META-ANALYSIS OF THE DIFFERENT EMS INTERVENTIONS FOR NON-TRAUMATIC OUT-OF-HOSPITAL CARDIAC ARREST

Darin Peterson
Master's Thesis
Public Health
School of Medicine
Faculty of Health Sciences
University of Eastern Finland
September 2015

UNIVERSITY OF EASTERN FINLAND, Faculty of Health Sciences
Public Health
PETERSON, DARIN: Meta-analysis of the different EMS interventions for non-traumatic out-of-hospital cardiac arrest
Master's thesis, 54 pages, 1 appendix (4 pages).
Instructors: Professors Georgios Bakalos MD, PhD and Sudhir Kurl MD, PhD
September 2015

Key words: Cardiac Arrest, Basic Life Support, Advanced Life Support, Emergency Medical Services, Meta-analysis

META-ANALYSIS OF THE DIFFERENT EMS INTERVENTIONS FOR NON-TRAUMATIC OUT-OF-HOSPITAL CARDIAC ARREST

Out-of-hospital cardiac arrest (OHCA) is an event with a very high incidence rate, and very low survival rate. The objective of this study was to identify if there is any one form of Emergency Medical Service which results in higher survival to hospital discharge rates for OHCA patients.

Electronic databases were searched including the Cochrane Central Register of Controlled Trials, EMBASE, and PUBMED for the time period from January 1985 until May 2014. Articles were reviewed and relevant articles were selected for inclusion. Data was extracted and assessment of potential bias was performed. Articles were then assigned to three categories, according to the level of Emergency Medical Services.

Nine articles were selected for final inclusion. The three categories of services were Basic Life Support with Defibrillation (BLS-D), Advanced Life Support with Emergency Medical Technicians (EMT) and Paramedics (ALS- EMT/Paramedics), and Advanced Life Support with Medical Doctors (ALS-MD). Two articles contained comparisons of BLS-D versus ALS-MD, five articles compared ALS-EMT/Paramedics versus BLS-D, and four articles compared ALS-MD versus ALS- EMT/Paramedics. Data in each group were pooled to form Odds Ratios with 95% confidence intervals.

In the ALS-MD vs BLS-D group, the ALS-MDs had a significantly greater chance for survival to hospital discharge OR = 4.36 (95% C.I. 1.04 to 18.3). In the ALS-EMT/Paramedics vs BLS-D group the ALS-EMT/Paramedics had a greater chance for survival to hospital discharge, OR = 1.22 (95% C.I 1.03 to 1.45). In the ALS-MD vs ALS-EMT/Paramedics group, the ALS-MD group has a non-significant chance for improved survival, OR of 1.57 (95%C.I. 0.65 to 3.82).

Since the ALS-MD treated patients in both comparisons had a much greater chance to survive to hospital discharge, albeit non-significantly in one of the two comparisons, this would strongly suggest that ALS-MD units are the best method of responding to non-traumatic OHCA.

This study does not proffer any specific areas or items which should be included for future research. Instead, it offers a concrete starting point, so that future studies can focus on the specific aspects of care to be included in OHCA care, and not continuing the discussion about who is best suited to provide those services.

ACKNOWLEDGEMENT

I want to express my sincerest gratitude and appreciation to my advisors, who have seen me through this process and supported me in so many ways. First, I wish to thank Dr Georgios Bakalos, who helped me to find inspiration for a topic, and passion to pursue my goal. Your friendship and guidance have meant a lot to me, both personally and professionally. Next, I would like to thank Dr Sudhir Kurl, who helped me to see a clear path for my future, and to focus on the steps needed to get there. Your door was always open, offering assistance and guidance, as well as your expertise.

Another person who has been of great assistance, and who I thank most sincerely, is Dr Sohaib Kahn. Your faith in me, encouragement, patience, support, and gentle prodding were the perfect balance, helping me to achieve a goal that I most probably would not have otherwise achieved. You have really been a blessing.

I would also like to offer very heartfelt thanks to Annika Männikkö and Paola Rosales Suazo de Kontro for their hard work, friendship, and support. In many ways they have been my unofficial advisors, offering friendship and support, advice, or sometimes just a sympathetic ear when I needed one. The pathway to this degree has been paved with a lot of paperwork which they have done.

I would like to thank all of the teachers who I have learned from during my time here. I came to Kuopio originally for one year, to work toward my Bachelor’s degree. The quality of the education, as well as the educators, kept me here for much longer.

My journey here would never have started, and certainly would not have continued, without wonderfully warm and helpful people such as Kirsi Konttinen and Sirpa Risto. You have been good friends to me throughout my entire time in Finland, offering encouragement, support, guidance, lots of coffee, sauna evenings, and many memories I will cherish forever.

I would also like to thank my wife Maria, who has supported and encouraged me through it all. I would not be here today completing this degree without you.

ABBREVIATIONS

AED - Automated External Defibrillator

ALS/ACLS - Advanced Life Support / Advanced Cardiac Life Support

BLS - Basic Life Support

CCR – Cardio Cerebral Resuscitation. This consists of continuous chest compressions without providing rescue breathing. After beginning compressions, the priority is to defibrillate first, administer adrenaline, and then begin ventilation procedures after the start of defibrillation.

CPR – Cardio Pulmonary Resuscitation.

EMS - Emergency Medical Services

OHCA /OOHCA - Out-of-Hospital Cardiac Arrest. This term refers to cardiac arrest cases that do not take place in a health care setting. In-hospital cardiac arrests have a higher level of survivability due to the rapid access to defibrillation and other support services.

ROSC - Return of Spontaneous Circulation. When a person without a pulse or identifiable cardiac rhythm begins to produce their own heartbeat which produces blood circulation.

Table of Contents

1 INTRODUCTION

Out-of-Hospital cardiac arrest (OHCA) is an event which occurs frequently throughout the world, has a significantly high mortality rate, and is a leading cause of death throughout Europe and the USA (Atwood et al 2005).

Many medical aspects which may improve OHCA survivability are currently under investigation. Automated Electronic Defibrillators (AEDs) have shown great results, and have revolutionized the treatment of OHCA. There are several different versions of automated mechanical compression devices being used. New guidelines for Cardio Pulmonary Resuscitation (CPR) have been developed, including Cardio Cerebro Resuscitation (CCR), where the focus is on compressions, and rescue breathing is withheld for several minutes. Therapeutic hypothermia has been introduced, and shows promise as an effective treatment, although there is still a lot to learn about its implementation.

There are also investigations into logistic issues which may improve survival, such as restructuring services in order to improve response times, dispatching different types of Emergency Medical Services depending on the specific situation of the patient, inclusion of motorcycles and helicopters as part of the EMS response vehicles, and including different professionals as “first responders”.

Unfortunately, even with all of these different options available, the fact is that overall survival rates are not improving. However, it can be seen in individual studies that some areas are in fact experiencing much higher survival rates than others. The purpose of this review was to identify one regimen of OHCA treatment which was widely used throughout the world, and determine if one specific factor of that regimen provided statistically better results that the other aspects encompassed in that regimen.

The regimen chosen for this review was the use of a 2-tier emergency response system, which includes the Basic Life Support tier, and the Advanced Life Support services tier. The specific factors within the response system are (Basic Life Support with Defibrillation units, Advanced Life Support units led by Paramedics, and Advanced Life Support units which include Medical Doctors). These three different types of EMS services will be compared to determine if one of them has statistically better survival rates than the others.

2 LITERATURE REVIEW

2.1 Incidence and survivability

A review of 37 different European studies occurring from 1980 to 2004 showed OHCA incidence and survival rates, with an overall incidence rate of 45 (per 100,00 person years) and a survival rate of 10.7% (see Figure 1) . Individual study rates in this review varied greatly, with incidence rates ranging from 5.5 (per 100,000 person-years) in Nottingham UK, to 119.4 (per 100,000 person-years) in Stockholm Sweden. Survival rates showed a similar, large variance, ranging from 6.4% in Stockholm Sweden, to 38.8 % in Rotterdam, Netherlands (Atwood et al 2005). One possible explanation for this large difference is the greater percentage of patients presenting with shockable rhythms in Rotterdam (67%) versus Stockholm (46%).

Figure 1 Mean Incidence and Survival of EMS-treated all-rhythm Out of Hospital Cardiac Arrest (Atwood et al. 2005; Berdowski et al. 2010)

Study Period	**Incidence***	**Survival**
1980-2004 (n=36**)	44.6 (±23.3)***	10.7% (±5.3)***
	Min/Max (5.5/119.4)	Min/Max (3.6/30.7)
2004-2008 (n=12**)	61.4 (±31.5)***	10.4% (±7.3)***
	Min/Max (20/141)	Min/Max (1/27)

* Per 100,000 person-hours
**number of studies included during study period
***Standard Deviation

A more recent collection of studies from 2004-2008 (see Table 1) conducted throughout Europe, North America, Asia and Australia also provides data on OHCA incidence and survival rates (see Figure 1). This new collation of data also shows high incidence and low survival rates, with large variance in both rates. It also shows differences between geographical regions. The highest average survival rates are in Europe and Australia (both around 13%) followed by North America (7.75%) and finally Asia (2.5%). This could be influenced by many factors, such as the education levels of the medical response personnel, the availability of the different levels of EMS services, and availability of economic or medical resources.

In Figure 1 we can see the variation in incidence and survival rates. Comparing the newer data with the older figures, it is apparent that, overall, incidence rates remain high and survival rates are not improving. In 2014 the American Heart Association confirmed this trend, reporting that 424,000 individuals experienced OHCA which was assessed by some form of Emergency Medical Service (EMS), of which only 5.2% survived to hospital discharge (AHA 2014).

