays in Reperfusion for ST-Elevation Myocardial Infarction. Circulation. 2006 November 7, 2006;114(19):2019-25.

23. Fibrinolytic Therapy Trialists' Collaborative G. Indications for fibrinolytic therapy in suspected acute myocardial infarction: collaborative overview of early

mortality and major morbidity results from all randomised trials of more than 1000 patients. The Lancet. 1994;343(8893):311-22.

24. Brophy JM, Bogaty P. Primary angioplasty and thrombolysis are both reasonable options in acute myocardial infarction. Ann Intern Med. 2004;141:292-7.

25. De Luca G, Suryapranata H, Ottervanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction: every minute of delay counts. Circulation. 2004;109:1223-5.

26. Silber S. Evidence-based management of ST-segment elevation myocardial infarction (STEMI). Latest guidelines of the European Society of Cardiology (ESC) 2010. Herz. 2010 Dec;35(8):558-64. PubMed PMID: 21107514. Evidenzbasiertes Vorgehen beim ST-Strecken-Hebungsinfarkt (STEMI). Neueste Leitlinien der Europaischen Gesellschaft fur Kardiologie (ESC) 2010. ger.

27. Rawles J. Quantification of the benefits of earlier thrombolytic therapy: 5 year results of the Grampian Early Anistreplase Trial (GREAT). J Am Coll Cardiol. 1997;30:1181-6.

28. Hazinski MF, Nolan JP, Billi JE, Böttiger B, Bossaert L, De Caen AR, et al. Part 1: Executive Summary : 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2010;122:S250-75.

29. Castle N, Naidoo R, Owen R. Initiation of prehospital thrombolysis in South Africa. S Afr Med J. 2006;96(1):28-30.

30. Bassand JP, Danchin N, Filippatos G, Gitt A, Hamm C, Silber S, et al. Implementation of reperfusion therapy in acute myocardial infarction. A policy

statement from the European Society of Cardiology. Eur Heart J. 2005;26(24):2733-41. Epub 005 Nov 25.

31. Alpert JS, Thygesen K, Antman E, Bassand JP. Myocardial infarction redefined--a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. J Am Coll Cardiol. 2000 Sep; 36(3):959-69.

32. Thygesen K, Alpert JS, White HD, Jaffe AS, Apple FS, Galvani M, et al. Universal definition of myocardial infarction: Kristian Thygesen, Joseph S. Alpert and Harvey D. White on behalf of the Joint ESC/ACCF/AHA/WHF Task Force for the Redefinition of Myocardial Infarction. European Heart Journal. 2007 October 1, 2007;28(20):2525-38.

33. Thygesen K, Alpert JS, White HD, on behalf of the Joint ESC/ACCF/AHA/WHF Task Force for the Redefinition of Myocardial Infarction, TASK FORCE MEMBERS: Chairpersons: Kristian Thygesen JSA, Harvey D. White ,, Biomarker Group: Allan S. Jaffe C, Fred S. Apple , Marcello Galvani , Hugo A. Katus , L. Kristin Newby , Jan Ravkilde ,, et al. Universal Definition of Myocardial Infarction. Circulation 2007 November 27, 2007;116(22):2634-53.

34. Bossaert L, O'Connor RE, Arntz HR, Brooks SC, Diercks D, Feitosa-Filho G, et al. Part 9: Acute coronary syndromes: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation.81(1, Supplement):e175-e212.

35. Weaver WD, Eisenberg MS, Martin JS, Litwin PE, Shaeffer SM, Ho MT, et al. Myocardial infarction triage and intervention project--Phase I: Patient characteristics

and feasibility of prehospital initiation of thrombolytic therapy. Journal of the American College of Cardiology. 1990;15(5):925-31.

36. United Kingdom Prehospital Thrombolysis Surveys. Prehospital Thrombolysis Checklist [cited 2011 18 April]. Joint Royal Colleges Ambulance Liaison Committee]. Available from: http://www.jrcalc.org.uk.

37. Castle N, Owen R, Vincent R, Ineson N. What percentages of patients are suitable for prehospital thrombolysis? Emerg Med J. 2006;23(6):444-5.

38. Castle N, Owen RC, Hann M. Is there still a place for emergency department thrombolysis following the introduction of the amended Joint Royal Colleges Ambulance Liaison Committee criteria for thrombolysis? . Emerg Med J. 2007;24:843-5.

