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A REVIEW OF IN-HOSPITAL CARDIOPULMONARY RESUSCITATION IN A PRIVATE HOSPITAL GROUP (PHG) IN SOUTH AFRICA

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, and Johannesburg in partial fulfilment of the requirements for the degree of:

Master of Science in Medicine in Emergency Medicine.

Johannesburg, 2020

DECLARATION

I, Mandy Jose Toubkin, declare that this research project is my own work. It is being submitted for the degree of Master of Science in Medicine in Emergency Medicine at the University of Witwatersrand, Johannesburg. It has not been submitted for any degree or examination at this, or any other university.

Signature on this the Day of 2020

I.

DEDICATION

When the little voice in your head tells you it just cannot be done and your child tells you:

“If you really want to achieve you will find a way to do it”

I would like to dedicate this work to my daughter Kelsey, who kept encouraging me and sat by me for many hours willing me on. I know that when I eventually succeed, she will be very proud of me.

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to Professor Efraim Kramer who started me on the MSc Med journey, who believed in me and recognised the potential, and who sat for hours encouraging me, week after week to complete this work. Efraim you have never given up and even when you just sat silently next to me to encourage me to focus it was essential and hugely appreciated.

Professor Mike Wells, thank you for starting me on this research journey and for encouraging me to try again, I will eventually achieve – you have taught me so much thank you for supporting me no matter what.

Professor Shelly Schmollgruber, this work would not have been possible without your mentorship, from the day I started nursing. You are the person who decided that not submitting my masters was just not good enough. Thank you for the motivation, the support and the never give up attitude; I trust this work will be good enough to make you proud.

Dr Caroline Maslow who literally tore my referencing apart and assisted me to get it to a presentable format, “merci”.

Sharlene Swart, who took an interest in everything I was doing and spent many hours proof reading for me, thank you Sharlene your assistance is invaluable and shows that a village is needed to hand in this paper.

There have been many others who have assisted, supported and encouraged, they say, “It takes a tribe to raise a child”; this is true for the support you have given me over the years. It has taken a tribe to assist me to achieve this THANK YOU ALL

Dr Richard Friedland, Yvonne Van Staden, Nicky Baltsoucos, Shannon Nell; David Stanton, Professor Roger Dickerson, Professor Walter Kloeck, Rene Grobler, Mariesa Human, Professor Feroza Motara, Dr Graham Hutton and Mr Peter Warrener .

ABSTRACT

Introduction:

The incidence of Sudden Cardiac Arrest (SCA) amongst in-hospital admitted patients, besides the very few that occur in visitors, hospital staff and on-site contractors, is unknown. Likewise, the relevant statistics regarding cardiopulmonary resuscitation (CPR) training, clinical resuscitative performance and clinical success is also unknown. This study reviewed in-hospital sudden cardiac arrest in a PHG in South Africa.

Methodology:

This is a quantitative, retrospective, descriptive and analytical, cross sectional study regarding in hospital cardiac arrest (IHCA) over a defined period occurring in a PHG in South Africa. The data collected for this research study was obtained from the PHG medical data bank that is housed in the head office in Johannesburg.

Results:

The number of IHCA events during the period of study, from 1st January 2007 until 31st March 2010 (First Period), indicates a very low volume of 825 IHCA events (Table 2) across the PHG. This volume is dramatically increased more than eight times to 6956 IHCA events (Table 3) during the study period from 1st January 2015 to 31st December 2018 (Second Period).

The majority of IHCA patients 57.7% were within the geriatric age group, of 60 years old and older. Those patients between 18 to 39 years old comprised a smaller 11, 27% of all IHCA events, leaving the remaining 24% patients in the 40 to 59-year-old group. Fifty-eight IHCA events did not have any age included to the data.

The sex classification of IHCA in the PHG for the First Period was obtained, from the Medical Data Bank, but no consistent entries were made for the Second Period. Although the updated post IHCA patient information data form in the Second Period.

The male IHCA appears consistently higher than the female rate of IHCA during the First Period.

The number of hospital beds influence the number of IHCA events that occur. A hospital bed capacity of less than 200 beds has a mean IHCA rate of 20,23 events per annum, hospitals with a bed capacity of between 200 to 400 beds have a mean IHCA rate of 41,08 events per annum, hospitals with a bed capacity exceeding 400 beds have a mean IHCA rate of 114,38 events per annum.

During the Second Period, the location of IHCA events listed only three locations, namely the Emergency Department (ED), ICU or General Wards. In the First Period, the majority of IHCA events occurred in the ICU (50.19%) and General Wards (33.94%), with no ED data being recorded at all. In the Second Period, the majority of IHCA events continue to be recorded in the ICU (51.12%) and in the General Wards (25.06%), with the ED, responsible for the remaining (23.82%) IHCA events.

In the First Period, 31.39% of IHCA events and in the Second Period 34, 93% IHCA events, resulted in ROSC. This presented an overall increase of 3.54% from the First Period to the Second Period.

In the First Period, 16.36% of patients and in the Second Period 16.86% patients were discharged home following IHCA and ROSC. This presented an overall increase of 0.5% from the First Period to the Second Period.

18.83% of IHCA events occurred between midnight and 06h00 within the hospital environments within the Second Period. There are no records of this data in the First Period.

Conclusion:

The standard of cardiopulmonary resuscitation practiced within the PHG in South Africa is well within international norms when the ROSC and STD rates of this company are compared to other hospitals internationally or to the GWTG registry in the USA.

IV.

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VII.

LIST OF ABBREVIATIONS

AHA	American Heart Association
CPR	Cardiopulmonary Resuscitation
EWS	Early Warning Score
GWTG®	GET With the Guidelines
IHCA	In Hospital Cardiac arrest
MET	Medical Emergency Team
OHCA	Out of Hospital Cardiac Arrest
PEA	Pulseless Electrical Activity
PHG	Private Hospital Group
ROSC	Return of Spontaneous Circulation
RSA	Republic of South Africa
SA	South Africa
SCD	Sudden Cardiac death
STD	Survival to Discharge
UK	United Kingdom
USA	United States of America
VA	Ventricular asystole
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia
WHO	World Health Organisation

CHAPTER ONE

OVERVIEW OF THE STUDY

1.0 INTRODUCTION

This chapter provides an overview of the study, which comprises of the problem statement, research questions, and the aim and objectives of the study.

This study sought to review an active in-hospital cardiopulmonary resuscitation (CPR) programme, from all hospitals in a PHG, in South Africa.

This study was in partial fulfilment for the requirements for the Master's in Science in Medicine (MScMed) in the specialty of Emergency Medicine.

1.1 THE PROBLEM

The student is fully employed by the PHG (PHG) involved in this research project. As a commercial entity, the hospital group provides emergency and hospital services across a national South African network comprising more than 50 hospitals and other health care facilities. Patients admitted to the hospital network succumb to the full range of acute and chronic medical illnesses and injuries.

The incidence of Sudden Cardiac Arrest (SCA) amongst in-hospital admitted patients, besides the very few that occur in visitors, hospital staff and on-site contractors, is unknown. Likewise, the relevant statistics regarding cardiopulmonary resuscitation (CPR) training, clinical resuscitative performance and clinical success is also unknown. It is therefore almost impossible for the Hospital Group, its national resuscitation committee and individual hospital nursing clinical facilitators to compare

the standard of practice and rate of successful CPR within the designated hospitals of the national Hospital Group, within individual hospital or to compare with other international hospital groups registries. Hence, there is an obvious, compelling need to undertake some form of research into the teaching, training, performance and success on CPR within this PHG and to incorporate the findings into national initiatives to improve outcomes from in-hospital cardiac arrest (IHCA) within this hospital group.

1.2 AIM AND OBJECTIVES

1.2.1 AIM

The study aimed to review the in-hospital cardiopulmonary resuscitation programme undertaken within the PHG in South Africa.

1.2.2 OBJECTIVE

The objectives of the study are to:

1. Describe the demographics of all adult in-hospital sudden cardiac arrest patients in a PHG in South Africa over two defined periods (First Period and Second Period).
2. Describe the incidence of in-hospital sudden cardiac arrest in a PHG in South Africa over two defined periods.
3. Describe the percentage of in-hospital sudden cardiac arrest patients who gain a Return of Spontaneous Circulation after attempted CPR in a large private hospital in South Africa.
4. Describe the number of in-hospital sudden cardiac arrest patients who survive to discharge after CPR in a large hospital group in South Africa.

1.3 DEFINITIONS

GWTG Resuscitation Get with the Guidelines®, a large national registry of in hospital cardiac arrests that characterises hospital level trends in in-hospital cardiac arrest survival over the past decade in the United States of America (USA).

ROSC Return of Spontaneous Circulation is defined as the presence of a central pulse with a blood pressure of at least 60 mmHg without any CPR.[··] ROSC is the resumption of sustained perfusing cardiac activity associated with significant respiratory effort after cardiac arrest. Signs of ROSC include breathing, coughing, or movement and a palpable pulse or a measurable blood pressure.

SCD Sudden cardiac death (SCD) is, defined as death from an unexpected circulatory arrest, usually due to a cardiac arrhythmia, occurring within an hour of symptom onset.

STD Survival to discharge following cardiac arrest and ROSC the patient, is discharged from hospital alive.

ILCOR International Liaison Committee on Resuscitation (ILCOR) formed in 1992 to provide a forum for liaison between principal resuscitation organisations worldwide.

AHA American Heart Association (AHA) is a non-profit organization in the USA that funds cardiovascular medical research, educates consumers on healthy living and fosters appropriate cardiac care in an effort to reduce disability and deaths caused by cardiovascular disease and stroke.

ERC	The European Resuscitation Council (ERC) is the European Interdisciplinary Council for Resuscitation Medicine and Emergency Medical Care. It was established in 1989. The ERC's objective is "To preserve human life by making high quality resuscitation available to all".
RCSA	Established in 1988 as an Association not for gain, the Resuscitation Council of Southern Africa (RCSA) is a Section 21 Company, a voluntary organisation that aims to foster & coordinate the practice & teaching of resuscitation, and to promote standardisation of resuscitation techniques in Southern Africa.

CHAPTER TWO

LITERATURE REVIEW

"On the morning of February 14, 2007, 3 minutes before my heart stopped, three people made choices that saved my life. A postman was selecting his route,, a nurse with an unexpected day off was heading to Starbucks, and my business partner called just before I ran out the door of my home… something compelled me to answer the call, so that 3 minutes later, instead of being on the highway going 60 miles per hour, I was driving up a side street near my home when I had my cardiac arrest. The postal worker and nurse appeared at just the right time to perform CPR for 8 minutes until the medics arrived. Which meant that it was not my day to die. Sue Nixon, 2014" (1) .

2.1 INTRODUCTION

This chapter presents an introduction and current English literature review for the purposes of the study. A literature review represents a critical review and summary of published research and material related to the topic of study, which assists in the understanding of the research topic. It also assists in formulating the researcher's knowledge with a clear understanding of what has been previously published.

While there is a myriad of literature related to IHCA within the global context, there appears to be a noticeable paucity of IHCA literature, both related to South Africa nationally and the South African private health care sector.

The literature search was undertaken using only the English versions of PubMed™, Scopus™, Google Scholar™ and Mendeley™, using the search terms cardiopulmonary resuscitation, CPR, cardiac arrest, in-hospital cardiac arrest, out-of-hospital cardiac arrest, cardiac arrest outcomes, resuscitation, return of spontaneous circulation, survival to discharge, cardiac arrest epidemiology, cardiac death, and defibrillation. The inclusion criteria for relevant literature were publication and peer

review journals, electronic media and books, websites, and any other media related to the subject matter.

2.2 PHG

For several years, there was no coordinated CPR training or dedicated resuscitation treatment programme in this PHG in South Africa.

As the national coordinator for the Emergency and Trauma Divisions in the PHG, the researcher was tasked with standardising emergency resuscitation of all critically ill and injured patients within the hospitals in the PHG.

As a result of a quality collaborative established within the PHG regarding patient safety, a quality improvement programme was instituted by the researcher to address an Early Warning System (EWS), for all patients who deteriorated clinically, to document resuscitation efforts by staff in the hospitals, and to institute a formal CPR training programme of all staff in the hospital group. This included the formation of Rapid Response and Medical Emergency Teams (MET) to respond to all in-hospital resuscitations. In 2010, a survey was carried out within the PHG to monitor the compliance of a quality improvement programme on in-hospital resuscitation.

The survey tried to assess the following:

- Adherence to the standard operating procedure, and protocols for in-hospital resuscitation;
- The implementation of the in-hospital early warning system;
- The implementation of mock CPR drills;
- The implementation of CPR training for all hospital staff;
- The required establishment of hospital resuscitation committees.

The results of this survey indicated the following:

- 32 hospitals participated in the survey;
- 68% of hospitals implemented the CPR policy;
- 53% of hospitals had a resuscitation committee;
- 79% of the hospitals were submitting post CPR resuscitation documentation and of those submitting, only 76.9% of the documents were correctly completed;
- 30% of the hospitals met the recommended criteria for undertaking two mock CPR resuscitation scenarios per ward per month;
- Hospital management (a member of the hospital executive management team) responded to 41% of all MET activations;
- Average compliance for implementation of the early warning score (EWS) was 50%;
- There was no standardisation of documentation for CPR responses;
- 43% of hospital CPR committees were less than a year old.



Figure 1 Survey Compliance Scores 2010

Coincidently, four weeks prior to the 2010 survey, the Institute for Healthcare Improvement (IHI) undertook a formal evaluation within the PHG and concluded that

the Early Warning Score (EWS) had to become an integral part of the CPR response programme (2). The IHI also reported that the reason for patient deaths in general wards within the hospitals was due to delayed or inadequate emergency care when the patients collapsed (3 to 5) prompting the researcher to implement the CPR programme in support of the "*Save 100 000 Lives"* campaign.

In 2010, the Chief Executive Officer (CEO) of the PHG visited the United Kingdom (UK) on various PHG related projects. During his stay, he was exposed to the UK National Health Service (NHS) CPR training and treatment programme. He realised how greatly this programme exceeded what was being undertaken, in South Africa and in the PHG.

On his return to South Africa, he set out to improve the PHG CPR programme and instructed the researcher to improve all CPR training in the PHG, to standardise a resuscitation programme within the PHG, all of which eventually resulted in the appointment of a PHG national resuscitation coordinator.