Table 1 Out of Hospital Cardiac Arrest Incidence of Treatment and Survival to Hospital Discharge (Berdowski et al. 2010; Ma et al. 2007)

Setting	Study data collection period	Study population	Age included	Incidence EMS attended OHCA	Incidence EMS treated OHCA	% survival to discharge
EUROPE						
Copenhagen, Denmark	2004-2007	593,000	All	73.8	53.4	11 %
Tampere, Finland	2004-2005	203,000	All	94.1	45.8	13 %
Dachau, Germany	2000-2006	134,019	All	101.2	67.0	11 %
Kaunas city, Lithuania	2005	360,627	All		20.0	* 27%
Oslo, Norway	2003-2007	436,265	GE18		70.1	* 3%
NORTH AMERICA						
Vancouver, Canada	2006-2007	2,779,373	All	85.4		10 %
Ottawa Ontario, Canada	2006-2007	4,030,696	All	73.6		5 %
Toronto Ontaria, Canada	2006-2007	5,627,021	All	91.6		6 %
Alabama, USA	2006-2007	644,701	All	110.9		3 %
Arizona, USA	2005-2006	5,500,000	All		21,6	3 %
Dallas Texas, USA	2006-2007	1,989,1357	All	123.8		5 %
Iowa, USA	2006-2007	1,015,347	All	101.2		11 %
Kansas City, Missouri, USA	2003-2007	350,848	GE18		141.4	6 %
King County	2006-2007	1,666,978	All		70.2	16 %

Washington, USA						
Milwaukee Wisconsin, USA	2006-2007	940,164	All		85.2	10 %
Pittsburg, Pennsylvania, USA	2006-2007	933,967	All	130		7 %
Portland, Oregon, USA	2006-2007	1,751,119	All	75.4		11 %
ASIA						
Okayama City, Japan	2003.2004	647,879	All		56,0	1 %
Yamaguchi, Japan	2002-2008	142,000	All	83.1		0.6%
Taipei, Taiwan	2003-2004	2,650,000	GE18	61.0		6 %
AUSTRALIA						
Adelaide, Australia	2005-2007	1,214,875	GE18	128.2	55.3	
Sydney, Australia	2004-2005	3,993,000	All		50.4	13 %

* survival to discharge, VF

A lot of time and effort has been spent to identify potential risk factors of cardiac disease. Many health promotion programs have been, and continue to be instituted, in order to reduce these risk factors, and consequently OHCA. Smoking cessation, maintaining proper body weight, healthy diet, and exercise are all stressed as means to reduce risk factors and incidence of cardiac disease. These types of health programs have great potential, and they are an excellent way to address this issue. However, they also have the limitation of being very slow to implement and achieve desired effects, especially when they aim to make permanent changes in the thinking and behavior at a societal level.

Another approach to address OHCA is to find ways to improve the treatment of individuals experiencing OHCA. As was shown in Table 1, there is great variation in the survival rates from area to area and country to country, etc. Many factors have been identified as possible reasons for this wide variation, including type of care provided, level of care provider, response time, and type of underlying cardiac rhythm. Many studies and reviews have also been conducted to try to discover the best combination of all of these factors, in order to achieve the highest survival rate. This, however, has proven to be a difficult task, and there is still no largely held consensus as to what is the best combination for preventing OHCA.

2.2 Medical treatments

There are numerous studies focusing on treatments (including ways to better perform existing treatments, new and up-and-coming treatments, new combinations of established treatments, evidence-based reviews of treatments, etc). Therapeutic hypothermia, such as Intranasal Evaporative Cooling (IEC) (Belohlavek et al 2012) or Targeted Temperature Management (TTM) (Drennan et al 2014) has been shown to have positive results as a means of providing better survival rates, and better quality-of-life for the survivors. Unfortunately, the best way to provide therapeutic hypothermia, (cold pads, cooling caps, IV saline, IV cooling catheters, IEC) is still uncertain (Fröhlich et al 2013).

Measurement of cerebral tissue oxygen saturation using near infra-red spectroscopy has also been tested and proposed as a means of improving the survival and quality-of-life of OHCA victims (Meex et al 2013).

Cardio Pulmonary Resuscitation (CPR) has undergone, and is still undergoing, many changes and transformations. It is no longer a simple ABC routine which follows the same guideline everywhere. Many of the well-known organizations, such as the European Resuscitation Council, Red Cross or American Heart Association continue to analyze new methods and update their guidelines, to include things such as changing ABC (Airway, Breathing, Compressions) to CAB (Compressions, Airway, Breathing), whether to administer CPR or give defibrillation first, how long to perform CPR before defibrillating, how many shocks to give (1 or 3) in each cycle of CPR, ideal defibrillator electrode placement and electrode size, and the use of external versus internal defibrillation (Link et al 2010).

The CPR cycle itself has been upgraded from cycles of 15 compressions to 1 breath, to include cycles of 30 compressions to 2 ventilations until an advanced airway is placed; then continuous chest compressions with ventilations at a rate of 1 breath every 6 to 8 seconds (8 to 10 ventilations per minute) should be performed (Berg et al 2010). Chest compressions should now be 2 inches (5 cm) in depth, with a rate of at least 100 compressions per minute (Travers et al 2010).

Another CPR regimen which has shown promising results is known as CardioCerebroResuscitation (CCR) (Mohler et al 2011). The idea of CCR is that circulation of blood is much more important than ventilation, so ventilations are withheld for longer periods of time while compression continues. This keeps more oxygen in the brain, which improves survival rates, and often provides better neurological function for survivors. One version of CCR practiced in the USA consists of 6 minutes of uninterrupted chest compressions, with the administration of defibrillatory shocks when necessary, before ventilating and intubating the patient (Hollenberg et al 2013). Another version of CCR is known as Compression Only CPR (CO-CPR) where compressions are given without ventilations until the EMS service arrives to continue CPR (Ewy 2014).

Since performing CPR is often very challenging, an easier-to-remember version of BLS has been designed, which says establish lack of pulse, alert EMS, get AED (if available), and initiate CPR. This new basic version gives the guideline for compressions “Push Hard, Push Fast” (Berg et al 2010).

There are many organizations which try to define the best method and practice for CPR. Some attempts have been made to form more widely accepted guidelines, such as the International Liaison Committee on Resuscitation (ILCOR). ILCOR’s members include the American Heart Association (AHA), the European Resuscitation Council (ERC), Heart and Stroke Foundation of Canada (HSFC), the Australian and New Zealand Committee on Resuscitation (ANZCOR), the Resuscitation Council of Southern Africa (RCSA), the InterAmerican Heart Foundation (IAHF), and the Resuscitation Council of Asia (RCA) Nolan et al 2010. They have not yet agreed upon the best course of action in all situations, but they have made progress, and continue to work toward that goal.

The last few years have also seen the introduction of many different automated chest compression devices which are being tested and used in numerous settings including OHCA (Ong et al 2012). Table 2 shows several CPR techniques and devices which the American Heart Association is using or investigating for future inclusion in their guidelines, including several automated compression devices.

Table 2 Cardio Pulmonary Recession Techniques and Devices (Cave et al. –AHA 2010)

	Treatment	Description
CPR Techniques	High-Frequency Chest Compressions	Greater than 120 compressions per minute
	Interposed Abdominal Compression	Three rescuer technique which includes 3rd person for abdominal compressions
CPR Devices		
Ventilation	Automatic Transport Ventilator	Pneumatically powered, time- or pressure-cycled mechanical ventilator
	Manually triggered, Oxygen-powered, flow-limited resuscitators	Traditional hand held ventilation bag
Circulation Support	Active Compression-Decompression (ACD-CPR)	Suction cup placed on chest to draw out during decompression phase
	Phased Thoracic-Abdominal Compression- Decompression CPR With a Handheld Device	Handheld device alternates chest compression and abdominal compression with chest and abdominal decompression
	Impedence Threshhold Device - ITD	Valve which limits air entry into lungs during decompression phase
	Mechanical Piston Devices	Gas or electric powered plunger mounted on backboard to perform compressions
	Load Distributing Band (Vest CPR)	Circumferential chest compressions from constricting band or backboard

2.3 Response times

There are also many investigations into different ways to improve response times to OHCA. It has been shown in large scale studies that shorter response times leads to higher survival rates, for both survival at hospital admission and discharge (Estner et al 2007, Woodall et al 2007, Olasveegen et al 2009). An old idea to improve response times which is being revisited is the "first responder". In the 1990's policemen and firefighters were being trained as first responders. Initially their role was to perform CPR until EMS units arrived. In time, as AED's gained acceptance, many first responder units were also trained and equipped with AED's. The data from the earlier trials of first responders was mixed. Some found them highly effective (Myerberg et al 2002), while others found them not effective (Groh et al 2001).

Recently, the distribution of EMS centers according to population size has been brought into question, as this can lead to inequality in health outcomes between urban and rural areas (Yasunaga et al 2011). This has lead to response times being viewed from the perspective of population density, distinguishing between urban and rural settings. It appears that larger urban areas are more likely to benefit from first responder units on motorcycles, since they can navigate through busy streets and heavy traffic, providing quicker response times than traditional ambulances.

Studies of helicopter use in EMS services have also been performed. There is evidence to support that their inclusion improves response rates, and therefore survival rates, in very congested areas as well as very remote areas (Yasunaga et al 2011) (Lyon and Nelson 2013). However this issue is difficult since dispatch of helicopter services is expensive and often limited to patients who have already achieved Return of Spontaneous Circulation (ROSC).

2.4 Care providers

The old idea of EMS services was an ambulance, with a Medical Doctor and an EMT to assist. Perhaps the ambulance had only a few EMT's who were supposed to rush the patient to the hospital. Innovative thinking from hospitals and colleges saw the creation of the paramedic, and the introduction of the nurse into the EMS field. The idea of the first responder has opened the door further to the introduction of many new individuals in the EMS field. People such as firefighters, policemen, lifeguards, security guards, airline cabin attendants and sky marshals, railway station personnel, post office workers, and pharmacy staff have been proposed as people who could be first responders (Kloeck et al 1997, Capucci et al 2002, Myerberg et al 2002, Hoyer and Christensen 2009). Schools and universities have considered the importance of having first responder training for members of their staff.

Since there are so many different levels of care providers, we have also seen a change in the levels of EMS care. Now there are BLS and BLS-D services (Basic Life Support with or without the inclusion of Defibrillation capabilities), and Advanced Life Support (ALS). ALS services now sometimes consist of only paramedics and EMTs, while other times including an MD and/or a paramedic as part of the primary response unit. With the widespread success and acceptance of the benefits of defibrillation, and the ease of using

AED’s (Capucci et al 2002), BLS services are being replaced more and more by BLS-D services. Many first responders are even being equipped with AED’s.

2.5 Education

While a lot of the literature uses the same terms to describe EMS care providers (EMTs and Paramedics), the education and skill level of these care providers is not very uniform. Table 3 below is a collection of EMT certification training requirements chosen randomly from different schools in different countries. (This table is not meant to show absolute minimum or maximum levels of training. It should only be viewed as a snapshot of the overall situation). It shows that there is great variation in the level of EMT education in different countries, and even in different parts of the same country. In Europe we see EMTs receiving as much as 26 weeks of training, and as little as 5 days. In North America training periods range from 1 year to 6 weeks. Australian EMT’s were certified in 12 to 17 days of training.