39. Steigen TK, Wiseth R, Nordrehaug JE. Pre-hospital thrombolytic therapy. Tidsskrift for den Norske laegeforening : tidsskrift for praktisk medicin, ny raekke. 2004;124(5):640-3.

40. Benger JR, Karlsten R, Eriksson B. Prehospital Thrombolysis: lessons from Sweden and their application to the United Kingdom. Emerg Med J. 2002;19:578-83.

41. Zoghi M. Pre-hospital thrombolytic therapy. The Anatolian journal of cardiology. 2007;7(1):59-64.

42. Silber S. Evidence-based management of ST-segment elevation myocardial infarction (STEMI). Latest guidelines of the European Society of Cardiology (ESC) 2010. Herz. 2010;35(8):558-64.

43. Vaishnav A, Khandekar S, Vaishnav S. Pre-hospital thrombolysis. J Assoc Physicians India. 2011 Dec;59(Suppl):14-8.

44. Ranchord AM, Prasad S, Matsis P, Harding SA. Paramedic-administered prehospital thrombolysis is safe and reduces time to treatment. N Z Med J 11 Sept 2009;122(1302):47-53.

45. Welsh RC, Travers A, Senaratne M, Williams R, Armstrong PW. Feasibility and applicability of paramedic-based prehospital fibrinolysis in a large North American center. Am Heart J. Dec 2006;152(6):1007-14.

46. Stephenson DT, Wardrope JW, Goodacre SW. Is prehospital thrombolysis for acute myocardial infarction warranted in the urban setting? The case against. Emerg Med J 2002;19:444-8.

47. McLean S, Wild S, Connor P, Flapan AD. Treating ST elevation myocardial infarction by primary percutaneous coronary intervention, in-hospital thrombolysis and prehospital thrombolysis. An observational study of timelines and outcomes in 625 patients. Emergency Medicine Journal. 2011, March;28(3):230-6.

48. Whitbread M, Leah V, Bell T, Coats TJ. Recognition of ST elevation by paramedics. Emerg Med J. 2002 January 1, 2002;19(1):66-7.

49. Millar-Craig MW, Joy AV, Adamowicz M, Furber R, Thomas B. Reduction in treatment delay by paramedic ECG diagnosis of myocardial infarction with direct CCU admission. Heart. 1997;78(5):456-61.

50. Naidoo R, Castle N. Prehospital Thrombolysis: It's All About Time. Novel Strategies in Ischemic Heart Disease: InTech; 29 February 2012 [cited 8 December 2012. Available from: http://www.intechopen.com/books/novel-strategies-in-ischemic-heart-disease/prehospital-thrombolysis-it-s-all-about-time.

51. A (not so) brief history of electrocardiography: ECG Library; [1 September 2012]. Available from: http://www.ecglibrary.com/ecghist.html.

52. Aufderheide TP, Hendley GE, Thakur RK, Mateer JR, Stueven HA, Olson DW, et al. The diagnostic impact of prehospital 12-lead electrocardiography**.** Ann Emerg Med. 1990;19(11):1280-7.

53. Aufderheide TP, Hendley GE, Woo J, Lawrence S, Valley V, Teichman SL. A prospective evaluation of prehospital 12-lead ECG application in chest pain patients. J Electrocardiol. 1992;24(Suppl 8-13).

54. Foster DB, Dufendach JH, Barkdoll CM, Mitchell BK. Prehospital recognition of AMI using independent nurse/paramedic 12-lead ECG evaluation: Impact on in-hospital times to thrombolysis in a rural community hospital. Am J Emerg Med. 2004;12(1):25.

55. Brown JP, Mahmud E, Dunford JV, Ben-Yehuda O. Effect of Prehospital 12-Lead Electrocardiogram on activation of the cardiac catheterization laboratory and door-to-balloon time in ST-segment elevation acute myocardial Infarction. Am J Cardiol. 2008;101(2):158-61.

56. Weaver WD, Cerqueira M, Hallstrom AP, Litwin PE, Martin JS, Kudenchuk PJ. Prehospital-initiated vs hospital-initiated thrombolytic therapy - The myocardial infarction triage and intervention trial. *JAMA*. 1993;270:1211-6.