The PHG national resuscitation coordinator was responsible for the overall coordination and management of resuscitation activities with all hospitals with a mandate:

- to ensure that a PHG resuscitation policy incorporating international best practice guidelines for resuscitation of patients be fully implemented, in order to reduce morbidity and mortality;
- To ensure that all hospital staff receive up to date resuscitation training, are instructed how to timeously identify the collapsed patient or the patient in need of acute resuscitation and initiate immediate CPR;
- To implement a Medical Emergency Team (MET) system within the PHG;
- To implement the Early Warning System in the PHG to assist in recognising patients, within the hospital, who may be at high risk of deteriorating into sudden cardiac arrest.

Additionally, the national coordinator revised the PHG resuscitation policy, implemented resuscitation committees in all hospitals and established a CPR training programme for all hospital staff members.

The MET programme was updated in all hospitals, staffed primarily by staff from the hospital ED, with inclusion of nursing staff from the adult and paediatric intensive care units. In addition, all MET members were exposed to formal Advanced Cardiac Life Support (ACLS™) and Paediatric Advanced Life Support (PALS™) training.

However, despite implementation all the aforementioned initiatives in order to improve CPR and resuscitation training and treatment within the PHG, no formal evaluation or research of the programme has been instituted. Therefore, it cannot be stated that the initiatives mentioned have had any positive effect on CPR training, CPR clinical management and hence patient mortality or morbidity.

The time was therefore right to analyse the CPR programme in PHG and compare it with other international hospital programmes.

2.3 INCIDENCE

Global Incidence of Sudden Cardiac Arrest and Sudden Cardiac Death (SCD)

It has been estimated that the annual global incidence of SCD is approximately 4 to 5 million cases (6). However, determining the actual incidence of Sudden Cardiac Death (SCD), an unfortunate negative result of Sudden Cardiac Arrest (SCA), is challenging. In the first instance, SCD occurs in the overall population throughout a country in an arbitrary manner. Secondly, it is mandatory to exclude those deaths which were not preceded by a cardiac triggered sudden cardiac arrest. Thirdly, even though there is a practical international definition of SCD, the practical application of this definition has many difficulties. Even in the USA the true incidence of SCD is

unclear (6). The ORE-SUDS (Oregon Sudden Unexpected Death Study) using prospective surveillance involving multiple sources of information, reported a SCD incidence of 53 cases per 100 000 population (7). Studies in other High Income Countries (HIC), such as Ireland (51 cases per 100 000 population) have reported similar rates of SCD (8). The SCD incidence rates in Low and Middle Income Countries (LMIC) may not at all be equivalent to those in HIC, probably higher. A recent analysis from China found an overall SCD incidence of 41.8 cases per 100 000 population (9). A report from South Africa investigating out-of-hospital cardiac arrest yielded a SCD incidence of 6.4 cases per 100 000 population. This value is likely an underestimate, because a multiple-source methodology was not used (10). A recent study from southern India found that SCD contributed to 10.3% of recallable deaths (11).

Reports of SCD in other communities are highly variable: 37 cases per 100 000 population in Okinawa, Japan; 90 to 100 cases per 100 000 population in Maastricht, Netherlands; 53 cases per 100 000 population in Oregon, USA; 51.2 cases per 100 000 population in Western Ireland and 30 - 100 cases per 100 000 population in Brazil (12).

Below is a graph taken from the Epidemiology of Sudden Cardiac Death: Global and Regional Perspectives study (12) which shows the high rate of variability of SCD cases per 100 000 population.

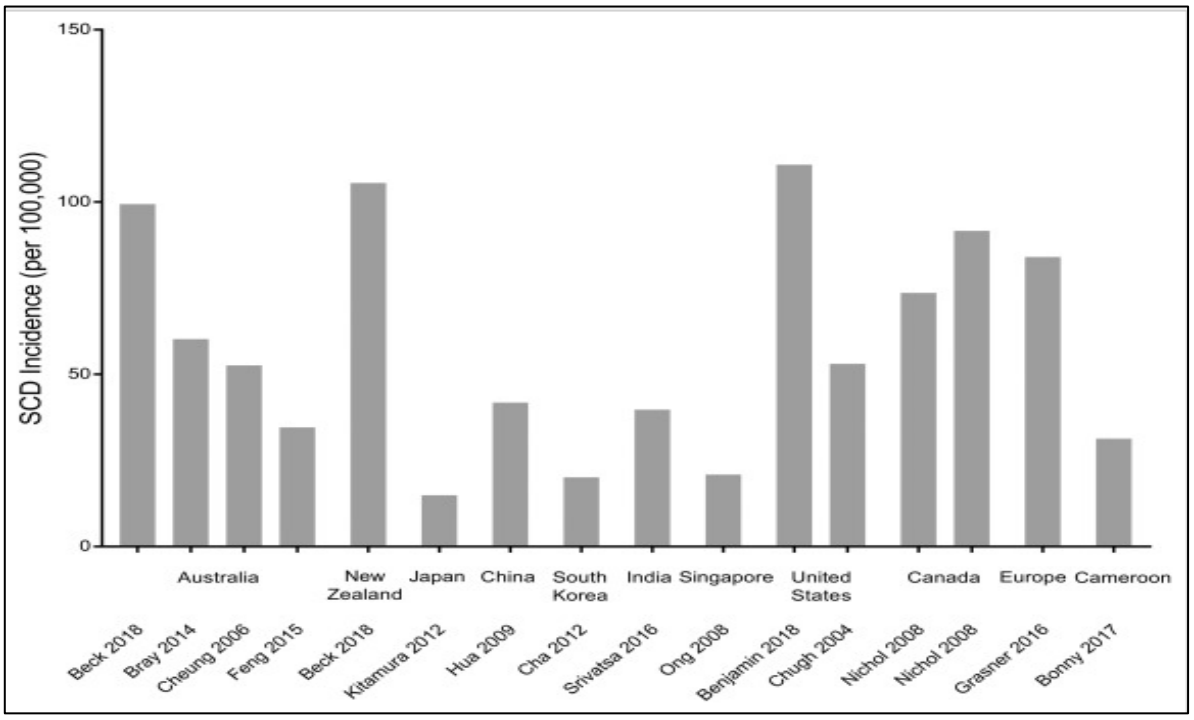


Figure 2 Epidemiology of Sudden Cardiac Death: Global and Regional Perspectives study (12)

Almost 17 million cardiac deaths occurred in 2007 and by 2030 the rate is expected to be 23.6 million annually which equates to 30% of all annual deaths in developed countries, 50% to 75% of deaths from cardiovascular-diseases occurs out-of-hospital, yet cardiovascular-related diseases is also a major contributor to IHCA (13).

2.4 IN – HOSPITAL INCIDENCE OF SUDDEN CARDIAC ARREST

The true incidence of IHCA internationally is not really known, because there appears to be no true standardised method internationally of reporting, making it difficult to establish adequate comparisons (14). Firstly, adult IHCA cases are classified as “pulseless cardiac arrest” whereas paediatric IHCA may include

“pulseless and non-pulseless” (cardiopulmonary resuscitation for poor perfusion) cases, with there being no established fixed age limit for classifying paediatric patients. Secondly, results may be confounded by including IHCA events that occur in or just prior to arrival in the ED’, which is not a true reflection of IHCA because these patients are not truly admitted in-hospital patients as such.

Thirdly, results are reported in varying formats, either as cardiac arrest events per 1 000 hospital admissions, as cardiac arrest events per hospital beds annually or as cardiac events per 1 000 patient days of hospital admission. Attempting to compare these varied formats is often difficult, if not impossible (15).

Sandroni et al in 2007 (16) reported an overall incidence of sudden cardiac arrest in the USA of between 1 to 5 events per 1 000 hospital admissions, or 0.175 events per bed annually, with the most common survival to hospital discharge being in the range of 15% to 20%. However, Ornato described actual numbers by reporting an incidence of 750 000 adult IHCA events annually in the USA (17).

Ehlenbach et al studied SCA events in the USA in the elderly (> 65years of age) , from 1992 to 2005, and reported 433 985 cases of in-hospital SCA, with an 18.3% survival to discharge. This equated to a incidence of 2.73 events per 1 000 admissions (18).

Peberdy et al reported on 14 720 cardiac arrests in 207 hospitals from the National Registry of Cardiopulmonary Resuscitation in the USA. The study found that the average number of IHCA events per year per hospital was 54.1 (±41.5), with the average number of initial IHCA events (no repeats) at 0.174 (+0.087) per bed per year. The study found that the incidence did not change whether it was a teaching hospital (0.17) or a non-teaching hospital (0.18) interestingly, hospitals with more than 500 beds had less IHCA per bed per year (0.17) than those with less than 500

beds (0.24). Similarly, those with less than 250 beds had a significantly higher IHCA rate than those hospitals with more than 250 beds (0.26 vs 0.19; P=0.01) (19).

Kazaure reported on an increased incidence of IHCA in the USA between 2000 to 2009, from 1 SCA per 453 in-hospital patients to 1 SCA per 339 in-hospital patients, an increase of 33.7%. This is yet another method of reporting the incidence of SCA (20).

Adamski et al investigated the incidence of IHCA in Polish hospitals during 2012 and reported that out of 7 775 553 patients hospitalized, IHCA was reported in a total of 22 602 patients, which included 22 317 adults (98.7% of all patients) and 285 children (1.3%). He states that these results are not substantially different from that observed in other countries (21).

Radeschi et al reporting on the incidence of IHCA events in the Piedmont Region, Italy, reported a total of 1 539 arrests, yielding an overall incidence of 1.51 arrests / 1 000 admissions (22).

Recently, Homberg et al, as part of the American Heart Association's (AHA) Get with the Guidelines–Resuscitation Investigators, recently developed a negative, binomial regression model in order to investigate the incidence of in-hospital cardiac arrest patients in all USA hospitals, using data from the American Hospital Association Annual Survey. They looked at all cases of IHCA from 2008 to 2017 and reported an incidence of 292 000 adult cases (95% prediction interval, 217 600 – 503 500) when considering only the first index IHCA, but when including both index and recurrent IHCA cases, the annual incidence increased to 357 900 (95% prediction interval, 247 100 – 598 400). Additionally, they stated that previous incidence estimates may no longer reflect the current public health burden of cardiac arrest in hospitalized adult and paediatric patients in the USA (23).

2.5 PATIENT CHARACTERISTICS: RACE

Socio-economic status, Sex, race and age has been shown to be a predictor of the incidence and also prognosis of IHCA and STD (7,18, 24 – 27). Studies indicated that male patients, those over the age of 60, black (African American) patients and lower socio-economic status had a higher incidence of IHCA and poorer outcomes amongst hospital patients (28).

Ehlenbach et al (18), in an epidemiological study of in-hospital cardiopulmonary resuscitation in the elderly, indicated that the average incidence of IHCA was 2.73 cases per 1 000 hospital admissions. However, there was a significant racial difference of 2.53 cases per 1 000 hospital admissions in white patients, and an almost double 4.35 cases per 1 000 hospital admissions in black patients, and 3.85 cases per 1 000 hospital admissions for other races. Of those that died, 4.21% were preceded by IHCA with attempted resuscitation, and this also varied by race (3.90% for white patients, 6.57% for black patients, and 5.83% for individuals of other races). Interestingly, the ratio of hospital deaths post IHCA with CPR increased more than 37% during the study period, from 3.78% in 1992 to 5.19% in 2005, and increased for each racial category accordingly ($p<0.001$). Non-white race was thus associated with significantly lower odds of survival compared to white patients. The study advocated that the difference in survival between white and black patients may be somewhat clarified by the fact that black patients were more likely to frequent hospitals where patients generally had lower survival rates following CPR, regardless of actual race or other personal factors. Other studies have likewise indicated lower survival rates in black patients after IHCA and OHCA, as well as reporting that black race is associated with delayed defibrillation in the hospital (29, 30). Additionally the initial cardiac arrest presenting rhythm may also differ by the patients race, suggesting possible genetic and environmental differences in the biological cause of the cardiac arrest (13). It is also possible, but not proven, that the general medical quality of patient care before, during, and after IHCA may be lower for black patients.

Ehlenbach et al also found that a higher proportion of black patients dying in the hospital received CPR prior to death, which seems to agree with proof that black patients are more likely to receive higher levels of care at the end of life (18) this was confirmed by Hernandez et al, in a 2015 study (31).

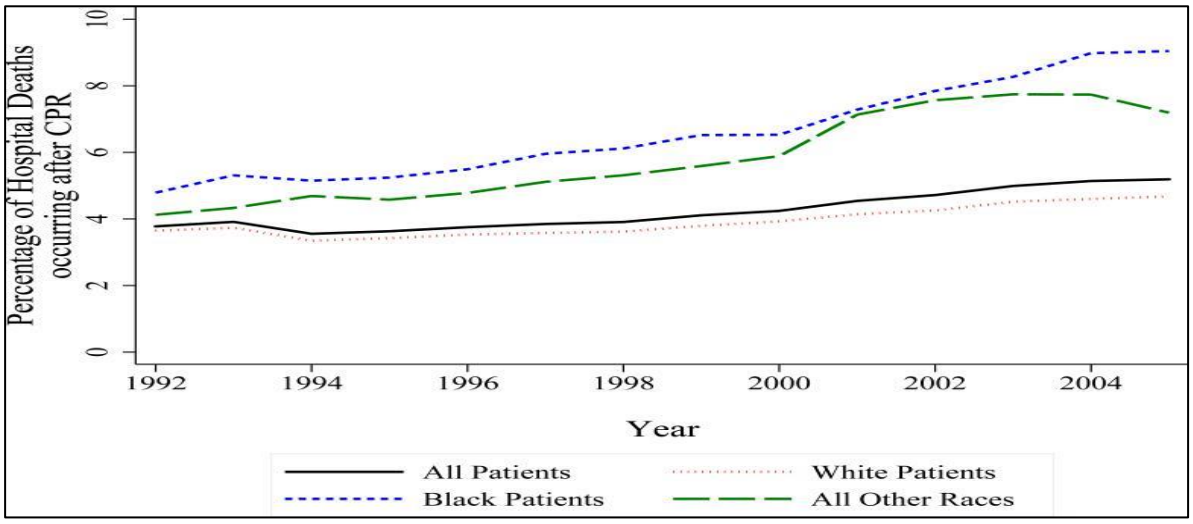


Figure 3 The incidence of in-hospital CPR (18).