In Table 3 we can also see that there is a great variation in the amount of time spent between classroom training (credit hours) and in-the-field training (contact hours). Some programs appear to focus more on credit hours, others on contact hours. It is also interesting to note that there are many different levels of EMT certification (Basic, Intermediate, Advanced, and Ambulance Technician).

Table 4 describes paramedic certification and training requirements chosen randomly from different schools in different countries (This table is also not meant to show absolute minimum or maximum levels of training. It should only be viewed as a snapshot of the overall situation). Paramedic training similarly shows a lot of variation in study requirements. In Europe, paramedic programs are from 7 months to 4 years. In North America lengths varied from 11 months to 3 years. In Australia, paramedic programs lasted from 1 to 3 years. There are also different levels of paramedic certification, such as Paramedic I or II, Paramedic certificate, an Associate Degree, and a Bachelor Degree. Surprisingly, Germany also has Paramedics with and without ALS certification.

Table 3 EMT Education and Training Levels

Institution/Location	Degree Title	Length of Study	Prerequisites	Contact Hours	Credit hours
EUROPE					
Germany	EMT	160 hours		80	
First Line Response Bournemouth UK	EMT Basic	2 weeks	Basic First Aid		
Irish Ambulance Training Institute Ireland	EMT	6 weeks		40	120
Medicall Ambulance Service Dublin Ireland	Ambulance Technician	26 weeks		18 weeks	8 weeks
Medicall Ambulance Service Dublin Ireland	EMT			40	120
Crown Training Academy South Wales UK	EMT Basic/Intermediate	5 days			
NORTH AMERICA					
Hillsborogh Community College Florida USA	EMT Certificate	4 months			11
Florida Southwestern State College	EMT Certificate	4 months			11
National Outdoor Leadership School Wyoming USA	Wilderness EMT	1 month	CPR certification		9
Foothill College California USA	EMT	9 months	Emergency Response Course	10	
Wharton County community College Texas USA	EMT	1 semester	CPR certification		7
Wharton County community College Texas USA	Advanced EMT	1 year	CPR certification		23

Ozarks Technical Community College Missouri USA	EMT Basic	16 weeks			6
Ozarks Technical Community College Missouri USA	EMT Intermediate	8 months		9	21
Sait Polytechnic Calgary Canada	EMT	10 months	EMR certificate of 12 weeks		
Prairie Bible Institute Alberta Canada	EMT	1 year	CPR and EMR certificate	9 months	15
AUSTRALIA					
First Response Queensland, Australia	EMT Basic	12 days	First Aid and precourse study manual		
First Response Queensland, Australia	EMT Advanced	17 days	First Aid and precourse study manual		

EMT-Emergency Medical Technician
EMR-Emergency Medical Responder
CPR-Cardio Pulmonary Resuscitation

Table 4 Paramedic Training and Education Levels

Institution/Location	Degree Title	Length of Study	Prerequisites	Contact Hours	Credit hours
EUROPE					
Germany	Paramedic (no ACLS)	1 year		360-hour internship	160
Germany	Paramedic ACLS	2 years		1 year + 10 weeks	1 year coursework
University of Hertfordshire UK	Bachelor of Paramedic Science	3 years			
PPA International via University of Ioannina Greece	Paramedic	7 months	EMT and 1 year experience	1 month	300
Metropolia University of Applied Sciences Helsinki Finland	Paramedic and Registered Nurse	4 years			240 credit points
NORTH AMERICA					
University of Washington, Washington USA	Paramedicine Certificate Program	1 Year	EMT cert and Anat and Phys course and % credits Math	1122 / (435 classroom, 171 practical laboratory, clinical/field 516).	88
Hillsborogh Community College Florida USA	Paramedic College Credit Certificate	11 months	EMT Certification		42
Hillsborogh Community College Florida USA	(Paramedic) EMS Associate Degree	16 months	Paramedic College Credit Certificate		73 (53 credited from EMT and

				Paramedic Certificate)
Brookhaven College Dallas Texas USA	Paramedic Certificate	2 years	EMT-B or EMT-I certification plus Anatomy and Physiology	
Wharton County Community College Texas USA	Paramedic-I	12-16 months	CPR certification	39
Wharton County Community College Texas USA	Paramedic II	16-20 months	CPR certification	45 (39 from Paramedic I certificate)
Wharton County Community College Texas USA	AAS in Emergency Medical Services (Associate of Applied Science)	2 years		60
Foothill College California USA	Paramedic Certificate	15 months	EMT Certification + 6 months experience	58
Foothill College California USA	Paramedic Associate Degree	18 Months	EMT Certification + 6 months experience + Paramedic Certificate	70 (58 from Paramedic Certificate Course)
Lansing Community College Michigan USA	Paramedic Certificate			36
Lansing Community College Michigan USA	Paramedic Associate Degree	3 years		

AUSTRALIA					
Victoria University Melbourne Australia	Bachelor of Health Science Paramedic	3 years			
Victoria University Melbourne Australia	Diploma of Paramedical Science	1 year			
University of Queensland Australia	Bachelor of Paramedic Science	3 years	Apply First Aid Card and Blue Card from Commission for Children and Young People and Child Guardian	8 units	40 units

ACLS-Advanced Cardiac Life Support
CPR-Cardio Pulmonary Resuscitation
EMT-Emergency Medical Technicia

2.6 Division of tasks and services

Another aspect which has received a lot of attention is determining if there is one combination of care providers that has the best results for OHCA victims. The idea of a two-tier system, comprised of separate BLS and ALS units has become quite widespread. At the same time, the education levels of EMTs and Paramedics increasingly includes skills which used to be reserved for nurses or MD's. This allowed for ALS services to take on a new form, with the introduction of ALS services led by a paramedic, and not an MD as had previously been the case with ALS. EMS services have also started including the use of AED and first aid/CPR trained first responders, such as police and fire services.

Some studies claim that ALS services have better outcomes than BLS or BLS-D services (Frandsen et al 1991). Others claim that BLS-D services have better outcomes than ALS services (Ma et al 2007), or that BLS-D in conjunction with a good first responder system results in the best outcomes. Still others compare the effectiveness of ALS paramedic units to ALS MD units (Olasveengen 2009).

A possible explanation for differences in the above findings is that one study had more than a 50% quicker mean EMS response time (Ma et al 2007), which in turn could improve the survival rates of BLS-D services. Another potential factor which could have influenced these findings is the population densities of these areas. For example, the population density in Odense, Denmark (Frandsen et at 1991) was 570 citizens per square kilometer at the time the study was conducted, compared to a population density of 9743 citizens per square kilometer in Taiwan (Ma et al 2007) and 1347 citizens per square kilometer in Norway (Olasveengen 2009).

Differences in population density may influence response times in different ways. Rural areas may experience slower response times if EMS services are centralized, and patients may not as quickly be discovered after experiencing OHCA. This would favor the ALS units, such as in Odense, Denmark (Frandsen et at 1991), since ALS units would be better equipped to handle patients in poorer conditions. In urban areas it is more probable that patient discovery times after experiencing OHCA are faster, since there are more people around to witness the event. This would lead to quicker response times in urban areas, which may favor the success rates of BLS-D units as in (Ma et al 2007), where BLS-D units did have better survival to hospital discharge rates.

2.7 Identifying and clarifying a topic for research

After reviewing the literature, two things were apparent. One, given the increasingly high rates of incidence and the consistently poor survival rates, the need to study this topic was undisputable. Two, this is such a multifaceted topic, and identifying one specific factor for further study with a good probability to produce a meaningful result was going to be more difficult than previously expected.

As a starting point, it was necessary to find some sort of order for all the information available. There had to be a simple way to categorize this mass of information. Eventually it was apparent that most of the literature could be divided into 3 main categories (with several subcategories for each):

1 -Who provides the best care

2- The type of care provided

3- How the care is delivered

After identifying the main categories the best starting point would be to answer the smallest, and least complex question first -"Who provides the best care?". Once it is determined who can best deliver the care, future research resources can be better focused on defining best care from the perspective of the individual patient given the resources available in each situation. The definition of "best care" may vary from place to place due to cultural, religious, or economic differences, but certain common definitions could be determined and more clearly described. These latter two topics will be continually evolving, driven by advances in medicine and technology. Once we can determine who is best suited to provide the care, then we can focus on defining and refining the education and training requirements for those care providers, specifying and developing new and existing medical advances to include in the care, and investigating better ways to bring the care services to the patient in urban and rural settings.

3 AIMS OF THE STUDY

This study aims to identify which form of EMS service is having the best results in OHCA, as defined by survival to discharge. After identifying this basic point, it would then be appropriate to investigate further more advanced topics, such as which specific treatment regimens and care delivery aspects are the most effective. This aim will be achieved by identifying the set of studies which are representative of the modern era, and evaluating the three more common forms of EMS service currently used. They will be compared as concepts, instead of analyzing each specific treatment they use, and the benefit of each.

4 METHODS

4.1 Criteria for considering studies for review

4.1.1 Definition of study period

Studies needed to be reflective of the modern era, and of current practice. Studies describing data collected before 1985 were not considered for inclusion. Furthermore, studies which were marked for further review and possible inclusion needed to clearly describe what care provider(s) were included in each type of EMS service.

4.1.2 Types of studies

In this review controlled clinical trials, and prospective or retrospective cohort or case-series studies were considered for inclusion.

Randomized controlled trials were not considered to be ethically correct in many studies of this nature (instead all patients are offered the best available treatment method). Some studies included a level of randomization. For example, during the introductory phase of new services where only a limited number of patients could receive the new treatment, these patients could be randomly assigned to receive the existing treatment or the introductory treatment. Again, 100% randomization even at this level is problematic because the needs of the patient were sometimes judged too critically to warrant the basic level of care, or in instances where other EMS services were already engaged, assignment to a treatment category was made solely on the availability of service providers.

4.1.3 Types of Participants

In order to be considered for this review, studies had to include information about primarily adult populations (defined as 16 or 18 years of age and older) who experienced non-trauma OHCA with suspected primary cardiac etiology. Some studies included this category of patient, along with other categories, such as pediatric or traumatic injury patients. These studies were also considered for inclusion as long as information about the desired participant category was present and clearly defined.

4.1.4 Types of Interventions

The focus of this review was to compare BLS-D with different types of ALS. The three intervention types included were BLS-D, ALS-EMT/Paramedic, and ALS-MD. There was also the possibility to include BLS units which do not offer defibrillation, but from the recent literature there is overwhelming data that defibrillation is beneficial, and already widely incorporated in modern BLS services. The case has already been made and proven that defibrillation is preferable, so investigation into its potential benefit is no longer necessary.