57. Ferguson JD, Brady WJ, Perron AD, Kielar ND, Benner JP, Currance SB, et al. The prehospital 12-lead electrocardiogram: Impact on management of the out-of-hospital acute coronary syndrome patient. Am J Emerg Med. 2003;21(2):136-42.

58. Clemmensen PM, Sejersten M, Sillensen M. Diversion of ST-elevation myocardial infarction patients for primary angioplasty based on wireless prehospital 12-lead electrocardiographic transmission directly to the cardiologist's handheld computer: a progress report. J Electrocardiol. 2005;Oct;38(4 suppl):194-8.

59. Ornato JP, Peberdy MA, Reid RD, Feeser VR, Dhindsa HS. Impact of resuscitation system errors on survival from in-hospital cardiac arrest. Resuscitation. 2012;83(1):63-9.

60. South African Qualification Authority: Registered Qualification: Bachelor Degree: Emergency Medical Care; [cited 20 October 2015]. Available from: http://allqs.saqa.org.za/showQualification.php?id=63129.

61. Feldman JA, Brinsfield K, Bernard S, White D, Maciejko T. Real-time paramedic compared with blinded physician identification of ST-segment elevation myocardial infarction: results of an observational study. Am J Emerg Med. 2005;23(4):443-8.

62. Sherrod M, Greenberg H, Marsella R. A pilot study of paramedic-administered,prehospital thrombolysis for acute myocardial infarction. Clin Cardiol. 1990;13:421-4.

63. Health Professions Council of South Africa. Professional Board of Emergency Care. Capabilities of Emergency Care Providers. September 2010.

64. MacFarlane C, Van Loggerenberg C, Kloeck W. International EMS systems in South Africa: past, present, and future. Resuscitation. 2005;64(2):145-8.

65. Vincent-Lambert C, Bezuidenhout J, van Vuuren MJ. Are further education opportunities for emergency care technicians needed and do they exist? African Journal of Health Professions Education. 2014;6(1):6-9.

66. Emergency Care News. Newsletter of the Emergency Board for Emergency Care. May 2011:10-1.

67. Health Professions Council of South Africa. Introduction of new scope of practice for registered emergency care practitioners. November 2009 [cited 15 July 2014]. Available from: http://www.hpcsa.co.za/Uploads/editor/UserFiles/downloads/emergency_care/important_notice_to_ecps_nov09_final.pdf.

68. iRegister: Health Professions Council of South Arica website; [9 April 2015]. Available from: http://iregister.hpcsa.co.za/RegisterSearch.aspx.

69. Hampton J R. The ECG Made Easy. 7 ed: Churchill-Livingston; 2008.

70. ACLS Training Centre: Frequently Asked Questions; [cited 28 September 2012]. Frequently Asked Questions. Available from: www.acls.net/help.htm.

71. American Heart Association: Advanced Cardiac Life Support - Classroom; [cited 28 December 2013]. Available from: http://www.heart.org/HEARTORG/CPRAndECC/HealthcareProviders/AdvancedCardiovascularLifeSupportACLS/Advanced-Cardiovascular-Life-Support---Classroom_UCM_306643_Article.jsp.

72. Wikipedia. North West (South African Province) [cited 27 September 2012]. Available from: en.wikipedia.org/wiki/North_West_(South_African_province).

73. Wikipedia. Gauteng [cited 27 September 2012]. Available from: en.wikipedia.org/wiki/Gauteng.

74. Franks PE, Kocher N, Chapman S. Emergency Medical Technicians and Paramedics in California: The Centre for Health Professions. University of California. San Francisco; 2004 January.

75. Wikipedia. The Free Encyclopedia. : Paramedic; [cited 4 March 2013]. Available from: http://en.wikipedia.org/wiki/Paramedic.

76. Hope LB. Addressing Burnout in Paramedics. National Fire Acadamy [Internet]. 2004. Available from: http://www.usfa.fema.gov/pdf/efop/efo37163.pdf.

77. Stassen W, Van Nugteren B, Stein C. Burnout among advanced life support paramedics in Johannesburg, South Africa. Emergency Medicine Journal. April 13, 2012.

78. Nirel N, Goldwag R, Feigenberg Z, Abadi D, Halpern P. Stress, Work Overload, Burnout, and Satisfaction among Paramedics in Israel. Prehospital and Disaster Medicine. 2008;23(06):537-46.