The incidence is higher for black and other non-white patients (P<0.001). There is a clinically insignificant but statistically significant positive linear trend in incidence among all patients from 1992 to 2005 (P<0.001).

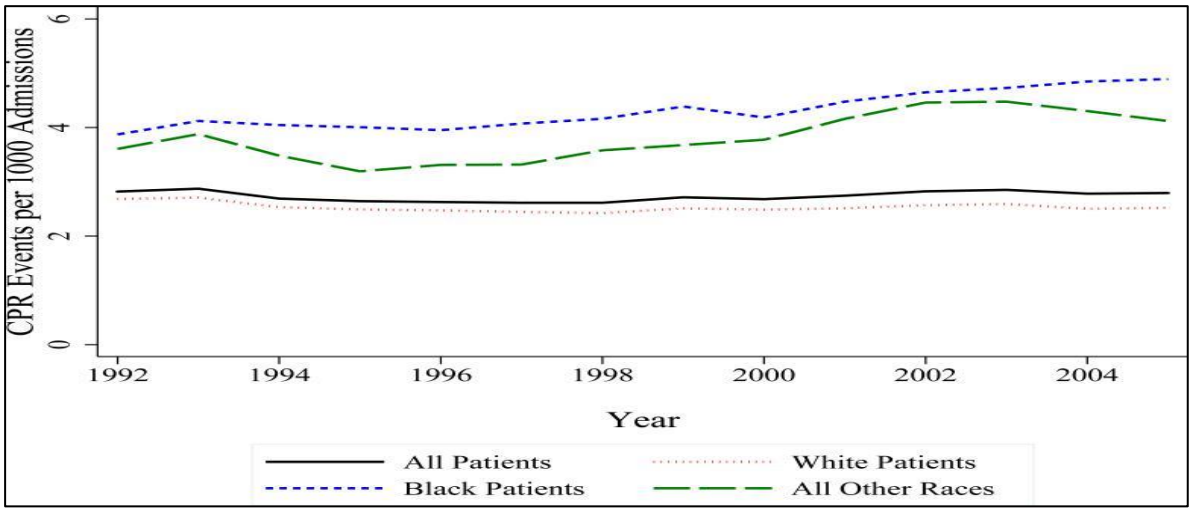


Figure 4 The percentage of all hospital deaths that occurred among patients who had undergone in-hospital CPR (18).

The percentage of all hospital deaths that occurred among patients who had undergone in-hospital CPR (18) increased in the period from 1992 to 2005 and was higher for black and other non-white patients ($P<0.001$). P for linear trend was less than 0.001 for all patients and for each racial group separately (18).

This anomaly may result from the fact that black patients less frequently select a (Do Not Resuscitate) DNR status, thus leading to more resuscitative efforts in the chronically ill, but with low prognoses, thus accounting for much of the racial difference in survival.

Larkin et al, who looked at risk factors that may have been present in patients before the onset of cardiac arrest, in 49 130 cases of IHCA, identified that black race was strongly associated with a poor prognosis. They suggested that this may have been due to various risk factors, singly or in combination, which included economic, medical or social factors, lower nitric oxide levels, lower use of DNAR orders, or higher rates of smoking (32).

Finally, Joseph et al, who forms part of the AHA Get with the Guidelines–Resuscitation Investigators, undertook a study to examine whether racial differences in survival after IHCA have narrowed at all over the years. (33) The study was performed from 1st January 2000 to 31st December 2014, reviewing a total of 112 139 patients with IHCA. Of the 30 241 black and 81 898 white patients with IHCA at 289 USA hospitals associated with the Get With The Guidelines–Resuscitation programme, it was found that risk-adjusted survival improved over time in both groups and differences in survival narrowed significantly. This means that racial differences in survival after IHCA have finally decreased substantially, although possibly only in those hospital that are part the Get With The Guidelines–Resuscitation quality national improvement programme.

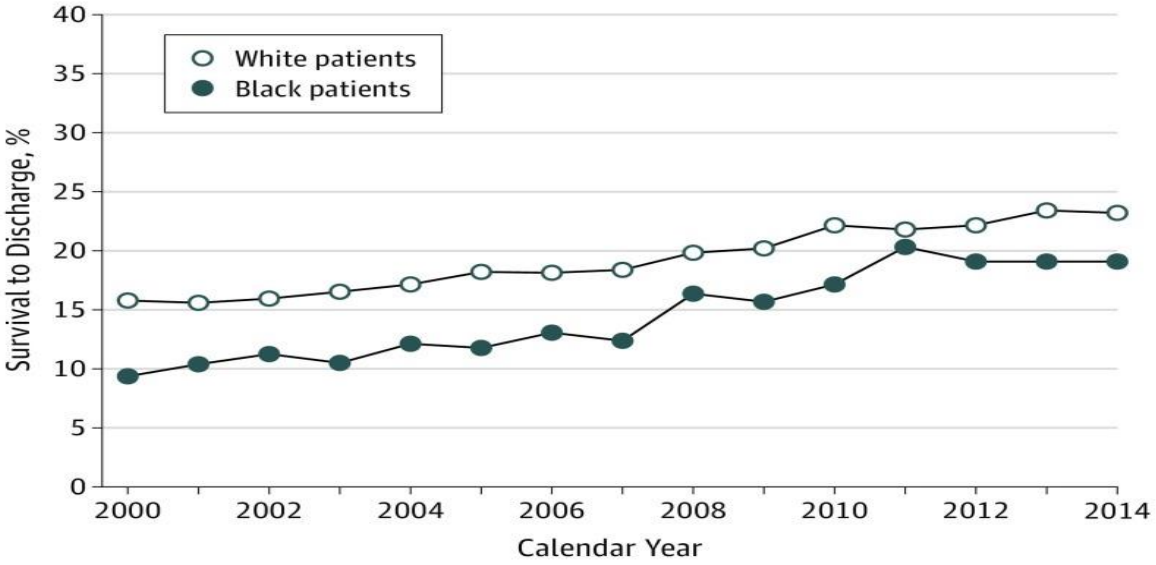


Figure 5 Unadjusted Rates of Survival to Discharge by Calendar Year amongst White and Black Patients.

Observed (crude) rates of survival to discharge by calendar year are shown for white and black patients. P for trend <.001 for both survival curves (33).

2.6 PATIENT CHARACTERISTICS: AGE

Bossaert et al., in the Ethics of resuscitation and end-of-life decisions section of the European Resuscitation Council Guidelines for Resuscitation 2015 guidelines, recommended that CPR decisions should not be made based on a single element, such as age (34). However, in daily clinical practice, age may indeed be an important factor affecting IHCA. Outcomes following IHCA in old adults, greater than 65 years of age, vary in survival rates from 0.3% to 10%. The decision to initiate CPR should depend on several factors, including; general health, functional status, DNR directives and resuscitation factors such as whether the IHCA is witnessed or not and the initial cardiac rhythm. Some studies have questioned whether CPR in older patients may in fact be futile (35, 36).

Ehlenbach et al, in an epidemiological study of in-hospital cardiopulmonary resuscitation in the elderly, indicated that the average incidence of IHCA in the elderly was 2.73 cases per 1 000 hospital admissions (18). Peberdy studied 14 720 IHCA cases from 207 hospitals that were part of the National Registry of Cardiopulmonary Resuscitation and concluded that patients who experienced an IHCA event were typically male in-patients in their mid to late 60s who have been hospitalized for management of a cardiovascular or a non-cardiovascular medical problem (37).

In a prospective, multicentre observational study of IHCA in 7 hospitals in Australia, by Jones et al from the Australia and New Zealand Cardiac Arrest Outcome and Determinants of ECMO (ANZ-CODE) Investigators Group, the study reviewed 159 IHCAs, in 152 patients, with the median age being 71.5 years. Therefore, although IHCAs were infrequent, mostly occurred in older medical patients early in the hospital admission. Most initial cardiac rhythms were non-shockable (38).

Sandroni et al, in a review of IHCA over the period January 1981 to January 2006, found that most patients resuscitated successfully from IHCA die before hospital discharge, and their prognosis has changed little over the past 30 years (39). One of the factors that may be associated with survival after IHCA appears to be patient age, (40 to 45) with some studies, not all indicating a significantly lower survival in older patients (40, 43 to 45). Unfortunately, the lack of consistency in results may be partly due to differences in methodology and study inclusion criteria: some studies include only adults (40, 45 to 47) but others also include children (48 to 50). Different cut-off age limits have been used to divide the younger adult from geriatric adults: 65 years and 70 years. Furthermore, the effect of age on survival may also be confused by the study selection bias: patients aged 70 years or over may be less likely to receive CPR in IHCA than younger persons (51, 52). Very old patients, older than 80 years, were shown to have a low survival rate to hospital discharge; no patient older than 90 years survived (40)(51).

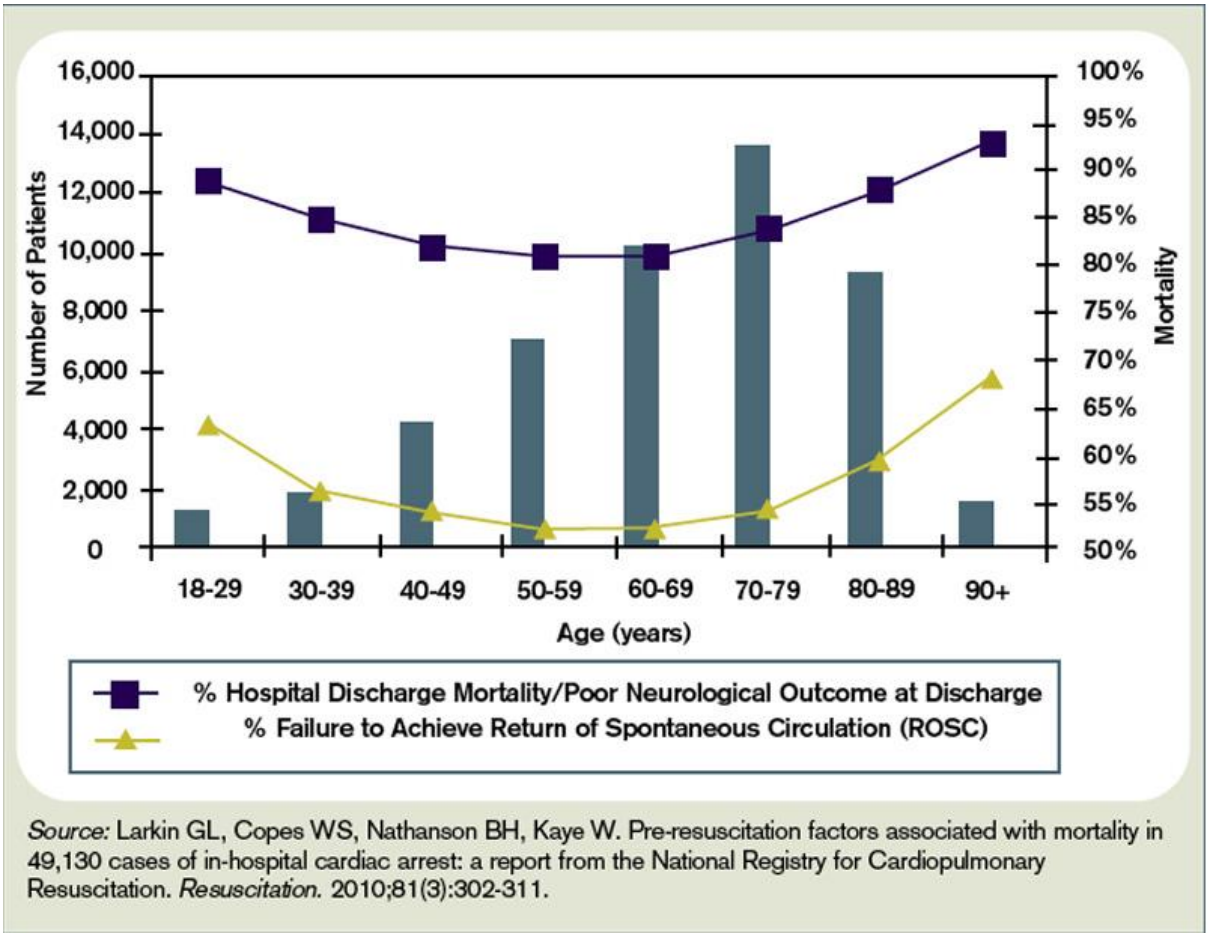


Figure 6 Age related survival rates in the Larkin study (32)

2.7 PATIENT CHARACTERISTICS: SEX

Ng et al., in a study of the association between Sex and cardiac arrest outcomes in Pan-Asian OHCA patients, reviewed a total of 37 311 OHCA cases. Of the total cases, 40% were women (35 099) with a mean age of 83 years (75 to 89 years; $\rho<0.001$). They found that women were more likely to have an initial non-shockable cardiac arrest rhythm, and therefore less likely to have return of spontaneous circulation (ROSC) at scene or in the ED, and thus lower rates of survival-to-admission and discharge. There was no significant Sex difference on outcomes after adjustment of other confounders. However, women in the reproductive age group (age 18 to 44 years) were more likely to have ROSC at scene or in the ED, and therefore higher rates of survival-to-admission and discharge. If this can be extrapolated to IHCA, then similar results can be expected (53).

Hasan et al, doing a systematic review of the literature on the influence of female Sex on cardiac arrest outcomes noted that women in cardiac arrest were generally older in age, more likely to have a non-shockable cardiac arrest rhythm as the initial rhythm and had a lower rate of in-hospital survival compared to men (54).

Jarman et al (55), in a systematic review entitled: "*When the Female Heart Stops: Sex and Sex Differences in Out-of-Hospital Cardiac Arrest Epidemiology and Resuscitation"*, indicates that although it is known that women who experience OHCA tend to be older, arrest from non-shockable initial rhythms, have more non-witnessed events, and have lower rates of bystander-administered CPR, studies have shown that women are more likely to survive to hospital admission at higher rates. However, several studies have found that women are less likely to survive to hospital discharge. In-hospital mortality after successful OHCA is higher in women than men (64% vs 61.4%; $P < 0.001$) even among those patients who have cardiac arrest due to a shockable ventricular rhythm (49.4% vs 45.6%; $P < 0.001$)(56).