BLS-D was performed by an EMT, Nurse, or Paramedic. BLS-D which was performed by police or first responders, without the assistance of an EMT, Nurse, or Paramedic, was originally considered for inclusion, but no such studies which met the other inclusion criteria were identified. Defibrillation could be performed using any form of external defibrillator including AED devices.

ALS services were subcategorized by the highest level of care provider involved in the provision of services prior to arrival at the hospital. ALS-MD included a Medical Doctor or physician as part of the primary response team, while ALS-EMT/Paramedics teams did not.

ALS services reported different regimens of medication use and medical interventions included, but no specific or minimum regimen or intervention was used to define study inclusion, exclusion, or assignment into different ALS subcategories.

4.1.5 Care Providers/ Level of care

BLS-D services were provided by EMTs, Paramedics and Nurses. In order to be considered as providing BLS-D services, no member of the group was providing advanced cardiac life support.

The ALS-EMT/Paramedics services could also include EMT's, Paramedics, and Nurses, but in this case either a Paramedic or Nurse, if not both, was able to provide advanced cardiac life support services.

It was possible to have all of the aforementioned care providers in the ALS-MD's groups, but these also included at least one MD. As long as the primary care providing group included at least one MD, it was not necessary that any of the additional response crew were ACLS certified.

There are no international standards which define the level of education necessary for any of these jobs. It was accepted that with each job title, there are general skills and expectations which are similar enough to meet the purpose of this review. The determination of definitions of optimal education and experience levels for each degree or certification is beyond the scope of this review. The only minimum standard which was set as a requirement for all care providers included was the ability to use an AED or other external defibrillator.

BLS was considered to include the use of CPR, rescue breathing, defibrillation, and limited used of medication. ALS included all of the aspects of BLS-D, along with more advanced medicinal and treatment interventions.

In order to have comparable data, every study included needed to describe the use of at least two of the interventions.

4.1.6 Outcome measures

For inclusion in this review, studies had to report survival to hospital discharge data as one of the outcome measures, whether or not Return of Spontaneous Circulation (ROSC) was achieved.

4.2 Search methods for identification of studies

The following databases were searched for relevant publications from 1 January 1985 until 1 January 2015: PubMed, SCOPUS, and the Cochrane Central Register of Controlled Trials. Keyword and MeSH terms included "Emergency Medical Services" ,"Critical Care", "Emergency Treatment", "Resuscitation", "Advanced Cardiac Life Support", "Emergency Medicine" , "Emergency Nursing", "Life Support Care" ,"Clinical Competence" and "First Aid. Limiting terms including "trauma" or "traumatology", "pediatric", "English language", "Controlled clinical trial" and "human" were also used. See Tables 5A-C for the complete search strategies.

Table 5A: PUBMED search strategy

Search criteria:
“Emergency Medical Services”[Mesh] OR “Critical Care”[Mesh] OR “Emergency Treatment”[Mesh] OR “Resuscitation”[Mesh] OR “Advanced Cardiac Life Support”[Mesh] OR “Emergency Medicine” [Mesh] OR “Emergency Nursing”[Mesh] OR “Life Support Care”[Mesh] OR “Clinical Competence”[Mesh] OR “First Aid”[Mesh] NOT “Traumatology” [Mesh
Advanced life support or ALS Field: Title/Abstract
Basic life support or BLS Field: Title/Abstract
(emergency or critical) AND (care or treat or treatment*) Field: Title/Abstract
(prehospital or pre-hospital or preclinical or pre-clinical) AND (care or support or treat or treatment*) Field: Title/Abstract
“Emergency Medical Technicians”[Mesh]
PARAMEDIC* Field: Title/Abstract
(emergency or critical or triage or ambulanc*) and (doctor* or nurse or nurses or nursing or crew or staff or team*) Field: Title/Abstract
(randomised OR randomized OR randomly OR random order OR random sequence OR random allocation OR randomly allocated OR randomized controlled trial [pt] OR controlled clinical trial [pt] OR randomized controlled trials [mh])
Limits: Limits: Date: Published between 01.01.1985 and 01.01.2015. Species Humans, Document type Controlled Clinical Trial, Language English, Age group Adult (19-44 years), Adults, all (19 years +), Aged (65+ years), Aged, 80 and over (80+ years), Middle aged (45-64 years), Young Adult (19-24 years)

Table 5B: SCOPUS search strategy

Search criteria:
Advanced life support or ALS
(TITLE-ABS-KEY ("Advanced life support") AND NOT TITLE-ABS-KEY (trauma) AND NOT TITLE-ABS-KEY (pediatric)) AND DOCTYPE (ar OR re) AND PUBYEAR > 1984
(TITLE-ABS-KEY ("Basic life support") AND NOT TITLE-ABS-KEY (trauma) AND NOT TITLE-ABS-KEY (pediatric)) AND DOCTYPE (ar OR re) AND PUBYEAR > 1984
Advanced life support or ALS
Basic life support or BLS
prehospital or pre-hospital or preclinical or pre-clinical
emergency or critical or triage or ambulance
randomized controlled trial [pt]
controlled clinical trial
Limits: Published between 1985 and 2015. LANGUAGE “English”. SUBJAREA “PHAR”, “MEDI”, “NURS”, “HEAL”

Table 5C: Cochrane Central Register of Controlled Trials search strategy

Search Terms:
MeSH descriptor Emergency Medical Services explode all trees
MeSH descriptor Critical Care explode all trees
MeSH descriptor Emergency Treatment explode all trees
MeSH descriptor Resuscitation explode all trees
MeSH descriptor Emergency Medicine explode all trees
MeSH descriptor Emergency Nursing explode all trees
MeSH descriptor Life Support Care explode all trees
MeSH descriptor Clinical Competence explode all trees
MeSH descriptor First Aid explode all trees
MeSH descriptor Emergency Medical Technicians explode all trees
(Advanced life support) or ALS
(basic life support) or BLS
(emergency or critical)
(prehospital or pre-hospital or preclinical or pre-clinical)
(emergency or critical or triage or ambulance)
Limits: Published between 1985 and 2015

4.3 Data collection and analysis

4.3.1 Selection of studies

Potential studies were identified using the listed key search words in three different electronic databases. Abstracts were read in order to identify any article which may include at least two different study categories, and which reported the desired endpoint, survival to hospital discharge.

Studies which included information about the desired study group, any of the appropriate interventions, information on the type of care provider, and an endpoint analysis variable were kept for further consideration. After reviewing all the literature identified in the initial data search, the full-length articles for all of the selected abstracts were collected (where possible), and these articles were further reviewed to verify that they did indeed include all of the necessary information for study inclusion.

Articles which did not include the appropriate information were excluded.

It was also checked that there were no articles discussing the same study, or different subcategories of the same study. In situations where two or more articles discussed the same study, the article which included the clearest, most complete description of the study and its concurrent analysis was included.

4.4 Data extraction

Articles were reviewed by one individual who collected data about the study design, overall timeframe and location of study, age of participants, diagnosis (primary cause of arrest), care providers involved, treatment type(s), number of study subjects included, and number of subjects who survived to hospital discharge.

4.5 Assessment of study quality

Studies were reviewed to identify sources of potential bias including selection bias, detection bias, performance bias, attrition bias, and reporting bias.

Selection bias refers to the systematic differences between baseline characteristics of the different treatment groups. It was determined by examining sequence generation, allocation concealment, and baseline imbalances.

Sequence generation

All studies were reviewed to determine how patients were allocated to interventions. Ideally all studies would have some predetermined method to randomly assign patients to the study groups. However, several studies in this review did not have the opportunity to randomly assign patients to a specific study group (treatment). By design, they reported data before-and-after the implementation of a new service level in the area of study, in order to assess the effectiveness of the new service.

Other studies reported a change in the treatment regime which took place on a limited basis within their area of coverage. These studies had the possibility to assign subjects randomly into different treatment groups. However, it was noted in these studies that the possibility to include the subject into the predetermined randomized care group was not always possible if the allotted care provider group was already dispatched to another incident, or were too far away to respond in a timely manner. Furthermore these studies did not report how frequently they were able to follow their randomization schedules. Overall, it was decided that studies which had this limitation could still be included in the final review, as long as they noted this as a limitation in the study, and discussed the steps they took to limit this source of bias as much as possible.

Allocation concealment

When the studies did have a method of random assignment defined, it was necessary to assess the adherence level to the allocation plan.

Randomization schedules were predetermined in studies where different levels of EMS service were concurrently available. It was not always possible to adhere to the randomization schedule for ethical and logistical reasons. When the allocated service was too far away to respond in a timely manner, or was already engaged with a patient, the allocation table was not followed. Several studies mentioned this phenomenon as a limitation, and sited the ethical obligation to treat patients in a timely manner. However, none of the studies reported the level of adherence to the randomization schedule. It was determined that this type of selection bias was unavoidable, and that adhering to the schedule in this manner would not introduce a significant bias.

Baseline imbalance

Studies involving OHCA potentially use many different aspects to define the baselines of their study groups, since many studies investigate factors which may influence the primary outcome of this review (survival to hospital discharge). Articles also included data regarding the time to EMS arrival, time until CPR is started, time spent on the scene before attempting to transport the patient to a hospital, type of cardiac rhythm, presence of a shockable rhythm. Descriptive statistics such as age, gender, bystander CPR started, witnessed arrest, and type of cardiac rhythm were used to compare for baseline differences between different study groups.

For the purpose of this review, assessment of baseline similarity was sufficient when age and gender were evaluated. No significant differences were observed in any of the included studies.

Detection bias refers to systematic differences between groups in how outcomes are determined. For this type of primary endpoint it would appear that there is very little possibility for any discrepancy, since the patient either died or was discharged from the hospital alive. However, there are differences in the underlying criteria for when EMS care is or is not provided, which in turn can influence the outcomes. Areas which may differ from study to study include the period of time a patient with a witnessed arrest remains untreated before EMS assistance arrives, and the initial cardiac rhythm upon arrival of EMS.

These cut-off times are determined by the practice of the local area or state. There is not always worldwide and timely agreement about what consists the best medical practice in all situations. For the purpose of this review, studies which clearly defined these underlying criteria were rated as “low” risk for bias, while studies which did not clearly or completely define these were marked as “uncertain” risk for bias.

Performance bias refers to the measures used to blind the study participants and care providers from knowing which treatment a patient received, and whether or not the desired blinding methods were effective. It is not possible to blind the patients from which kind of care they received in this instance. Neither is it possible to blind the care providers on what level of care they will provide. They provide care based solely on the need of the patient. The only area where some level of blinding could have taken place is in the dispatch of services area. Here some studies did have randomization tables defining which type of EMS service should be dispatched. However, it was not always possible to follow these schedules when the allocated service was not in range, or was already engaged with another patient. It was felt that there is a low risk of this type of bias. Studies which did not try to address or discuss this issue were listed as “uncertain” level of risk.

Attrition bias refers to the completeness of data, regarding the outcomes. In this review there is only one endpoint, which is survival to hospital discharge. It is important to know what exclusions were made in each study, and the reasons for exclusion.

Assessment of incomplete outcome data.

The completeness of the data being reported was assessed for every included study. All included articles described the overall number of included/excluded patients, and described the reasons for exclusions. Sighted reasons for excluding patients from studies included; patients with traumatic injuries or who clearly had non-cardiac etiology, EMS did not attempt resuscitation due to illness or presence of Do Not Attempt Resuscitation (DNAR) order, no bystander resuscitation had been attempted for 15 minutes or longer before EMS arrival, pediatric patients. One study also excluded pregnant women, and cardiac arrests that were witnessed by emergency medical personnel (Mitchell 2000). This study doesn't state how many pregnant women were excluded. Even lacking this description, it was considered to have a "low risk" for bias, since it is highly unlikely that there were a large number of pregnant women excluded, and their exclusion would have been for reasons other than to influence the true outcome.

Reporting bias refers to the possibility of selecting only specific data to report, instead of reporting all of the data which was listed in the study design or protocol.

Assessment of Selective outcome data.

Only studies which listed the primary outcome as one of the study objectives, and also included said data were included into the review. It was checked in each article that the complete data set regarding the primary outcome was described, and that it was described in the manner stated in the objectives. In one study there was a subset of patients who were treated by more than one type of EMS service, and they were later excluded from the study results. In an attempt to limit any bias from this, the number of patients in this subcategory, and the rationale for receiving combined treatments were stated in the article.

4.6 Assessment of intervention

Results of interventions were established in a stepwise process. First the treatment categories and comparison groups for each study were identified. In total, there were three treatment categories and three comparison groups.

Treatment Categories:

BLS-D, -basic life support provided by EMTs/paramedics including the use of a defibrillator

ALS-MDs - advanced life support provided by groups including an MD, and

ALS-EMTs/Paramedics -- advanced life support provided by EMTS/paramedics

Comparison Groups:

ALS MDs vs BLS-D

ALS EMTs/Paramedics vs **BLS-D**

ALS MDs vs **ALS EMT/Paramedics**

Statistical comparisons

Second, the number of patients included, and the number who survived to hospital discharge for each treatment category in each study were determined. Odds ratios (OR) and confidence intervals (CI) for survival to hospital discharge were then calculated for each comparison group in each study.

Third, the results of the studies were pooled, according to comparison groups. For each comparison group, a forest plot was created to show the individual ORs and CIs, along with the pooled results for that group. Confidence intervals which did not include the number 1.0 were considered to be statistically significant at the 0.05 level. See Table 6 for comparison groups.

Table 6: Summary of Characteristics of Trials and Enrolled Patients

Study	Number of patients survived at hospital discharge	Number of patients recieved care	Number of patients survived at hospital discharge	Number of patients recieved care			
	BLS-D		**ALS-EMT/Paramedic**		**OR**	**Lower**	**Upper**
Ma M.H-M et al 2007	53	1037	27	386	1,396	0,865	2,254
Mitchell RG et al 2000	15	259	19	294	1,124	0,559	2,26
Soo LH et al 1999	28	617	44	804	1,218	0,749	1,98
Stiell I et al 2004	69	1391	217	4247	1,032	0,781	1,362
Woodall et al 2007	60	1288	113	1687	1,469	1,065	2,027
	BLS-D		**ALS (MD)**				
Frandsen F et al 1991	2	148	11	85	10,851	2,344	50,233
Soo LH et al 1999	28	617	13	126	2,42	1,216	4,815
	ALS−MD		**ALS−EMT/Paramedic**				
Dickinson E et al 1997	4	9	2	40	15,2	2,192	105,416
Olasveengen et al 2009	31	232	78	741	1,311	0,84	2,046
Soo LH et al 1999	13	126	44	804	1,987	1,038	3,805
Yen ZS et al 2006	3	115	4	43	0,261	0,056	1,219

4.7 Data synthesis

The data for these studies was analyzed using the Open Meta Analyst software program. It calculates Odds Ratios with 95% Confidence Intervals for survival to hospital discharge, using the total number of patients admitted into the study and those who survived to hospital discharge. Then, the OR's for all the studies in the same comparison group were pooled to determine an overall OR and CI, which was then illustrated using a forest plot graph.

5 RESULTS

5.1 Results of the search

The initial search for literature resulted in 518 potentially relevant articles for further review. These articles were then reviewed by title and/or abstracts to assess their possible eligibility. In total, 503 articles were removed, since they were either duplicate articles, did not include data about the primary endpoint (survival to hospital discharge), or they did not compare at least 2 of the identified EMS care provider groups. This resulted in 15 articles where the full articles were reviewed to determine their eligibility. Of these, 7 were excluded and 8 were accepted for final inclusion in the study. After reviewing the reference lists of all the 15 articles chosen for full review, one additional article was identified and included in the final review. This resulted in a total of 9 articles which were included in the final analysis. See Table 7 below for full details of the review process.

Table 7: PRISMA chart of study selection process

518 potentially relevant records identified and screened for retrieval through database review
PubMed (n= 80)
SCOPUS (n= 236)
Cochrane (n=202)

1 additional record identified through review of references of idenitified articles

519 total records identified for further review

Articles excluded based on Title and Abstract: (n=503)
Excluded due to duplication, did not include primary endpoint, did not compare 2 or more of the EMS service groups

16 potentially eligible articles remaining after abstract selection and review

Articles excluded after retrieval of full-text: (n=7)
Discussion about BLS vs BLS-D, not BLS-D vs ALS (n=1)
BLS services did not include Defibrillation (n=1)
Pediatric patients included (n=2)
No description of EMT-D education level (n=1)
Discussion about BLS-D from different providers, not BLS-D vs ALS (n=2)

9 articles identified which describe BLS-D vs ALS and meet all inclusion criteria

5.2 Included studies

Study design

Table 8 below describes in detail the studies included in this review, including study design and the EMS system(s) which were included in each item. It is important to note that the article by Soo LH et al is listed 3 times, since it contains data for EMS System comparison of all 3 comparison groups.

Table 8: Description of Included Studies

Author	Year	Location	Study Design	EMS System
Dickinson E et al	1997	Colonie, New York, USA	Retrospective case series	ALS (MDs) + ALS (EMTs/Paramedics)
Frandsen F et al	1991	Odense, Denmark	Retro-Prospective cohort	BLS-D + ALS (MDs)
Ma M.H-M et al	2007	Taiwan	Prospective cohort	BLS-D + ALS (EMTs/Paramedics)
Mitchell RG et al	2000	Scotland	Before-After, Prospective cohort	BLS-D + ALS (EMTs/Paramedics)
Olasveengen et al	2009	Oslo, Norway	Prospective cohort	ALS (MDs) + ALS (EMTs/Paramedics)
Soo LH et al *	1999	Nottinghamshire, UK	Retrospective cohort	BLS-D + ALS (EMTs/Paramedics)
Soo LH et al*	1999	Nottinghamshire, UK	Retrospective cohort	BLS-D + ALS (MDs)
Soo LH et al *	1999	Nottinghamshire, UK	Retrospective cohort	ALS (MDs) + ALS (EMTs/Paramedics)
Stiell I et al	2004	Canada	Before-After, Prospective cohort	BLS-D + ALS (EMTs/Paramedics)
Woodall et al	2007	Queensland, Australia	Retrospective cohort	BLS-D + ALS (EMTs/Paramedics)
Yen ZS et al	2006	Taipei, Taiwan	Prospective cohort	ALS (MDs) + ALS (EMTs/Paramedics)

* same study, describing different EMS system comparison groups

Table 9 shows a list of the studies which were excluded from the final list of relevant studies, sighting the reason for exclusion. Although there are an enormous amount of articles, including clinical trials, which discuss in some capacity the topic of OHCA, very few examined the topic in a similar manner. Some included non-cardiac etiology patients, such as trauma or drowning. Others mix adult and pediatric populations, or discuss variations of who can provide BLS care (policemen, firefighters, lifeguards, first responders, etc). This is one major reason for difficulty in comparing the EMS services. Many authors discuss in very dissimilar terms and concepts.

Before the mid 1980's defibrillation was part of ALS care only. Even with the introduction of defibrillation to BLS services, many BLS services did not include the administration of any medications. It is not very easy to include any studies from this time period or earlier, since the skills and treatments that were considered as ALS skills then are now considered part of BLS care.

Table 9: EXCLUDED STUDIES

Author	**Year**	**Location**	**Study Design**	**EMS System**	**Reason for Exclusion**
Brison R et al	1992	Ontario, Canada	Before-After, Prospective cohort	BLS + BLS-D	Discussion about BLS vs BLS-D, not BLS-D vs ALS
Estner H et al	2007	Dachau, Germany	Prospective cohort	ALS (MDs) + ALS (EMTs/Paramedics)	Pediatric Pts included. All patients are followed up by MD before hospital arrival
Eisenburger P et al	2001	Austria Alpine area	Prospective cohort	EMT-D + ALS (MDs)	No description of EMT-D education level = Acting as BLS-D or ALS (EMT/Paramedic)
Frandsen F et al	1991	Odense, Denmark	Retro-Prospective cohort	BLS + BLS-D	Discussion about BLS vs BLS-D, not BLS-D vs ALS
Frandsen F et al	1991	Odense, Denmark	Retro-Prospective cohort	BLS + ALS (MDs)	BLS services did not include Defibrillation
Groh W et al	2001	Indiana, USA	Prospective cohort	BLS-D (Police/EMS) + BLS-D (EMTs/Paramedics)	Discussion about BLS-D from different providers, not BLS-D vs ALS
Myerberg RJ et al	2002	Miami, USA	Prospective cohort	BLS-D (Police/EMS) + BLS-D (EMTs/Paramedics)	Discussion about BLS-D from different providers, not BLS-D vs ALS
Rainer T et al	1997	Glasgow UK	Prospective cohort	BLS-D (EMT) + ALS (EMTs/Paramedics)	"Adult" included 13 or older. Paramedics did not administer medication
Sipria A et al	2000	Tartu, Estonia	Retrospective cohort	BLS + ALS (MDs)	BLS services did not include Defibrillation

5.4 Risk of bias in included studies

The risk of bias for the included studies was performed using the *Cochrane Handbook for Systematic Reviews of Interventions* version 5.1.0. 2011. Table 10 contains specific details of the risk of bias assessment.