In a recent study by Bosson et al, women had higher mortality, had worse neurologic outcomes, and received less post arrest intervention (56). However, after adjustment for these differences, sex was not associated with worse outcomes in comparison to men. Therefore, the sex-related differences in survival may be a result of inadequate use of standardised protocols, both in the out-of-hospital and in-hospital environments.

Jarman therefore concludes that: "*understanding sex-based differences in critical care treatments and interventions in patients with cardiac arrest may help us to understand sex-based differences in survival outcomes*" (55).

2.8 TIME OF IHCA EVENT: DAY AND NIGHT

Various studies (14, 16, 57, 58) have reported that the success rate of resuscitation from IHCA is related to the time of day of the event, with higher success rates during the day.

Ofoma et al. (59) reviewed 151 071 adults at 470 USA hospitals that contributed to the Get With The Guidelines–Resuscitation registry during 2000 to 2014. They examined whether survival trends in IHCA differed during on-hours (Monday to Friday 7:00 a.m. to 10:59 p.m.) vs. off-hours (Monday to Friday 11:00 p.m. to 6:59 a.m., and Saturday to Sunday, all day). They found that there was a significant difference between the IHCA success rates of on-hours versus off-hours (20.6% vs 16.8%, P <0.0001).

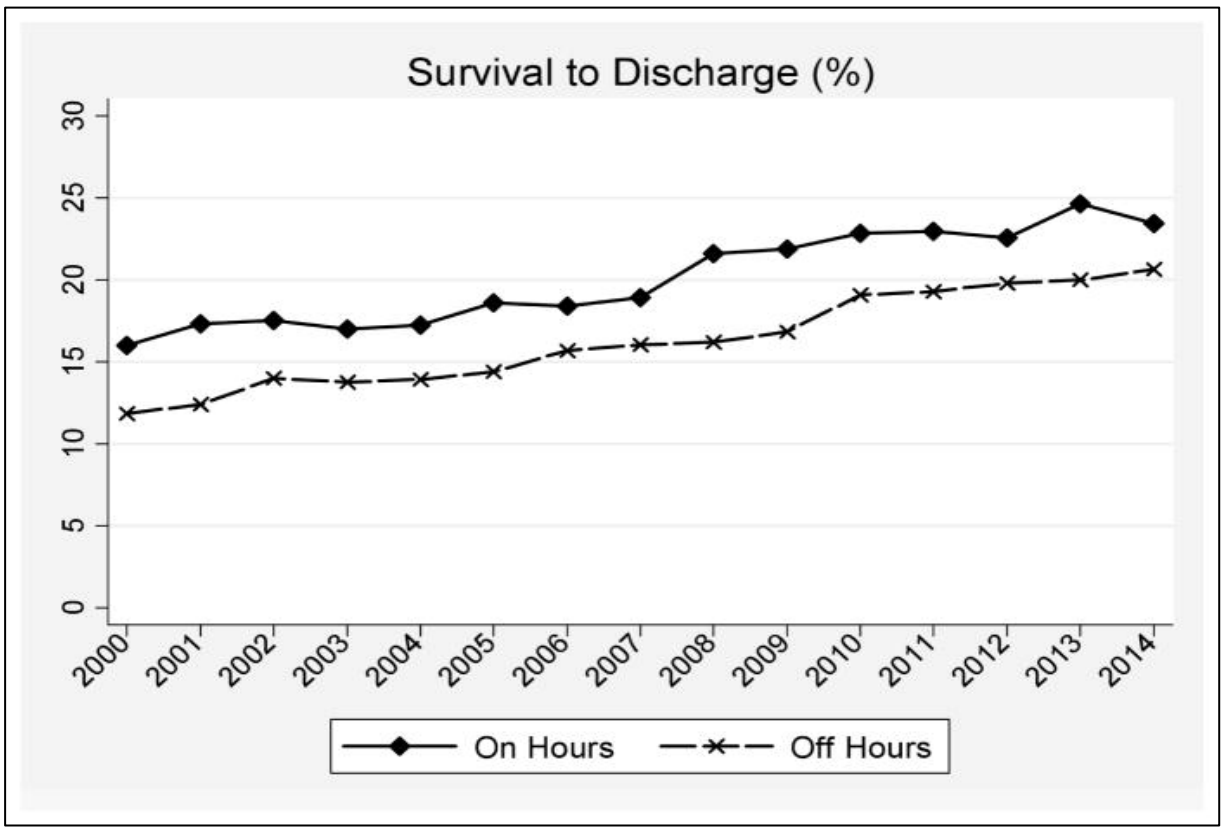


Figure 7 Trends in Survival to Discharge Stratified by Timing of IHCA (59)
The graph shows unadjusted survival to discharge by calendar year in patients who arrested during on-hours (solid line) and off-hours (dashed line).

Although this difference decreased during the study period, a significant gap remains throughout. In addition, although the post-IHCA resuscitation survival also improved over time in both groups (P for trend <.001 for both), the absolute and relative difference once again persisted. The study also demonstrated that 52.4% of IHCA occurs during off hours (79 091 of 151 071 participants) and that the improvement of care to these patients would significantly improve the rates of STD for all hospitalised patients (59).

Matot et al, reviewed the relationship between successful IHCA resuscitation, survival to hospital discharge and hospital shifts (morning, evening and night) in 174 in-hospital. The incidence of IHCA was 43%, 32% and 25% in morning, evening and night shifts respectively, with patient demographic and resuscitation factors being similar. Ventricular asystole ($p < 0.01$) and unwitnessed IHCA ($p = 0.05$) were more common during the night shift, with poorer survival to discharge rates ($p = 0.04$). The relative risk of eventual in-hospital death for patients with return of spontaneous circulation (ROSC) following night shift resuscitation was 1.9x that of those with ROSC following morning or evening resuscitation. Therefore, unwitnessed IHCA is more prevalent during the night shift and resuscitation during this shift is associated with poorer outcomes, independently of whether the IHCA was witnessed or not (60).

Christ M et al. reviewed (65) IHCA resuscitations and reported that there was a higher incidence of IHCA at night than during the day in the hospital under study. They found that with 24/7 in-hospital resuscitation teams, although survival rates following in-hospital resuscitation were poor at any time, successful resuscitation appears to depend less on time-dependent effects of the quality of resuscitation and more on time-dependent effects of recognition of cardiac arrests (61).

Robinson et al., in a study entitled "*Risk-adjusted survival for adults following in-hospital cardiac arrest by day of week and time of day: Observational cohort study",* found survival for adults, following IHCA to be lower for patients having the event at

weekends and at night, in comparison to similar events that occurred during the weekday and in regular working hours, Monday to Friday, 08:00 to 19:59.

They looked at data from 27 700 patients aged ≥16 years who had an IHCA event and found that the risk-adjusted outcomes (OR 95% CI)) were worse ($p<0.001$) for both weekend daytime (ROSC>20 min 0.88 (0.81 to 0.95); hospital survival 0.72 (0.64 to 0.80), and night-time (ROSC>20 min 0.72 (0.68 to 0.76); hospital survival 0.58 (0.54 to 0.63) compared with weekday daytime.

Therefore, IHCAs attended by the hospital-based resuscitation team during nights and weekends had significantly poorer outcomes than during the weekday daylight hours. It was noted that this difference could be staffing differences on the weekend and night shifts (57).

Of the number of studies looking at the specific time of IHCA events, none has been able to objectively identify the cause of this significant difference in ROSC or STD.

Some of the factors that may be involved in this reduction in rates of survival may include:

- Reduced numbers of staff on the wards at night;
- Lack of training of night staff in CPR skills;
- Less practice at night compared to day shift. Interestingly Cooper et al showed that even with increased training of night staff there was no difference in the immediate survival of patients (62);
- Delays in recognising the patient at night who may have suffered a cardiac arrest, unwitnessed cardiac arrest is more common at night;
- Delays in initiating CPR at night;
- Delays in calling the resuscitation teams at night;
- Organisational or care differences IHCA and Hospital Factors (62 to 66).

Choi et al., in a study of IHCA in Korea, included hospital characteristics in their review. The study found that the rate of IHCA varied according to the “Level of Care” classification of the hospital e.g. tertiary level hospitals and according to the size of the hospital as defined by the number of inpatient beds (67).

With regard to hospital size, Choi et al, found a higher IHCA incidence in hospitals with more than 600 beds, which may result from the fact that in Korea, there may be a personal patient preference for tertiary level hospitals, which have a larger number of inpatient beds, but correspondingly also have patients with illnesses of high severity.

This contrasts with the USA study by Peberdy MA et al, on 14750 IHCA cases from the National Registry of Cardiopulmonary Resuscitation, which found a lower incidence of IHCA in hospitals with more than 500 beds (37). The GWTG study by Girotra S et al (68), identified , 93 342 adults with IHCA from 231 hospitals and reported that 35.5% of IHCA occurred in hospitals with less than 250 beds, 44.2% in hospitals with 250 to 499 beds and a lower 20.3% in hospitals with more than 500 beds.

Perman SM et al, in reviewing the location of IHCA, whether in the ward or intensive care units, divided the size of hospitals into small (6 to 99 beds), medium (100 to 400 beds) and large (>400 beds) underscoring the fact that there is no international consensus regarding hospital sizing in resuscitation research (69).

Additionally, in the Choi et al study, regarding various “Levels of Care” hospitals, the incidence of IHCA in tertiary-care hospitals and secondary-care hospitals was 4 to 5 times the incidence in primary care hospitals and long-term-care hospitals. This may be due to the higher incidence of critical patients among the hospitalized patients in tertiary-care hospitals and secondary-care hospitals. The slightly higher incidence in long-term-care hospitals over primary care over hospitals may be due to patients being older and at the end stage of life (67).

Class of hospital	Male			Female			Total		
	Admission	IHCA	Incidence[a]	Admission	IHCA	Incidence[a]	Admission	IHCA	Incidence[a]
Tertiary hospital	104,070	669	6.43	103,052	402	3.90	207,122	1,071	5.17
Secondary hospital	142,159	820	5.77	143,086	538	3.76	285,245	1,358	4.76
Hospital	179,836	194	1.08	181,524	164	0.90	361,360	358	0.99
Geriatric hospital	54,601	82	1.50	101,747	103	1.01	156,348	185	1.18
Clinic	75,344	6	0.08	127,048	0	0.00	202,392	6	0.03
Total	556,010	1,771	3.19	656,457	1,207	1.84	1,212,467	2,978	2.46

Table 1 In-hospital cardiac arrest (IHCA) cases classified according to the class of hospital (67)

Carr BG et al., in a study reviewing the relationship between hospital factors and post-IHCA mortality, also confirmed that hospital factors, including teaching status, level of care classification and size are associated with mortality differences in patients resuscitated from IHCA. Resuscitation of IHCA in teaching hospitals, urban hospital location and large volume bed hospitals were found to be linked with lower in-hospital mortality. This survival benefit may be attributable to many factors relating to proactive staff training, acquisition of modern technology, application of current evidence based medical protocols, post resuscitation mortality reviews and so forth (66).

2.9 CARDIAC ARRESTS WITHIN AN EMERGENCY DEPARTMENT

The ED traditionally manages the largest number of patients with sudden cardiac arrest, either OHCA presented to the ED by the emergency medical services (EMS) or critically unwell patients brought to the ED, who deteriorate into sudden cardiac arrest while receiving initial care. Because of this trend to often mix the OHCA and ED IHCA patients, the incidence IHCA statistics may be miscalculated. The ED itself is influenced by the number of out-of-hospital cardiac arrests (OHCA) presenting to the ED undergoing CPR by the emergency medical services, as these cases may be classified as IHCA and entered into the hospital statistics as such, including and STD.

Sittichanbuncha Y et al, looked at the results of CPR outcomes in an ED in Thailand from January 2005 to December 2010. The study includes 181 of ED IHCA, with an overall ROSC rate of 34.8% and STD rate of 11.1%. However, of the 181 cases in ED caridac arrest, 145 patients sustained OHCA, in whom the ROSC rate was 52.4% and STD rate was 7.6%. For the trully IHCA cases, there were only 36 patients, with a ROSC of 86.1% and STD of 25.0%. Therefore IHCA rates can therefore be confusing and inaccurate if these rates include patients who sustain OHCA and because they are admitted to the hosital ED for continued treatment, they are included as IHCA statistics (70).

Similarly Moosajee US et al (71), undertook a retrospective review of 468 adult patients that sustained IHCA and OHCA and underwent CPR in the ED of a tertiary care hospital in Karachi, Pakistan, between 2008 to 2015. They report their overall results as a ROSC of 27.4% and STD as 7.5%, which would be inaccurate if it were to be classfied as IHCA results. The same can be stated for the study by Chew KS et al, on the outcomes of CPR in an Emergency Department, Hospital Universiti Sains Malaysia (72).

2.10 RETURN OF SPONTANEOUS CIRCULATION (ROSC) AND SURVIVAL TO DISCHARGE (STD)

The two main markers of CPR success used in the literature are traditionally the Return of Spontaneous Circulation (ROSC), which is defined as signs of life which include breathing (more than an occasional gasp), coughing or body movements. For healthcare personnel, signs of ROSC also may include evidence of a palpable pulse or a measurable blood pressure, all of which must be present for in excess of 30 seconds. The second marker of success is Survival to Discharge (STD).

Radeschi G et al, investigating the incidence and outcome of in-hospital cardiac arrest in the Piedmont region in Italy, yielded 1 539 IHCA events, with a ROSC rate of 35.7% (549 / 1 539) and a STD of 14.8% (228 / 1 539) (22). In a review of IHCA

by Sandroni C et al, STD was found to vary from 0% to 42%, with the most common range being between 15% and 20% (16). This rate has been slowly increasing with time, and in 2016, the GWTG Registry noted a STD rate in the USA of 25%, with regional variations in survival to hospital discharge ranging from 3.4% to 22.0% between 132 counties. Data obtained from the USA show a STD of 18% for the time period 2011 to 2013 (73). Peberdy MA et al, in a study reviewing CPR in adults for IHCA events, reported on 14 720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation (37). The results found that 44% of IHCA events had a ROSC and 17% STD.