Sequence Generation (Selection Bias)

Sequence generation was the most common source of potential bias, with six out of the nine studies having a ”High” level of sequence generation bias. It was very difficult for this type of study to be designed in a manner that would facilitate proper sequence generation, since it describes the changes after the introduction of a new category or level of EMS service. The provision of the new EMS service was determined by geographic location (to facilitate fast response times), and availability of the EMS service. By design it is not possible to have a level of randomness.

Allocation Concealment (Selection Bias)

Allocation concealment was also “Uncertain” in five of the nine studies. Even though these studies did have a” High” potential for selection bias, they were determined to be of high enough quality to include in a review, since the specific type of bias seemed unlikely to effect the outcomes, and also very difficult to avoid in most situations.

Blinding (Performance Bias)

It isn’t possible to blind the participants or the care providers in this specific instance. However, in some studies it was possible to have a degree of blinding at the level of the service dispatch. It was not possible to follow the predetermined allotment of services when the desired service was out-of-range, or already engaged with another patient. Blinding was “Uncertain” in four of the nine articles, since there was no description of efforts to blind the dispatch services.

Detection, reporting and attrition biases were “Low” for all studies, since they included baseline descriptions of the included participants, clear descriptions of the eligible subjects, excluded subjects, and reasons for exclusions. With this information it was possible to account for all study subjects.

Table 10: Risk of Bias

Study	Sequence generation	Allocation concealment	Blinding of participants, personnel and outcomes	Incomplete outcome data (attrition and exclusions)	Selective outcome reporting	Baseline imbalance
Dickinson et al	High	Uncertain	Uncertain	Low	Low	Low
Frandsen et al	Uncertain	Uncertain	Low	Low	Low	Low
Ma M.H-M et al	High	Low	Low	Low	Low	Low
Mitchell et al	Uncertain	Uncertain	Uncertain	Low	Low	Low
Olasveengen et al	High	Uncertain	Uncertain	Low	Low	Low
Soo et al	High	Uncertain	Uncertain	Low	Low	Low
Stiell et al	Low	Low	Low	Low	Low	Low
Woodall et al	High	Low	Low	Low	Low	Low
Yen ZS et al	High	Low	Low	Low	Low	Low

5.5 Effectiveness of interventions

5.5.1 ALS MDs vs BLS-D

The combined OR's for both of the studies in the ALS MDs vs BLS-D category showed a significantly greater chance of survival to hospital discharge when patients were treated by an ALS MD's group with an OR = 4.36 (95% C.I. 1.04 to 18.3) see Figure 2

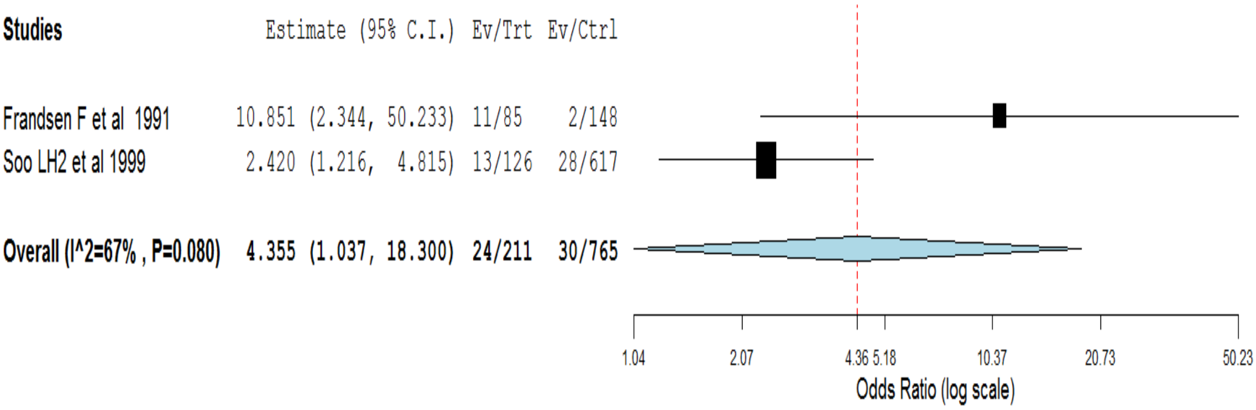

Figure 2: Forest Plot of ALS MDs vs BLS-D

5.5.2 ALS EMTs/Paramedics vs BLS-D

The combined OR for the five studies in the ALS EMTs/Paramedics vs BLS-D group showed a significantly greater chance of survival to hospital discharge when patients were treated by the ALS EMTs/Paramedics group with an OR = 1.22 (95% C.I 1.03 to 1.45) See Figure 3.

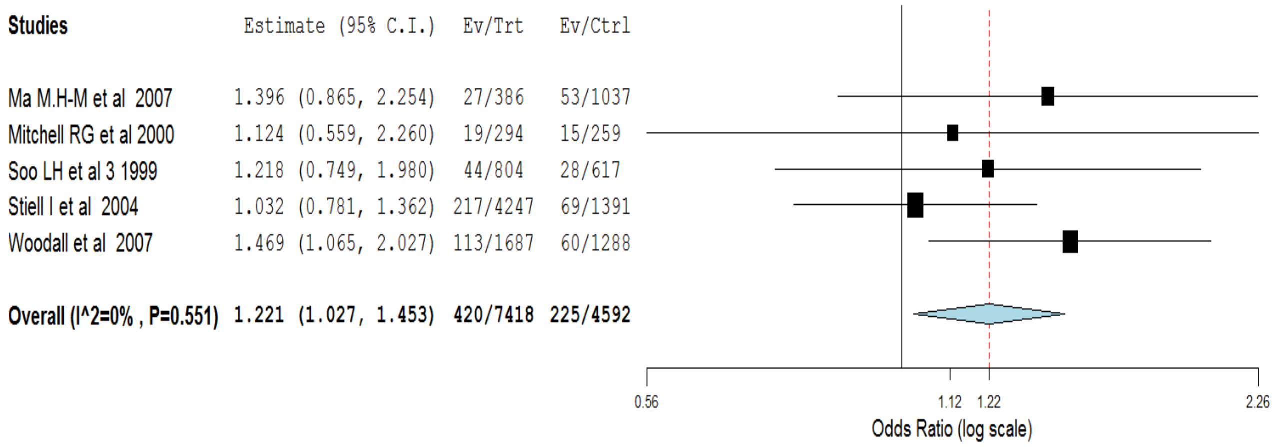

Figure 3: Forest Plot of ALS EMTs/Paramedics vs BLS-D

5.5.3 ALS MDs vs ALS EMT/Paramedics

The four studies in the ALS MDs vs ALS EMT/Paramedics group (figure 4) show that there is non-significant increase in the survival to hospital discharge rate amongst the ALS MDs group, with an OR of 1.57 (95%C.I. 0.65 to 3.82).

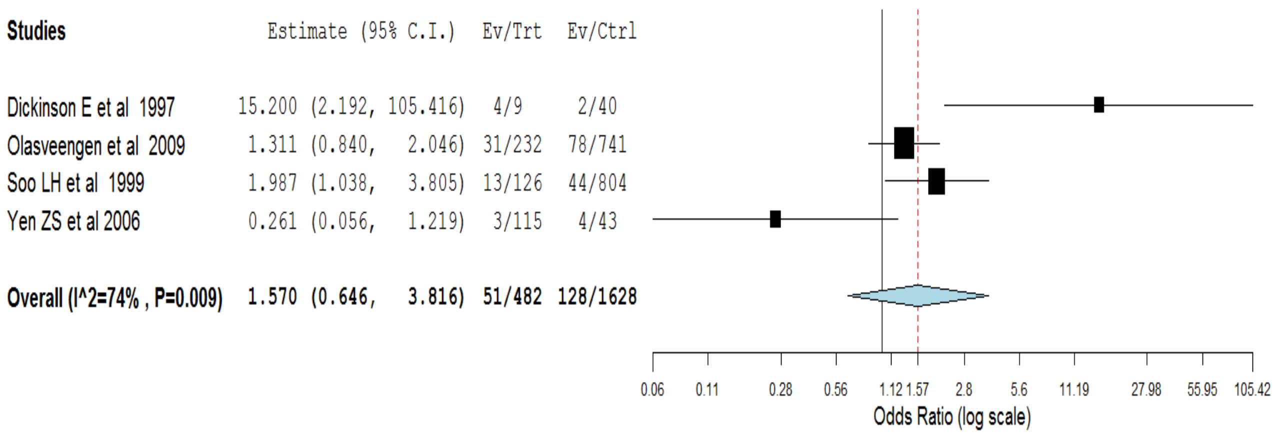

Figure 4: Forest Plot of ALS MDs vs ALS EMT/Paramedics

5.6 Heterogeneity / subgroup analysis

One of the difficulties in reviewing trials related to OHCA is the issue of heterogeneity. The knowledge and available technology have changed tremendously in the past 30 to 40 years. Skills which were once performed only by ALS MDs, such as defibrillation and the administration of certain medications, are now performed by Paramedics and EMTs, and in many instances offered as part of BLS services. Bystander assistance has improved greatly with the continued efforts from organizations such as the American Heart Association and the Red Cross, who offer CPR and AED courses to laypersons.

Deliberate efforts were taken in the selection of articles for this review, in order to reduce the differences in EMS service and care levels. Studies which were performed prior to 1985 were not included. Only articles which clearly stated who provided the care (EMT, Paramedic, MD), what level of care was provided (BLS or ALS), and what skills were included in each level of care (CPR, ventilation, defibrillation, administration of medication) were included. The studies chosen also treated similar types of patients, meaning adult patients with non-trauma OHCA.

It would not be practical to find many studies which used the exact same definitions and treatments for the same patients, but the studies chosen for this review are similar enough to allow for meaningful comparison.

There is also the issue regarding the time it takes for the EMS services to begin treatment. While there is a lot of discussion regarding this topic, it was felt that this particular issue addresses how care is delivered, and not who provides the best care. Perhaps after determining who provides the best care, the next topic could be how to best deliver that care in different settings.

6 DISCUSSION

6.1 Summary of results

There was a significantly better probability of survival to hospital discharge when patients were treated by an ALS team, compared to BLS-D services. This increased probability was seen for both ALS-MDs and ALS EMT/Paramedics groups. Of the two ALS groups, the ALS-MDs group had the greater probability of survival to hospital discharge.

In the comparison of ALS MDs to ALS EMT/Paramedics, patients treated by the MDs also had a greater, although not significant, probability of survival.

6.2 Completeness and applicability of evidence

In the planning phase of this study, it was difficult to decide what limiting factors to use when identifying studies for inclusion. There are many large reviews of OHCA previously conducted which combine and compare a multitude of different patient types, care levels, and secondary outcomes. These reviews often don't provide clinically meaningful recommendations regarding the care of OHCA for non-trauma patients. Instead, they unfortunately become "meta-descriptions". This review included 9 studies, which were found to be of good quality, compared similar patients, where similar levels of care were provided for each subgroup.

Since the key search terms originally chosen brought up over 60,000 possible titles, it was necessary to use several limiting factors, including language. Excluding studies not written in English could have excluded some articles. However, since this review includes articles from several countries (Australia, Canada, Denmark, Norway, Taiwan, UK, and USA), it appears that non-native English speaking countries are also being included.

The treatment categories of BLS-D, ALS-MDs, and ALS EMT/Paramedics were considered more as concepts, and they were defined using minimum standards of care in order to ensure a level of comparability. The hope was to identify which service, as a concept, provides the best outcome. If a definitive conclusion regarding the best treatment category can be reached, then discussions about what specific skills or medical treatments to include in the treatment category, how to best deliver the care, etc can be discussed with more relevance in the future.

Since EMS services in many countries do include a 2-tiered system, BLS and ALS services, it was felt that the three treatment categories used in the review have a good overall representativeness and general applicability worldwide. If not all three of the services are used, at least BLS and one form of ALS are used.

6.3 Quality of evidence

The studies included in this review had a good overall level in the quality of evidence. Only one category of bias had studies with a "High" risk rating. Six studies were rated as having a "High" risk of bias in regards to the sequence generation process used when determining what service would respond to the patient. In a "before-after" type of study, which measures the change in care quality after a new treatment category is introduced, it is difficult to have any system of random response. The patients cannot be assigned to a different treatment category in a specific geographic location, if only one category is available there. It was also noted in some of the "High" risk studies that the randomization table followed by the EMS dispatch services could not be followed if the EMS unit was not in the area, or was already engaged with another patient. It would be unethical to leave the patient for an extended period of time without care in order to adhere to the dispatch randomization schedule. Since these exclusions to adherence were noted in the articles and the schedules were followed when possible, the authors have taken appropriate steps to ensure that quality of evidence was as good as could be expected given the situation.

The bias categories of "allocation concealment" and "blinding of participants" in some studies were marked as being "uncertain". These designations stem from the same issue mentioned above. In "before-after" studies, when there is only one option for care to be provided, allocation concealment and blinding of participants becomes virtually impossible. This should not be considered as a reason to demean the quality of the study, since by the design of the study it is not possible to include these elements.

6.4 Potential biases

One area where the potential for bias exists is in the exclusion of studies not written in English. It was not feasible to review all of the potentially relevant literature in all languages. However, since articles from non-native English speaking countries are commonly published in English, it is possible to get some level of representativeness, if not collecting every single potential article. This review contained articles from several countries, hopefully minimizing any bias creating by limiting the study language.

The study exclusion process could also be an area where potential bias was introduced. Since the initial search terms resulted in over 600,000 possible articles, it became necessary to refine the searches and add limitations. Several layers of refinement were needed in order to bring the result level to something that could be reviewed. It would have been incredibly time consuming to review abstracts for 10,000 papers, for example. A large list of key terms was used, and search trees were exploded in order to identify related key terms which may include eligible studies. However, it is possible that there are existing studies which did not use the same Key words or Mesh terms, and were not included

As one method to try to locate any such articles, I reviewed all of the articles listed in the bibliographies of all the studies which had been chosen for inclusion. I also went to the internet search engines Google and Bing, and searched using several related key words.

7 CONCLUSIONS

7.1 Implications for practice

In the comparisons between BLS-D and ALS services, the ALS services were found to have significantly better outcomes, with the ALS MD group rating the highest, OR 4.36 (95% C.I. 1.04 to 18.3). The comparison of ALS MDs to ALS EMT/Paramedics also favored the ALS MD groups (OR of 1.57), although the result was not significant (95%C.I. 0.65 to 3.82). Since the ALS MD treated patients had a much greater chance to survive to hospital discharge, albeit non-significantly in one of the two comparisons, this would strongly suggest that ALS MD units are the best method of responding to non-traumatic OHCA.

When hospitals or health care authorities are planning and providing existing and future EMS services, they should consider the ALS MD unit as the primary response unit. ALS Paramedic/EMT units should not necessarily be removed from health care services, but can be reprioritized and dispatched to different types of patients. It is in the best interest of the patient, (he/she has a better chance to survive), and the hospital, in so far as it is a more efficient use of their resources/services.

7.2 Implications for research

This study does not proffer any specific areas or items which should be included for future research. Instead, it offers a concrete starting point, so that future studies can focus on the specific aspects of care to be included in OHCA care, and not continuing the discussion about who is best suited to provide those services. Intriguing topics of current discussion include response times and methods to improve them and the use of new medical treatment methods such as CardioCerebro Resuscitation or mild therapeutic hypothermia.

8. REFERENCES

References for included studies

Dickinson ET, Schneider RM, Verdile VP. The impact of prehospital physicians on out-of-hospital nonasystolic cardiac arrest. Prehosp Emerg Care. 1997; Jul-Sep;1(3):132-5.

Frandsen F, Nielsen JR, Gram L, Larsen CF, Jørgensen HR, Hole P, Haghfelt T. Evaluation of intensified prehospital treatment in out-of-hospital cardiac arrest: survival and cerebral prognosis. The Odense ambulance study. Cardiology. 1991;79(4):256-64.

Ma MHM, Chiang WC, Ko PCI, Huang JCC, Lin CH, Wang HC, Chang WT, Hwang CH, Wang YC, Hsiung GH, Lee BC, Chen SC, Chen WJ, Lin FY. Outcomes from out-of-hospital cardiac arrest in Metropolitan Taipei: Does an advanced life support service make a difference?. Resuscitation. 2007;74, 461-469.

Mitchell RG, Guly UM, Rainer TH, Robertson CE. Paramedic activities, drug administration and survival from out of hospital cardiac arrest. Resuscitation. 2000;43, 95–100.

Olasveengen TM, Lund-Kordahl I, Steen PA, Sunde K. Out-of hospital advanced life support with or without a physician: Effects on quality of CPR and outcome. Resuscitation. 2009; 80, 1248–1252.

Soo LH, Gray D, Young T, Huff N, Skene A, Hampton JR. Resuscitation from out-of-hospital cardiac arrest: is survival dependent on who is available at the scene?. Heart. 1999;81:47–52.

Stiell, IG, Wells GA, Field B, Spaite WB, Nesbitt LP, De Maio VJ, Nichol G, Cousineau D, Blackburn J, Munkley D, Luinstra-Toohey L,Campeau T, Dagnone E, Lyver M, for the Ontario Prehospital Advanced Life Support Study Group. Advanced Cardiac Life Support in Out-of-Hospital Cardiac Arrest. N Engl J Med 2004;351:647-56.

Woodall J, McCarthy M, Johnston T, Tippett V, Bonham R. Impact of advanced cardiac life support-skilled paramedics on survival from out-of-hospital cardiac arrest in a statewide emergency medical service Emerg Med J 2007;24:134–138.

Yen ZS, Chen YT, Ko P C-I, Ma MHM, Chen ST, Chen WJ, Lin FY. Cost-effectiveness of Different Advanced Life Support Providers for Victims of Out-of-hospital Cardiac Arrests. J Formos Med Assoc 2006;105(12):1001 - 1007

References for excluded studies

Brison RJ, Davidson JR, Dreyer JF, Jones G, Maloney J, Munkley DP, O'Connor M, Rowe BH. Cardiac arrest in Ontario: circumstances, community response, role of prehospital defibrillation and predictors of survival. CAN MED ASSOC J 1992; 147 (2): 191-199

Estner HL, Gunzel C, Ndrepepa G, William F, Blaumeiser D, Rupprecht B, Hessling G, Deisenhofer I, Weber MA, Wilhelm K, Schmitt C, Schomig A. Outcome after out-of-hospital cardiac arrest in a physician-staffed emergency medical system according to the Utstein style. Am Heart J 2007; 153(5):792-799.

Eisenburger P, Czappek G, Sterz F, Vergeiner G, Losert H, Holzer M, Laggner AN. Cardiac arrest patients in an alpine area during a six year period. Resuscitation 2001;51: 39–46.

Groh WJ, Newman MM, Beal PE, Fineberg NS, Zipes DP. Limited Response to Cardiac Arrest by Police Equipped with Automated External Defibrillators: Lack of Survival Benefit in Suburban and Rural Indiana—The Police as Responder Automated Defibrillation Evaluation (PARADE). Acad Emerg Med 2001;8(4): 324-330.

Myerburg RJ, Fenster J, Velez M, Rosenberg D, Lai S, Kurlansky P, Newton S, Knox M, Castellanos A. Impact of Community-Wide Police Car Deployment of Automated External Defibrillators on Survival From Out-of-Hospital Cardiac Arrest. Circulation 2002; 106:1058-1064.

Rainer TH, Marshall R, Cusack S. Paramedics, technicians, and survival from out of hospital cardiac arrest. Accid Emerg Med 1997; 14:278-282.

Sipria A, Talvik R, Korgvee A, Sarapuu S, Oopik A. Out-of-Hospital Resuscitation in Tartu: Effect of Reorganization of Estonian EMS System. AMERICAN JOURNAL OF EMERGENCY MEDICINE 2000;18(4): 469 – 473.

Additional references

AHA Releases Latest Statistics on Out-of-Hospital Cardiac Arrest. Sudden Cardiac Arrest Association 2.13.2014.
http://www.sca-aware.org/sca-news/aha-releases-latest-statistics-on-out-of-hospital-cardiac-arrest

Atwood C, Eisenberg MS, Herlitz J, Rea TD. Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. Resuscitation 2005;67:75–80.