Although a cardiac, arrhythmia was primarily the main cause of the IHCA events in nearly 50% of IHCA events, ventricular fibrillation (VF) was the initial pulseless rhythm in only 16% of IHCA events. In Ventricular Fibrillation, ROSC occurred in 58% cases, with a STD rate of 34%. Patients with Ventricular Asystole had a ROSC of 35% and STD of 0% whilst those presenting with a Pulseless Electrical Activity had a ROSC of 39% and STD of 10%. Interestingly, all adult (18 years of age and over) patients, visitors, employees, and staff within a hospital environment who experienced a resuscitation event were included in this study (73).

Similarly, Skogvol E et al, undertook a review of 4 927 patients and noted an overall ROSC of 34% and overall STD of 17%. However, the actual STD rate depended on the initial IHCA primary cardiac arrhythmia, namely ventricular fibrillation (VF) or tachycardia was 40%, ventricular asystole 11% and pulseless electrical activity 3% (74).

These studies emphasise that average or mean overall statistics for ROSC and STD may not be a true reflection of success, which seems to be dependent on the primary cardiac arrhythmia.

2.11 CARDIOPULMONARY RESUSCITATION TRAINING

The performance of CPR has an important impact on the chain of survival, both in the OHCA and the IHCA scenario. Girotra S et al, demonstrated this in their study on the variation in IHCA hospital survival results. The study reported that hospital processes of care, rather than structure, are more important in achieving IHCA survival over time (68). CPR simulation scenarios or mock CPR training sessions were also shown to improve the response to the collapsed patient and the quality and outcome of CPR (75, 76). Other studies have similarly indicated hospital quality improvements when the use of routine simulated cardiac arrests, post resuscitation briefing, automated defibrillation by non-medical personnel and participation in quality improvement registries were added to the overall in-hospital CPR training programme (76, 77)(

Unfortunately, even the progressive GWTG registry nor any other existing hospital data bases, failed to collect information on any of these innovative resuscitation processes of care and management approaches to try and better understand the organisational and systemic process variables that motivate hospital resuscitation performance (68).

In the study by Pareek M et al (78), on the effect of training of nurses in CPR in a tertiary care hospital on patient mortality, the rate of ROSC improved from 19.7% to 30.1% following committed basic life support (BLS) and advanced cardiac life support (ACLS™) training of the nurses.

Three strategies that have been found to have a significant effect on the success of cardiopulmonary resuscitations:

1. Frequent review of cardiac arrest resuscitation cases;
2. Monitoring for interruptions of chest compressions during acute cardiopulmonary resuscitation;

3. Staffs global assessment of the adequacy of resuscitation training at their site.

In a training study conducted in Jordan, Impact of simulation training on Jordanian nurses' performance of basic life support skills: A pilot study, nurses indicated that CPR training, increased their competency to respond to patients with IHCA that required CPR (4).

2.12 SUMMARY

The chapter discussed the literature review related to IHCA and some of the related factors that affect its incidence, management and survival to discharge. These factors included:

- discussion of the global incidence of sudden cardiac arrest and sudden cardiac death;
- the incidence of in-hospital sudden cardiac arrest as a specific group of cardiac arrests;
- IHCA patient related factors, namely race, age and Sex;
- the effects of time and day of the week on the incidence of IHCA;
- hospital related factors, namely size of hospital, level of care and the presence of an ED.

Finally, a discussion around training of hospital personnel in cardiopulmonary resuscitation to diagnose IHCA quicker and treat IHCA more efficiently and effectively in order to decease the mortality.

Chapter 3 discusses the research methodology used in this research study.

CHAPTER THREE

METHODS AND MATERIALS

3.1 INTRODUCTION

Polit and Beck refer to the research methods as "*the techniques researchers use to structure a study, gather and analyse information relevant to the research question in a systematic way*" (79).

This chapter will detail the research methodology, materials and design used in this research project study in order to achieve the planned aims and objectives. The research methods consist of the research design, research study setting, research target population and research sampling. Also included is the data collection process, method of data analysis and ethical considerations.

This study reviewed in-hospital sudden cardiac arrest in a PHG in South Africa.

3.2 STUDY DESIGN

This is a quantitative, retrospective, descriptive and analytical, cross sectional study regarding in hospital cardiac arrest (IHCA) over a defined period occurring in a PHG in South Africa.

3.3 STUDY LOCATION

This study did not have a defined location for the research, as the research data was downloaded from a medical databank located within the PHG Information System in the head office in Johannesburg.

3.4 STUDY POPULATION

The study population involved persons within the PHG individual hospital environments, amongst all the hospitals in South Africa that presented in clinical cardiac arrest and treated with full CPR attempts. This would usually involve patients who were admitted to the hospital as an in-patient, but would also involve any outpatient, patient visitor, hospital staff or commercial contractor and other on-site non-patient persons.

3.4.1 INCLUSION CRITERIA

- All adult patients 18 years and older that presented in sudden cardiac arrest and treated with full CPR attempts.
- Sudden cardiac arrest must have occurred within the PHG designated hospital environment.
- The sudden cardiac arrest must have been managed by the in-hospital "*cardiac arrest response team*" with completion of the event on the designated official hospital sudden cardiac arrest CPR form.

3.4.2 EXCLUSION CRITERIA

- Patients brought to the hospital, usually the ED who were clinically in a state of cardiac arrest, with or without ongoing active cardiopulmonary resuscitation attempts.
- Patients who underwent sudden cardiac arrest whilst under or having recovered from anaesthesia within the operation theatre complex.
- Patients undergoing cardiac electrophysiology or cardiac intervention procedures who developed sudden cardiac arrest during the procedure.
- All sudden cardiac arrests that occurred under an official Do Not Resuscitate (DNR) Order. This includes sudden cardiac arrests that were not resuscitated at all and those where CPR was begun but subsequently stopped when a DNR Order was found to be in existence.

3.5 DATA COLLECTION

The data collected for this research study was obtained from the PHG medical data bank, which is housed in the head office in Johannesburg.

All IHCAs that are managed by the individual hospital emergency medical response team, have a written resuscitation form completed after each event. The information from this paper form is then individually uploaded into the PHGs medical databank for later use, including analysis, research, training and so forth.

It was from this medical databank that all the information pertaining to this research study was downloaded.

The following information was collected for analysis in this research study:

1. Patient age, Sex;

2. Hospital geographical location;
3. Number of hospital beds;
4. Level of care classification of the hospital;
5. Number of events in the ED;
6. Location of IHCA events;
7. Number of events in each hospital by date and time;
8. Return of Spontaneous Circulation data;
9. Survival to Discharge data;
10. Hospital CPR staff training data per hospital.

As a result of the nature of the data collection, collection and analysis could only be undertaken from the information in the medical databank. The validity and accuracy of the data could not at all be verified and therefore remains as a possible source of error in this study. The researcher did not attempt to validate the data by comparing the medical databank with a sample of the original written CPR report, because of the logistical complications and complexities involved.

3.6 DATA ANALYSIS

Descriptive statistics, namely averages, means and medians were used to present the interpretation of the demographic data.

3.7 ETHICAL CONSIDERATIONS

Permission to conduct the research study was obtained from the Faculty of Health Sciences: Human Research Ethics Committee (Medical) – M10814. (Appendix A).

Approval was also obtained from the PHG research committee to undertake the research using data from its medical databank for the sole purposes of the research study (Appendix B).

The downloaded data printed out by the researcher from the PHG medical databank was always kept in a locked cupboard, inside the researcher's office, which is itself locked, and which is located at the head office of the PHG, thus ensuring its secure, private and confidential location. Only the researcher and supervisor had access to this data during the research study.

All clinical data downloaded remain totally anonymous with no patient identifying criteria available at all. Nor is there any mention of any individual sudden cardiac arrest incident in any hospital location, at any time or date that may possibly be identified by any reader in the future.

Costs for the study were not recorded but were made up of only basic materials such as printing. It is estimated they were less than R1 000.00.

3.8 SUMMARY

This chapter described the research methodology used for this research study. The specific type of study was designed to meet the study aims and objectives.

The following Chapter presents the results of the research study.

CHAPTER FOUR

RESEARCH STUDY RESULTS

4.1 INTRODUCTION

This chapter describes the results that were obtained from downloading the sought-after information from the PHG Medical Data Bank covering the designated time period.

4.2 STUDY PERIODS

The research study periods cover two distinct periods, one from the 1st January 2007 until the 31st March 2010, which is a 3-year 3 month period, whilst the latter study period extends from the 1st January 2015 until the 31st December 2018, which is a 3 year period. These two distinct periods reflect a change in the Medical Data Bank data forms, which were completed after each IHCA event by the nursing staff involved in the resuscitation. Each form, when updated, either adds or deletes information as is believed appropriate, which means that the researcher can only retrieve and analyse what data is available. Hence, two study periods have been analysed, with each period reflecting the data that was available from the Medical Data Bank during that specific period, but which may not have been available in the other period necessarily.

This limitation is beyond the scope of the researcher to change but does not detract from the overall analysis undertaken in the PHG and its attendant scientific value under analysis and discussion.

4.3 NUMBER OF IN-HOSPITAL CARDIAC ARREST (IHCA) EVENTS

The number of IHCA events during the period of study, from 1st January 2007 until 31st March 2010 (First Period), indicates a very low volume of 825 IHCA events (Table 2) across the PHG. This volume is dramatically increased more than eight times to 6956 IHCA events (Table 3) during the study period from 1st January 2015 to 31st December 2018 (Second Period).

It is very possible that the volume of IHCA events reflected in the First Period is not a true reflection of the actual numbers of IHCA events across the PHG, but due to possible failures of the responsible hospital staff in uploading the necessary data after each IHCA event into the Medical Data Bank, as is mandated by the hospital Standard Operating Procedures.

Total number of In-Hospital Cardiac Arrest cases during 1/1/2007 to 31/3/2010					
Number	2007	2008	2009	2010	Total
	16	371	247	191	825

Table 2 Number of In-Hospital Cardiac Arrest cases 1/2/2007 to 31/3/2010 First Period

Total number of In-Hospital Cardiac Arrest cases during 1/1/2015 to 31/12/2018					
Number	2015	2016	2017	2018	Total
	962	2 227	2 068	1 699	6 956

Table 3 Number of In-Hospital Cardiac Arrest cases 1/1/2015 to 31/12/2018 Second Period

4.4 IHCA PATIENT CHARACTERISTICS: AGE

The data regarding the age of the patient who went into IHCA was entered for each event that was uploaded to the Medical Data Bank during the First Period but was not done so during the Second Period for reasons that are not known. It is therefore only possible to analyse the age of IHCA patients during the First Period.

It was apparent that the majority of IHCA patients totalling 476 (57.7%) were within the geriatric age group, of 60 years old and older. Those patients between 18 to 39 years old comprised a smaller 93 (11.27%) of all IHCA events, leaving the remaining 198 (24%) patients in the 40 to 59-year-old group. Fifty-eight IHCA events did not have any age included to the data.

Age of patients who underwent CPR during 1/1/2007 to 31/3/2010					
	2007	2008	2009	2010	Total per Age Group
18-29	1	25	4	9	39
30-39	1	23	18	12	54
40-49	1	34	13	27	75
50-59	3	53	34	33	123
60-69	4	95	51	41	191
70-79	2	62	61	37	162
80-89	3	41	37	27	108
90-99	0	6	3	4	13
100+	0	0	2	0	2
unknown	1	32	24	1	58
Total Period One	16	371	247	191	825

Table 4 Age of Patients who underwent CPR 1/1/2007 - 31/3/2010

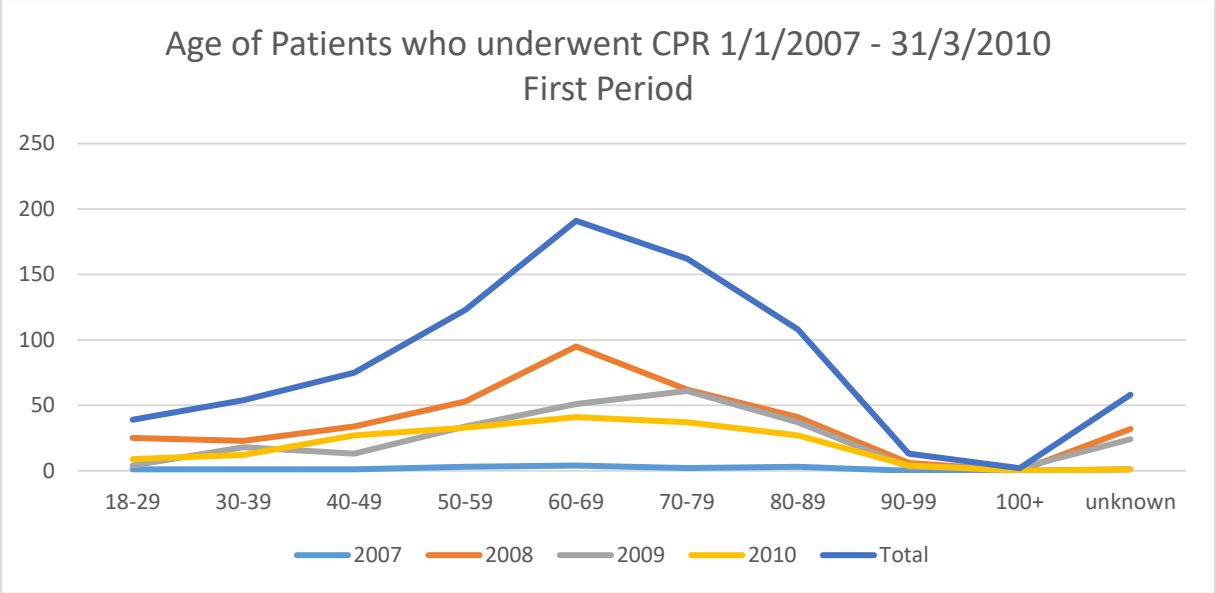


Figure 8 Graph Depicting Age of Patients who underwent CPR 1/1/2007 - 31/3/2010

4.5 IHCA PATIENT CHARACTERISTICS: SEX

The Sex classification of IHCA in the PHG for the First Period was obtained, from the Medical Data Bank, but no consistent entries were made for the Second Period. Although the updated post IHCA patient information data form in the Second Period contained the Sex of the patient, inconsistent and sporadic entry into the medical data bank precluded any statistical use. Hence only the First Period Sex data will be used for this study.

The male IHCA appears consistently higher than the female rate of IHCA during the First Period.

Sex	2007	2008	2009	2010	Total
Male	8 (50%)	227 (61.19%)	134 (54.25%)	108 (56.54%)	497 (60.24%)
Female	8 (50%)	130 (35.04%)	96 (38.87%)	83 (43.46%)	329 (39.87%)
Unknown	0	14 (3.7%)	17 (6.8%)	0	59 (7.15%0
Total	16	371	247	191	825

Table 5 Sex of patients who suffered IHCA in the first period

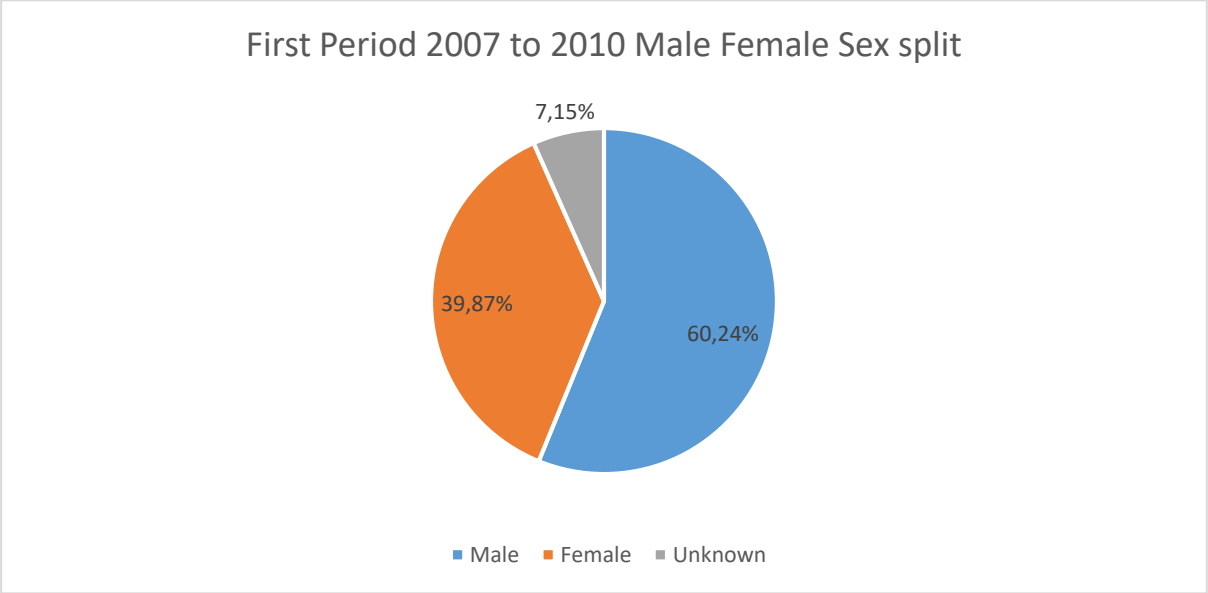


Figure 9 First Period 2007 to 2010 Male Female Sex split

4.6 IHCA RELATED TO HOSPITAL BED CAPACITY (SIZE)

The number of hospital beds, and hence the size of the hospital, influence the number of IHCA events that occur. A hospital bed capacity of less than 200 beds has a mean IHCA rate of 20,23 events per annum. Similarly, hospitals with a bed capacity between 200 to 400 beds, have a mean IHCA rate of 41,08 events per annum, whilst the two hospitals with a bed capacity exceeding 400 beds have a mean IHCA rate of 114,38 events per annum. All these IHCA rates relate to IHCA events during the Second Period.

PHG	**IHCA related to hospital bed capacity**		
Bed number	< 200 beds	200-400 beds	>400 beds
Number of hospitals	32	21	2
Total IHCA	2590	3451	915

Mean IHCA	80,9	164,3	457,5
Mean IHCA per annum	20,23	41,08	114,38

Table 6 IHCA Event rate per annum per size of hospital Second Period

Table 7 illustrates that the hospital bed capacity is not the only factor that may determine the IHCA rate. The hospital bed status of the hospitals included in **Table 7**, all of whom fall within the 200 to 400 bed group with an annual expected IHCA rate of 41,08 events, have higher than predicted rates of IHCA events.

Hospital	**Bed capacity**	**IHCA events**	**Mean per annum**
A	350	421	105,25
B	340	410	102,5
C	260	406	101,5
D	235	393	98,25
E	210	298	74,5
F	290	291	72,75

Table 7 Rates of IHCA in 6 hospitals in the PHG

Location of In-Hospital Cardiac Arrest Events					
Location	2007	2008	2009	2010	**Total**
Cardiac Cath Laboratory	0	12	3	5	**20**
Delivery Room	0	1	0	0	**1**
Dialysis	0	0	3	1	**4**
Doctor's Rooms	0	2	0	0	**2**
Pathology	0	1	0	0	**1**
High Care	0	23	23	11	**57**
Intensive Care Unit	9	186	115	104	**414**
Maternity Ward		1	1	1	**3**
Theatre Recovery Room	1	6	0	0	**7**
Radiology Dept	0	2	1	5	**8**
Operating Theatre	0	0	0	3	**3**
General Ward	5	121	93	61	**280**
Unknown	1	16	8	0	**25**
Total	16	371	247	191	**825**

Table 8 Location of IHCA 2007 – 2010 First Period

Location of In-Hospital Cardiac Arrest events 1/1/2015 to 31/12/2018		
Emergency Departments	1 657	23.82%
Intensive Care Unit	3 556	51.12%
General Wards	1 743	25.06%
Total	**6 956**	**100%**

Table 9 Location of IHCA 2015 - 2018 Second Period

Table 9 indicates the location of IHCA events within the PHG. The First Period has a comprehensive list of locations within the hospital environment where IHCA events occurred.

During the Second Period, the location of IHCA events listed only three locations, namely the ED, ICU or General Wards. In the First Period, the majority of IHCA events occurred in the ICU (414, 50.19%) and General Wards (280; 33.94%), with no ED data being recorded at all. In the Second Period, the majority of IHCA events continue to be recorded in the ICU (3 556; 51.12%) and in the General Wards (1 743; 25.06%), with the ED, responsible for the remaining 1 657 (23.82%) IHCA events.

4.7 RETURN OF SPONTANEOUS CIRCULATION

Return of Spontaneous Circulation after CPR during 1/1/2007 to 31/3/2010		
Number of ROSC	259	31.39%
Total IHCA events	825	100%

Table 10 Return of Spontaneous Circulation after CPR during 1/1/2007 to 31/3/2010 First Period

Return of Spontaneous Circulation after CPR during 1/1/2015 to 31/12/2018		
Number of ROSC	2 430	34.93%
Total INHA events	6 956	100%

Table 11 Return of Spontaneous Circulation after CPR during 1/1/2015 to 31/12/2018 Second Period

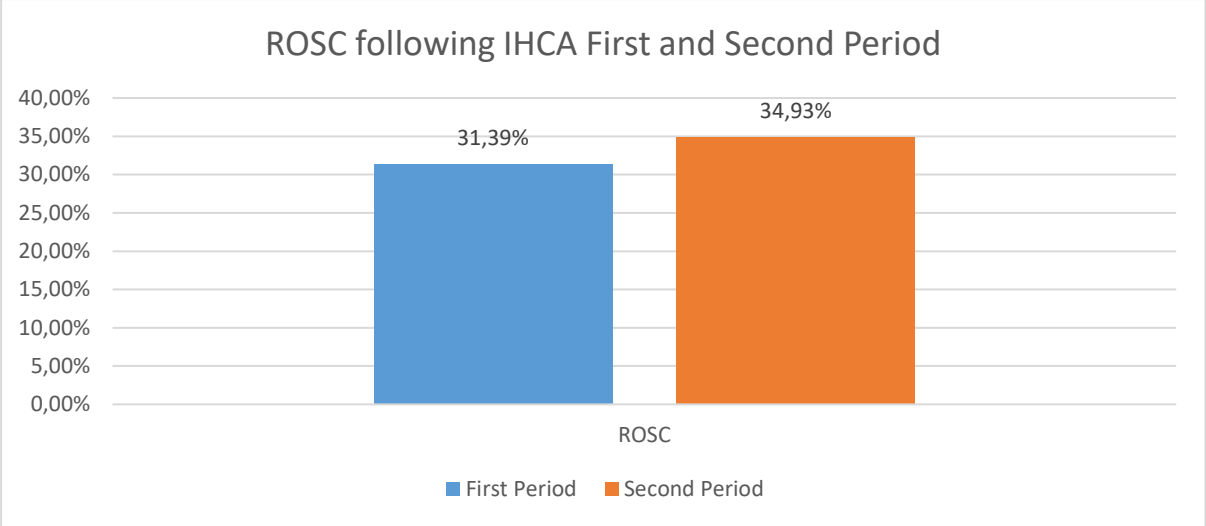


Figure 10 ROSC following IHCA First and Second Period

Table 10 and Table 11 and Figure 10 illustrate the number of IHCA events that resulted in a Return of Spontaneous Circulation (ROSC) during CPR resuscitation. In the First Period, 259 out of the 825 (31.39%) IHCA events and in the Second Period 2 430 out of 6 956 (34.93%) IHCA events resulted in ROSC. This presented an overall increase of 3.54% from the First Period to the Second Period.

4.8 SURVIVAL TO DISCHARGE

Survival to Discharge after CPR during 1/1/2007 to 31/3/2010		
Number of Hospital discharges	135	16.36%
Total IHCA events	825	100%

Table 12 Survival to Discharge after CPR during 1/1/2007 to 31/3/2010 First Period

Survival to Discharge after CPR during 1/1/2015 to 31/12/2018		
Number of Hospital discharges	1 173	16.86%
Total IHCA events	6 956	100%

Table 13 Survival to Discharge after CPR during 1/1/2015 to 31/12/2018 Second Period

Table 12 and **Table 13** illustrate the number of IHCA events that resulted in final hospital discharge of the patient after IHCA CPR resuscitation. In the First Period, 135 out of the 825 (16.36%) patients and in the Second Period 1 173 out of 6 956 (16.86%) patients were discharged after presenting with IHCA with subsequent CPR resuscitation. This presented an overall increase of 0.5% from the First Period to the Second Period.

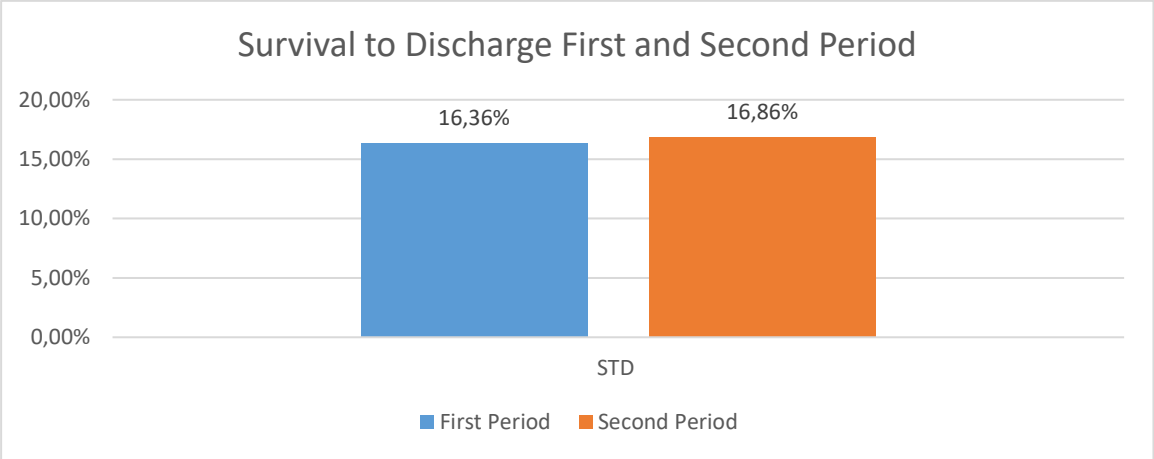


Figure 11 STD following IHCA First and Second Period

4.9 TIMING OF IHCA EVENTS

IHCA Events occurring between 24h00 to 06h00		
Number of Events	1310	18.83%
Total	6956	100%

Table 14 IHCA Events occurring between 24h00 to 06h00

Table 14 illustrates that 1 310 (18.83%) of IHCA events occurred between midnight and 06h00 within the hospital environments within the Second Period. There is no records of this data in the First Period.

4.10 IN-HOSPITAL CPR TRAINING

Basic Life Support training for Hospital Nursing Staff Second Period	
Number of Nurses trained	38 241
Total nursing staff	60 780
Ratio	62.92%

Table 15 Basic Life Support training for Hospital Nursing Staff

In the Second Period, of 60 780 nursing staff employed by the PHG, 38 241 were recorded as having been certified in Basic Life Support training 62.92%, which included CPR and AED practical training.

4.11 SUMMARY

This chapter described all the results obtained from the PHG Medical Data Bank that was downloaded for the purposes of this research study. The next chapter, Chapter 5 Discussion, will discuss the results in this chapter, the significance of these results within the PHG and its relation to the literature review in Chapter 2.

CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

This chapter will discuss the results found during this research study and attempt to compare and analyse them to other studies that were mentioned in the literature review.

The primary focus of the discussion is to analyse the results, which have been obtained from this South African PHG computer data bank over the selected time interval and attempt to compare it to either similar studies and results found in other South African or international PHGs and/or public / governmental hospital group studies, whichever is available and applicable.

From a detailed search using various English online search engines such as PubMed, Scopus, Google Scholar, Embase, Medline and Ovid, there was not a single scientific publication from any South African PHG regarding the topic of cardiac arrest, cardiopulmonary resuscitation, either in-hospital or out of hospital. Less than five publications concerning out of hospital cardiac arrest or cardiopulmonary resuscitation was found from the various South African departments of emergency care who offer various undergraduate and postgraduate degrees in out of hospital emergency medical care. As a result, discussion of the study results will overwhelmingly utilise international research, as there is very little South African data available for study comparison.

5.2 STUDY PERIODS

The research study periods cover two distinct periods, one from the 1st January 2007 until 31st March 2010, which is a 3 year 3 month period, whilst the latter study period extends from the 1st January 2015 until 31st December 2018. These two distinct periods reflect a change in the Medical Data Bank data forms, which were completed after each IHCA event by the nursing staff involved in the resuscitation. Each form, when updated, either adds or deletes information as is believed appropriate, which means that the researcher can only retrieve and analyse what data is available. Hence, two study periods have been analysed, with each period reflecting the data that was available from the Medical Data Bank during that specific period, but which may not have been available in the other period necessarily.

This limitation is beyond the scope of the researcher to change but does not detract from the overall analysis undertaken in the PHG and its attendant scientific value under analysis and discussion.

5.3 NUMBER OF IN-HOSPITAL CARDIAC ARREST (IHCA) EVENTS

The number of IHCA events during the period 1st January 2007 until 31st March 2010 (First Period), indicates a very low volume of 825 IHCA events across the PHG. This volume is dramatically increased more than eight times to 6 956 IHCA events during the study period from 1st January 2015 to 31st December 2018 (Second Period).

It is probable that the low volume of IHCA events reflected in the First Period is not a true reflection of the actual numbers of IHCA events across the PHG, but may reflect the low compliance of the responsible hospital staff in either completing and/or uploading the necessary data after each IHCA event into the Medical Data Bank, as was and still is mandated by the hospital group Standard Operating Procedures.

The dramatic increase in the number of IHCA events reflected in the Second Period is probably a combination of factors, which include an increased compliance in completion of the Resuscitation Form and its data uploading into the Medical Data Bank of the PHG by the attending nursing staff, aided by updated Resuscitation Form, which was made easier to complete. Additionally, acquisition of more hospitals, extensive renovations to existing hospitals, including increased intensive medical care unit bed capacity and the resultant increased bed numbers to the PHG's overall capacity would naturally increase the overall numbers of patients admitted and hence related increase in IHCA events.

Sandroni et al (39) in 2007 reported an overall incidence of sudden cardiac arrest in the USA of between 1 to 5 events per 1 000 hospital admissions, or 0.175 events per bed annually. Using this calculation and with the PHG having a capacity of 10 605 registered beds (10 180 registered beds in South African and 425 beds in Lesotho), the expected number of IHCA expected annually would be approximately 1 856. This calculation would indicate that the number of IHCA in the First Period is way below the expected number of IHCA, and therefore probably not a true reflection of the authentic number during the study period. However, in the Second Period, with a predicted volume 7 423 IHCA events, the actual number of 6 956 IHCA events is very likely to be closer to the authentic total number, if not the actual total number itself, as the discrepancy between predicted and actual is only 6.3%.

Similarly, Peberdy et al (38) reported on 14 720 cardiac arrests in 207 hospitals from the National Registry of Cardiopulmonary Resuscitation in the USA and noted similar predicted IHCA rates of 0,174 per bed per year, as did Sandroni et al. This incidence did not change significantly whether the hospital was classified as a teaching hospital (0.71) or not (0.18). Interestingly, hospitals with more than 500 beds had less IHCA per bed per year (0.17) than those with less than 500 beds (0.24).

5.4 PATIENT CHARACTERISTICS: RACE

As mentioned in the Literature Review, the racial classification of the patients, in USA studies, show a definite prediction for the incidence and prognosis of IHCA and STD. USA studies indicated that patients who are male, those older than 60 years of age, those classified as African American / Black patients and from lower socio-economic status had a higher incidence of IHCA and poorer outcomes amongst hospital patients.

Ehlenbach et al (18), in an epidemiological study of in-hospital cardiopulmonary resuscitation in the elderly, indicated that the average incidence of IHCA was 2.73 cases per 1 000 hospital admissions. However, there was a significant racial difference of 2.53 cases per 1 000 hospital admissions in white patients, and an almost double 4.35 cases per 1 000 hospital admissions in black patients. Non-white race was thus associated with significantly lower odds of survival compared to white patients.

South African demographics note a current population of 58 812 491, divided into four main racial groups, namely Black (79.4%), White (9. 2%), Coloured (8.8%), Indian / Asian (2.6%). According to the latest General Household Survey, only 17 in 100 South Africans have private healthcare. As many as 45 million, or 82 out of every 100 South Africans, fall outside the medical aid net, and as a result are largely dependent on public healthcare. (80, 81)

This would mean that public versus private healthcare in South Africa is more directly dependent on wealth and privilege, than it is on race per se. Employment offers the opportunity for persons to be able to afford a medical aid.

Therefore, although race is a factor regarding the incidence and prognosis of IHCA events in USA studies, and although race may indirectly also be related in South

Africa to disease prevalence and prognosis, due possibly to population demographics, wealth distribution and employment factors, all of which relate to health wellbeing and level of healthcare, it was not possible to obtain data for research from the Medical Data Bank of the PHG.

5.5 PATIENT CHARACTERISTICS: AGE

The data regarding the age of patients who experienced IHCA was uploaded to the Medical Data Bank during the First Period but was not done during the Second Period for reasons that are not known. It is therefore only possible to analyse the age of IHCA patients during the First Period.

The results indicate that the majority of IHCA patients in the First Period, totalling 476 (57.7%) were within the geriatric age group, of 60 years old and older. Those patients between 18 to 39 years old comprised a smaller number, namely 93 (11.27%) of all IHCA events, leaving the remaining 198 (24%) patients in the 40 to 59-year-old group.

Therefore, the elderly patient admitted to hospital appears to comprise the majority of IHCA events. This is confirmed in the study by Peberdy et al who studied 14 720 IHCA cases from 207 hospitals in the USA, as part of the National Registry of Cardiopulmonary Resuscitation, and found that IHCA events were characteristically male, in the mid to late 60s, and were admitted for generally either a cardiovascular or alternatively a non-cardiovascular medical problem (37).

Likewise, in the multicentre observational study of IHCA in 7 hospitals in Australia by Jones et al (38) (from the Australia and New Zealand Cardiac Arrest Outcome and Determinants of ECMO (ANZ-CODE) Investigators Group), of the 159 IHCAs analysed, the median age was 71.5 years. They concluded that, although IHCA events were infrequent, those that did occur presented in older medical patients.

Bossaert et al (34) recommends in the European Resuscitation Council Guidelines for Resuscitation 2015 guidelines that although outcomes following IHCA in geriatric adults are generally poor, ranging from 0.3% to 10%, the decision to initiate CPR should depend on several factors and not solely on age. Factors that should be considered holistically, when decisions to initiate CPR are required in geriatric IHCA patients, include patient general state of health, daily functional status and activities, any current DO Not Resuscitate (DNR) orders, besides the general resuscitation factors such as witnessed or non-witnessed IHCA and the initial cardiac dysrhythmia. However, Ehlenbach et al (18) , who studied IHCA events in the USA in the elderly (> 65years of age), from 1992 to 2005, reported on 433 985 cases of IHCA events with a 18.3% survival to discharge, far greater than the 0.3% to 10% success rate quoted by Bossaert.

However, other studies have questioned whether IHCA resuscitation in older geriatric patients may in fact be futile. Sandroni et al (16), in a review of IHCA over the period January 1981 to January 2006, found that one of the main factors associated with survival after IHCA was patient age, with significantly lower survival in older patients. Sandroni notes that the effect of age on survival may be confused by study selection bias: patients aged 70 years or over may be less likely to receive CPR in IHCA than younger persons. Very old patients, older than 80 years, were shown to have a low survival rate to hospital discharge and no patient older than 90 years survived.

Therefore the 57.7% majority of IHCA events presenting in geriatric patients in the PHG appears consistent with USA trends, as do the multifactor decision factors used to decide whether initiation of CPR should be attempted. This is supported by resuscitation of IHCA events undertaken in the 34.5% (285 / 825) of patients, all above 70 years of age, including 108 patients between 80 to 89 years of age, 13 patients between 90 to 99 years of age and 2 patients over 100 years of age. Clearly, age was not the only factor used to determine initiation of CPR in these IHCA patients.

5.6 PATIENT CHARACTERISTICS: SEX

The average Sex divide of IHCA events for the First Period in this PHG was 60, 24% male versus 39.88% female. This is in line with other international studies such as Ng et al (53), who looked at the association between Sex and cardiac arrest outcomes in an Asian OHCA study, reviewing a total of 37 311 OHCA cases. In this study 40% of OHCA events were in women (35 099), with a mean age of 83 years (75 to 89 years; $\rho<0.001$). Unfortunately, it was not possible to obtain Sex-based outcome results for either of the Study Periods, because ROSC and STD results were never divided into Sex categories.

However, Ng also found that women were more likely to have an initial non-shockable cardiac arrest rhythm, were therefore less likely to have a successful return of spontaneous circulation (ROSC) on scene or in the ED and finally lower rates of survival-to-admission and discharge. However, women in the age group 18 to 44 years, were more likely to have an initial shockable rhythm on scene, a successful ROSC on scene and in the ED, and hence higher rates of survival-to-admission and discharge. Whether this could be generalized to IHCA events is not known, but if so then similar results can be expected.

It is interesting to note that Hasan et al (54), who also looked at the association between female Sex, on cardiac arrest outcomes found that women in cardiac arrest were generally older in age, more likely to have a non-shockable cardiac arrest rhythm as the initial rhythm and had a lower rate of in-hospital survival compared to men. Their results are the same as Jarman et al (55), who also noted that woman in OHCA events tend to be older, have non-shockable initial rhythms, but also have more non- witnessed OHCA events, and have lower rates of bystander-administered CPR.

However, several studies have found that women are less likely to survive to hospital discharge. In-hospital mortality after successful OHCA is higher in women than men (64% vs 61.4%; P < 0.001) even among those patients who have cardiac arrest due to a shockable ventricular rhythm (49.4% vs 45.6%; P < 0.001). However, in a recent study by Bosson et al (56), women presenting with IHCA had a higher mortality, worse neurologic outcomes, and received less post arrest intervention.

Jarman (55) therefore concludes that: "*understanding sex-based differences in critical care treatments and interventions in patients with cardiac arrest may help us to understand sex-based differences in survival outcomes".*

5.7 IHCA RELATED TO HOSPITAL BED CAPACITY (SIZE)

When looking at hospital size, Choi et al (67), found a higher rate of IHCA events in hospitals with more than 600 beds. The study notes that this may result from the fact that Korean patients seem to prefer academic tertiary level hospitals, which have a greater number of beds, and as a result have patients with illnesses of high severity.

In the USA, Peberdy MA et al. (38), reviewing 14 750 IHCA cases from the National Registry of Cardiopulmonary Resuscitation, found a lower incidence of IHCA in hospitals with more than 500 beds.

In the GWTG study, Girotra S et al (68), reviewed 93 342 adults with IHCA events from 231 hospitals and noted a IHCA incidence of 35.5% in hospitals with less than 250 beds, a rate of 44.2% in hospitals with 250 to 499 beds and a lower rate of 20.3% in hospitals with more than 500 beds.

Perman SM et al (69), in reviewing the location of IHCA events in the hospitals, divided the size of hospitals into small (6 to 99 beds), medium (100 to 400 beds) and

large (>400 beds) highlighting that there is no international consensus regarding hospital sizing in resuscitation research.

In this study, the researcher divided the hospital of the PHG into less than 200 beds, between 200 to 400 beds and greater than 400 beds. This was based on logistical and geographical factors, relating to where the private hospitals were in South Africa. The results indicate that hospital bed capacity of less than 200 beds have a mean IHCA rate of 20,23 events per annum, those with 200 to 400 beds a mean IHCA rate of 41,08 events per annum, whilst the two hospitals with a bed capacity exceeding 400 beds have a mean IHCA rate of 114,38 events per annum. All these IHCA rates relate to IHCA events during the Second Period. These results clearly indicate that in this PHG, as the size of the hospital capacity increases, the number of patients admitted increases, as do the number of IHCA events per annum. The reason for this proportional rate of increase in hospital size to IHCA event rate has never been studied in this PHG. However it is possible to speculate that it may be due to the fact that as the private hospitals increase in size, so do the number of specialists and medical procedures, that larger hospitals are located in the greater metropolitan rather than the rural or semi urban locations and hence also located near academic medical institutions, all of which may result in patients with increased illness and injury severity, similar to Choi et al in Korea.

Additionally, it was noted in the Choi et al (67) study, regarding the different “levels of care” in different size hospitals, that the incidence of IHCA in tertiary-care hospitals and secondary-care hospitals was four to five times the incidence in primary care hospitals. Choi postulated that this was due to the higher incidence of severely ill patients presenting to tertiary-care and secondary-care hospitals.

Similarly, Carr BG et al (66), in a study reviewing the association between hospital factors and post-IHCA mortality, also confirmed that teaching status, level of medical care and hospital size seems to determine post-IHCA prognosis. This review therefore indicated that CPR in IHCA events undertaken in teaching hospitals, urban hospital location and large volume bed hospitals is linked with lower in-hospital mortality. Carr notes, “*this survival benefit may be attributable to many factors*

relating to proactive staff training, acquisition of modern technology, application of current evidence based medical protocols, post resuscitation mortality reviews and so forth".

However, this relationship between hospital size and post-IHCA mortality is not true for the PHG because they have hospitals with less than 400 beds that have levels of medical care that could be classified as equivalent to teaching / academic hospitals. As the results of Table 16 below indicates, six hospitals with 200 to 400 beds, located in metropolitan locations and with levels of medical care equivalent to teaching hospitals, have IHCA rates that are greater than the predicted rate of 41,08.

Hospital	Bed capacity	IHCA events	Mean per annum
A	350	421	105,25
B	340	410	102,5
C	260	406	101,5
D	235	393	98,25
E	210	298	74,5
F	290	291	72,75

Table 16 hospitals with 200 to 400 beds PHG Stats

5.8 LOCATION OF IHCA EVENTS PARTICULARLY THE EMERGENCY DEPARTMENT

Table 8 and Table 9 indicate the location inside the hospital and its environments of IHCA events within the PHG. It is important to note that not all hospitals have a single building that houses all departments. Many hospitals in South Africa, from various building extensions over time, may be composed of multiple buildings on a particular site, and any responding cardiac arrest resuscitation team may have traverse these different, and possibly, difficult routes, within the hospital environment, in order to reach the exact site of a IHCA event. It is not possible to investigate and analyse each of the hospitals in this PHG regarding the architectural layout of each

hospital to ascertain the effect on a responding cardiac arrest resuscitation team, usually form the hospital ED.

The First Period, (Table 8) has a comprehensive list of locations within the hospital environment where IHCA events occurred. During the Second Period (Table 9), the location of IHCA events listed only three locations, namely the ED, ICU or General Wards.

In the First Period, the majority of IHCA events occurred in the ICU (414; 50.19%) and General Wards (280; 33.94%), with surprisingly no ED data being recorded at all. In the Second Period, the majority of IHCA events continue to be recorded in the ICU (3 556; 51.12%) and in the General Wards (1 743; 25.06%), with the ED, responsible for the remaining 1 657 (23.82%) IHCA events.

The ICUs, which account for the most severe and critical patients within the hospital environment, would naturally be expected to have the highest rate of IHCA events, more than any other single department, and in both Periods account for 50.19% and 51.12% of IHCA events respectively. However, it must also be mentioned that many hospitals have more than a single ICU, and may in fact have a Trauma ICU, Coronary Care ICU, Neurological / Neurosurgical ICU, General Medical / Surgical ICU etc, all of which may have been put together in order to generate a single IHCA ICU event.

The ED has the second highest rate of IHCA for a single department and may in fact even be the highest if each specific ICU is analysed as a single unit. This would seem logical as the ED traditionally manages the largest number of patients with sudden cardiac arrest, originating either from OHCA presented to the ED by the emergency medical services or from critically unwell patients brought to the ED who develop IHCA while receiving initial care in the ED. If both of these sources of

cardiac arrest mixed, that is both OHCA and ED IHCA patients, the incidence the hospital's IHCA statistics may be miscalcualted.

5.9 TIME OF IHCA EVENT: DAY AND NIGHT

Table 14 illustrates that 1 310 (18.83%) of IHCA events occurred between midnight and 06h00 within the hospital environment within the Second Period. There is no records of this data in the First Period. It is therefore not possible to make definitive comparisons with the international studies published.

However, because studies (57 to 60) have reported that the success rate of resuscitation form IHCA is related to the time of day of the event, with higher success rates during the day than during the night, it is possible to look at the incidence rate of IHCA events after midnight in the Second Period in the PHG and compare these to other studies, to see if the incidence is similar or vastly different.

Ofoma et al (59) reviewed 151 071 adults at 470 USA hospitals that contributed to the Get With The Guidelines–Resuscitation registry during 2000 – 2014. They examined whether survival trends in IHCA differed during on-hours (Monday to Friday 7:00 a.m. to 10:59 p.m.) vs. off-hours (Monday to Friday 11:00 p.m. to 6:59 a.m., and Saturday - Sunday, all day). They found that there was a significant difference between the IHCA success rates of on-hours versus off-hours (20.6% vs 16.8%, P <0.0001). The study demonstrated that 52.4% of IHCA occurs during off hours (79 091 of 151 071 participants) and that the improvement of care to these patients would significantly improve the rates of STD for all hospitalised patients. The 52.4% of IHCA events in off-hours is vastly different to the 18.83% of IHCA events from midnight to 06h00 found in the current research study in the PHG in South Africa.

As we have seen, Matot et al (60), reviewed the relationship between successful IHCA resuscitation, survival to hospital discharge and hospital shifts (morning, evening and night) in 174 in-hospital. The incidence of IHCA was 43%, 32% and 25% in morning, evening and night shifts respectively, with patient demographic and resuscitation factors being similar. These results of 25% of IHCA events occurring during the night shift is much closer to the 18.83% found in the current study, from midnight to 06h00.

Robinson et al. (82), in a study entitled "*Risk-adjusted survival for adults following in-hospital cardiac arrest by day of week and time of day: Observational cohort study",* found survival for adults following IHCA to be lower for patients having the event at weekends and at night in comparison to similar events that occurred during the weekday and in regular working hours, Monday to Friday, 08:00 to 19:59. They looked at data from 27 700 patients aged ≥16 years who had an IHCA event and found that the risk-adjusted outcomes (OR (95% CI)) were worse ($p<0.001$) for both weekend daytime (ROSC>20 min 0.88 (0.81 to 0.95); hospital survival 0.72 (0.64 to 0.80), and night-time (ROSC>20 min 0.72 (0.68 to 0.76); hospital survival 0.58 (0.54 to 0.63) compared with weekday daytime. Therefore, IHCAs attended by the hospital-based resuscitation team during nights and weekends had significantly poorer outcomes than during the weekday daylight hours. It was noted that this difference could be staffing differences on the weekend and night shifts with reduced numbers of staff on the wards at night, possible lack of training of night staff in CPR skills, delays in recognising the patient at night who may have suffered a cardiac arrest, particularly when studies indicate that unwitnessed cardiac arrest is more common at night, delays in initiating CPR at night, delays in calling the resuscitation teams at night and other possible organisational or care differences.

5.10 RETURN OF SPONTANEOUS CIRCULATION (ROSC) AND SURVIVAL TO DISCHARGE (STD)

As was stated in the Literature Review, the two main markers of IHCA CPR success rates used in the literature are traditionally the Return of Spontaneous Circulation

(ROSC) and the Survival to Hospital Discharge (STD). These rates determine the overall success of IHCA resuscitation and are the main results scrutinised when comparing different hospitals and systems. It is therefore mandatory that in this research study of IHCA in a PHG in South Africa, the ROSC and STD rates be reviewed, to see how they compare with the global literature, some of which are included below.

Radeschi G et al (22), investigating the incidence and outcome of in-hospital cardiac arrest in the Piedmont region in Italy, yielded 1 539 IHCA events, with a ROSC rate of 35.7% (549 / 1 539) and a STD of 14.8% (228 / 1 539).

In a review of IHCA by Sandroni C et al (39), STD was found to vary from 0% to 42%, with the most common range being between 15% and 20%. This rate has been slowly increasing with time, and in 2017, the GWTG Registry noted a STD rate in the USA of 25%, with regional variations in survival to hospital discharge ranging from 3.4% to 22.0% between 132 counties.

Peberdy MA et al (37), in a study reviewing CPR in adults for IHCA events, reported on 14 720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. The results found that 44% of IHCA events had a ROSC and 17% a STD. Although a cardiac arrhythmia was primarily the main cause of the IHCA events in nearly 50% of events, ventricular fibrillation (VF) was the initial pulseless rhythm in only 16% of IHCA events. In Ventricular Fibrillation, ROSC occurred in 58% cases, with a STD rate of 34%. Patients with Ventricular Asystole had a ROSC of 35% and STD of 10% whilst those presenting with a Pulseless Electrical Activity had a ROSC of 39% and STD of 10%. Interestingly, all adult (18 years of age and over) patients, visitors, employees, and staff within a hospital environment who, experience a resuscitation event were included in this study.

Similarly, Skogvol E et al (74), undertook a review of 4 927 patients and noted an overall ROSC of 34% and overall STD of 17%. However, the actual STD rate depended on the initial IHCA primary cardiac arrhythmia, namely ventricular fibrillation (VF) or tachycardia was 40%, ventricular asystole 11% and pulseless electrical activity 3%. These studies emphasise that average or mean overall statistics for ROSC and STD may not be a true reflection of success, which seems to be dependent on the primary cardiac arrhythmia.

Li H et al (83) reviewed the outcomes of IHCA in three tertiary level hospitals in Fujian, China from 1st January 2012 to 30th December 2016. Of the 21 337 patients reviewed with Acute Coronary Syndrome, 320 deteriorated into IHCA, with 139 (41.9%) experiencing ROSC and a STD rate of 68 (21.2%).

Finally, from an international perspective, Merchant RM et al (84), using GWTG results in the USA, analysed 135 896 IHCA events from 468 hospitals. They found that the unadjusted rates of STD varied markedly across the entire hospital range, from a median rate of 8.3% (0% to 10.7%) STD for the bottom level results compared to a mean STD rate of 31.4% (28,6% to 51,7%) for the upper level results.

In our research study, the ROSC rate in the First Period was 31.39% (259 / 825) with a STD rate of 16.36% (135 / 825). During the Second Period, the ROSC rate increased to 34.93% (2430 / 6 956) as did the STD rate of 16.86% (1 173 / 6 956). These rates, for both the First Period and Second Period appear to compare favourably with many international studies discussed.

Therefore when comparing the ROSC and STD rates of the international studies mentioned, that is the studies mentioned in the following table our results compare favourably with Skogvol E, et al (74), at 34% and 17% respectively, Peberdy MA et al, at 44% and 17% respectively, Sandroni C et al, at 15% to 20% respectively, Radeschi G et al, at 35.7% and 14.8% respectively and Li et al, at 41.9% and 21.2%

respectively, those of the PHG in South Africa are very acceptable. With ROSC and STD rates of 31.39% and 16.36% respectively in the First Period and an increased 34.93% and 16.86% in the Second Period, the local ROSC and STD rates within the PHG in South Africa are well within accepted international norms. However, there is always room for improvement. This need for improvement is already reflected in the increased STD rates of 16.36% in the First Period to 16.86% in the Second Period. This 0.5% increase in successful post IHCA CPR resuscitations equate to a total of 35 patients leaving hospital alive.

	ROSC	STD
Skogvol E et al (74),	34%	17%
Peberdy MA et al (37)	44%	17%
Sandroni C et al (39)	15%	20%
Radeschi G et al (22)	35.7%	14.8%
Li et al (83)	41.9%	21.2%
First Period	**31.39%**	**16.36%**
Second Period	**34.93%**	**16.86%**

5.11 SUMMARY

Merchant RM et al, reviewed the results of IHCA Resuscitation results in 468 hospitals in the USA and noted various patient and hospital factors that had a direct influence on the prognosis of IHCA to hospital discharge. These predictors included, amongst the 36 risk factors mentioned, age, race, comorbidities, initial cardiac arrhythmia, location of cardiac arrest and cardiac arrest time and day of the week.

This chapter has discussed a number of these predictors both from the international literature and from what was obtained from the PHG Medical Data Bank, wherever possible.

The following chapter will conclude this research study with conclusions, limitations and future research opportunities.

CHAPTER SIX

CONCLUSION

6.1 LIMITATIONS

The research study encountered several limitations, which must be noted, because these either may have or did influence the obtaining of results for the study.

1. The time periods from which data was obtained spanned two periods because of the updating of the Resuscitation Forms used within the PHG. As the forms were updated, certain data was deleted and other data was added, resulting in a non-uniform set of Resuscitation Forms historically. This resulted in different sets of data from the different periods of data collection, called the First Period and Second Period.
2. The data that was sought was not always available from both periods because of the different forms used. This prevented comparison between the two periods in several instances.
3. It is not known how many IHCS events were attended to without subsequent completion of the mandated Resuscitation Form. These IHCA events would not be included in any statistics and depending on their number, may have an effect of the true incidence and outcomes of IHCA events in each of the hospitals and the total. It is believed that this figure is low because of the active Resuscitation Process available in each hospital, governed and directed form the private hospital Head Office.
4. Likewise, it cannot be guaranteed that all the data entered into the Medical Data Bank is true as no procedure was undertaken to compare a set of patient notes with the relevant Medical Data Bank in this study to prove data uploading validity.
5. The results obtained and the conclusions drawn can only be related to those hospitals within the specific PHG in South Africa and cannot be extrapolated to any public hospital or other PHGs in South Africa.

6.2 CONCLUSIONS

From the results and discussion that have formed part of this research study, several conclusions can be made that have relevance.

1. The standard of cardiopulmonary resuscitation practiced within the PHG in South Africa is well within international norms when the ROSC and STD rates of this company are compared to other hospitals internationally or to the GWTG registry in the USA.
2. The IHCA training programme involving nursing personnel and non-medical personnel is making a positive contribution towards recognition, diagnosis and resuscitation of IHCA events in the PHG and this endeavour should be further encouraged and expanded to achieve even better STD results in the future.
3. A concerted effort should be attempted to formalise a standard, non-changing Resuscitation Form that is not regularly changed with the addition or deletion of required data, so that future analysis of this data can be undertaken with consistent historical data.

6.3 FUTURE RESEARCH OPPORTUNITIES

From the research that has been currently undertaken in this study, a number of research opportunities have been revealed which future researchers could explore. These include:

1. This research study was concerned only with adult IHCA events, leaving the scope of paediatric sudden cardiac arrests in the hospital environment wide open for a researcher to explore and research, not only in the IHCA location, but also OHCA.
2. No data exists that allow an investigation into the primary arrhythmias and outcomes in IHCA in different hospital locations. Location is one of the predictors regarding IHCA event prognosis and once this data is available, research on this predictor may have an influence on future IHCA within this.

APPENDICES

Appendix A

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

TO: Ms M Toubkin
School of Therapeutic Sciences
Department of Nursing Education
Medical School
University

E-mail: mande.toubkin@netcare.co.za

CC: Supervisor: Professor S Schmollgruber <Shelley.Schmollgruber@wits.ac.za>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 12/12/2018

REF: *R14/49*

PROTOCOL NO: **M1811132** *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

PROJECT TITLE: *An epidemiologic study of in-hospital cardiopulmonary resuscitation in Netcare hospitals*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

Appendix B

Netcare Management (Pty) Limited

Tel: + 27 (0)11 301 0000
Fax: 011 217 9869
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa

05 March 2010

Mande Toubkin
Netcare Limited
Head Office
76 Maude Street
Cnr West
Sandton
2196

E mail: Mande.Toubkin@netcare.co.za

Dear Mande

RESEARCH: An Epidemiologic study of In-hospital Cardiopulmonary Resuscitation in Netcare Hospitals

Your research proposal as forwarded to Netcare on 24 February 2010 in partial fulfilment of the degree: Master in Science in Medicine (Emergency Medicine) is acknowledged and subject to the following:

i) submission of Ethics Committee approval from the education institution at which you are registered for this degree (The University of the Witwatersrand)

ii) All information relating to and regarding Netcare will be treated as strictly confidential.

iii) Netcare's name will not be mentioned without written consent from the Academic Board of Netcare.

Directors: E J Brannigan, M S F da Costa, I M Davis, J du Plessis, V Firman, R H Friedland, V L J Litlhakanyane, M B Nkosi, C Pailman, P Warrener

Company Secretary: L Kok **Reg. No.** 1995/012717/07

iv) A copy of the research will be provided to Netcare once it is finally approved by the tertiary institution, or once complete.

v) All legal requirements with regards to patient rights and confidentiality will be complied with.

We wish you success in your research.

Yours faithfully



SHANNON NELL
General Manager: Netcare education and
Chairperson - Netcare Research Committee

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