Berdowski J, Berg RA, Tijssen J GP, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. Resuscitation 2010;81:1479–1487.

Berg R, Hemphill R, Abella B, Aufderheide T, Cave D, Hazinski M, Lerner E, Rea T, Sayre M, Swor R. Part 5: Adult Basic Life Support 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122[suppl]:S685–S705.

Cave DM, Gazmuri RJ, Otto CW, Nadkarni VM, Cheng A, Brooks SC, Daya M, Sutton RM, Branson R, Hazinski MF. Part 7: CPR techniques and devices: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation.2010;122(suppl 3):S720 –S728.

Hollenberg J, Svensson L, Rosenqvis M. Out-of-hospital cardiac arrest: 10 years of progress in research and treatment. Journal of Internal Medicine, 2013, 273; 572–583

Link M,. Atkins D, Passman R, Halperin H, Samson R, White R, Cudnik M, Berg M, Kudenchuk P, Kerber R. Part 6: Electrical Therapies Automated External Defibrillators, Defibrillation, Cardioversion, and Pacing 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122[suppl 3]:S706 –S719.)

Mohler MJ, Wendel CS, Mosier J, Itty A, Fain M, Clark L, Bobrow M, Sanders AB. Cardiocerebral Resuscitation Improves Out-of-Hospital Survival in Older Adults. JAGS 2011;59:822–826.

Nolan JP, Hazinski MF, Billi JE, Boettiger BW, Bossaert L, de Caen AR, Deakin CD, Drajer S, Eigel B, Hickey RW, Jacobs I, Kleinman ME, Kloeck W, Koster RW, Lim SH, Mancini ME, Montgomery WH, Morley PT, Morrison LJ, Nadkarni VM, O'Connor RE, Okada K, Perlman JM, Sayre MR, Shuster M, Soar J, Sunde K, Travers AH, Wyllie J, Zideman D. Part 1: executive summary: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation 2010;81:e1-e25

Proclemer A, Dobreanu, Pison L, Lip G Y-H, Svendsen JH, Blomstrom-Lundqvist C. Current practice in out-of-hospital cardiac arrest management: a european heart rhythm association EP network survey. Europace 2012; 14: 1195–1198.

Sasson C, Rogers MAM, Dahl J, Kellermann, AL. Predictors of Survival From Out-of-Hospital Cardiac Arrest - A Systematic Review and Meta-Analysis. Circ Cardiovasc Qual Outcomes 2010;3:63-81.

Travers AH, Rea TD, Bobrow BJ, Edelson DP, Berg RA, Sayre MR, Berg MD, Chameides L, O'Connor RE, Swor RA. Part 4: CPR overview: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122(suppl 3):S676 –S684.

Capucci A, Aschieri, D, Piepoli, M.F., Bardy G, Iconomu E, Arvedi M. Tripling Survival From Sudden Cardiac Arrest Via Early Defibrillation Without Traditional Education in Cardiopulmonary Resuscitation. Circulation 2002; 106:1065-1070.

Yasunaga, H, Miyata H, Horiguchi H, Tanabe S, Akahane M, Ogawa T, Koike S, Imamura T. Population density, call-response interval, and survival of out-of-hospital cardiac arrest. Int J Health Geogr 2011; 10:26.

Lyon R M, Nelson M J. Helicopter emergency medical services (HEMS) response to out-of-hospital cardiac arrest. Scand J Trauma Resusc Emerg Med 2013; 21:1.

Ewy G. Another step towards the acceptance of chest compression only CPR for primary cardiac arrest. Evid Based Nurs January 2014; volume 17: number 1.

IMeex I, De Deyne C, Dens J, Scheyltjens S, Lathouwers K, Boer W, Vundelinckx G, Heylen R, Jans F. Feasibility of absolute cerebral tissue oxygen saturation during cardiopulmonary resuscitation. Critical Care 2013; 17:R36.

Belohlavek J, Kucera K, Jarkovsky J, Franek O, Pokorna M, Danda J, Skripsky R, Kandrnal V, Balik M, Kunstyrj, Horak J, Smid O, Valasek J, Mrazek V, Schwarz Z, Linhart A. Hyperinvasive approach to out-of hospital cardiac arrest using mechanical chest compression device, prehospital intraarrest cooling, extracorporeal life support and early invasive assessment compared to standard of care. A randomized parallel groups comparative study proposal. "Prague OHCA study". J Transl Med 2012; 10:163.

Ong M, Fook-Chong S, Annathurai A, Ang S, Tiah L,Yong K, Koh Z, Yap S, Sultana P. Improved neurologically intact survival with the use of an automated, load-distributing band chest compression device for cardiac arrest presenting to the emergency department. Critical Care 2012; 16:R144.

Drennan, S, Thorpee K.E., Morrison L. The effect of time to defibrillation and targeted temperature management on functional survival after out-of-hospital cardiac arrest. Resuscitation 2014; 85: 1623–1628.

Fröhlich G, Lyon R, Sasson C, Crake T, Whitbread M, Indermuehle A,Timmis A, Meier P. Out-of-Hospital Cardiac Arrest –Optimal Management. Curr Cardiol Rev, 2013;9: 316-324.

References for table 3 (URL links for EMT Schools)

First Line Response Professionalism Through Experience. Level 3 EMT-B. (Accessed 05.2015)
http://www.firstlineresponse.co.uk/training/medical/emt-b-emergency-medical-technician/#

Irish Ambulance Training Institute. EMT. (Accessed 05.2015)
http://www.ambulancetraining.ie/index.php?page=emergency-medical-technician

Medicall Ambulance Service. Emergency Medical Technician (EMT) - PHECC Registered Practitioner. (Accessed 05.2015)
http://www.medicall.ie/medicall-courses/emt/emergency-medical-technician

Crown Training Academy Training and Courses in South Wales. TQUK Endorsed Level 3 National Award in Pre-Hospital Emergency Medical Technician - Basic/ Intermediate. (Accessed 05.2015)
http://www.crownmedicaltraining.co.uk/pre_hospital_care/pre_hospital_emergency_medical_technician.html

E. Broda. HCC Paramedic. Hillsboro Community College. 11 November 2012
http://www.hccfl.edu/departments/health-science/ems-programs/curriculum-emt-program.aspx

Florida Southwestern State College. Emergency Medical Technician-Certificate. (Accessed 05.2015)
https://www.fsw.edu/academics/programs/certemt

National Outdoor Leadership School. Wilderness Emergency Medical Technician. (Accessed 05.2015)
http://www.nols.edu/wmi/courses/wemt.shtml

Foothill College. BIOLOGICAL & HEALTH SCIENCES DIVISION EMERGENCY MEDICAL TECHNICIAN. 24 April 2014
http://www.foothill.edu/bio/programs/emt/

Ozark Technical Community College. EMT (Basic & Intermediate) & Paramedic. (Accessed 05.2015)
https://www.otc.edu/alliedhealth/1896.php

Sait Polytechnic. Emergency Medical Technician. (Accessed 05.2015)
http://www.sait.ca/programs-and-courses/full-time-studies/certificates/emergency-medical-technician-course-overview.php

Prairie. Emergency Medical Responder/Technician (EMR/EMT) Certificate. (Accessed 05.2015)
http://www.prairie.edu/emt

First Response Australia. Emergency Medical Technician. (Accessed 05.2015) http://www.firstresponseaustralia.com.au/docs/courses/certificate/COURSE%20OUTLINE%20EMT.pdf

References for table 4 (URL links for Paramedic Schools)

Paramedics in Germany. Wikipedia. 9 October 2014
http://en.wikipedia.org/wiki/Paramedics_in_Germany#Curriculum

University of Hertfordshire. Paramedic Science BSc. (Accessed 05.2015)
http://www.herts.ac.uk/courses/bsc-hons-paramedic-science

PPA – INT Medical Training Center – Denmark. Accelerated Paramedic Course. (Accessed 05.2015)
http://www.ppa-int.com/index.php/component/k2/itemlist/category/2-paramedic-course

Helsinki Metropolia University of Applied Sciences. Emergency Care. 20 December 2014
http://www.metropolia.fi/en/degree-programmes/health-care-and-nursing/emergency-care/

Paramedic Training Program Curriculum. University of Washington 2015. (Accessed 05.2015)
https://depts.washington.edu/pmedic/node/18

E. Broda. HCC Paramedic. Hillsboro Community College. 11 November 2012
http://www.hccfl.edu/departments/health-science/ems-programs/curriculum-paramedic-program.aspx

Broohaven College. Paramedic Course Curriculum. (Accessed 05.2015)
https://www.brookhavencollege.edu/programs/hhs/ems/paramedic_program/Pages/curriculum_paramedic.aspx

Wharton County Junior College. Program Curriculum. 13 April 2015
http://www.wcjc.edu/Programs/vocational-science/emergency-medical-services/program-curriculum.aspx

Foothill College. Biological and Health Sciences Division Paramedic Department. 24 April 2014
http://www.foothill.edu/bio/programs/paramed/programs.php?title_id=Paramedic

Lansing Community College. Paramedic Program. (Accessed 05.2015)
http://www.lcc.edu/hhs/programs/paramedic/

Victoria University Melbourne Australia. Bachelor of Health Science (Paramedic). (Accessed 05.2015)
http://www.vu.edu.au/courses/bachelor-of-health-science-paramedic-hbpx

The University of Queensland. Bachelor of Paramedic Science (BParamedSc). (Accessed 05.2015)
https://www.uq.edu.au/study/program.html?acad_prog=2323

APPENDIX 1: CHARACTERISTICS OF INCLUDED STUDIES

Dickinson et al 1997

Methods	Retrospective case series
Participants	Individuals 18 years of age or older experiencing non-traumatic out-of-hospital cardiac arrest. Patients were grouped into those receiving care from an on-scene medical control physician (OSMCP), or those who only received initial treatment from paramedics.
Interventions	Interventions for OSMCP group and paramedic group were described as being similar in treatments provided (CPR, defibrillation, mechanical ventilation, drug administration) with the exception of administered medication volumes. The physician lead group reported an approximately 2-fold increase in the amount of medication administered per patient.
Outcomes	The physician led group more often had ROSC and had a higher rate of survival to hospital discharge.

Frandsen et al 1991

Methods	Retrospective cohort study
Participants	Adult patients experiencing out-of- hospital cardiac arrest who received pre-hospital cardiopulmonary resuscitation. One section of the study included patients from a rural setting, defined as having a population density of 570/km2. The second section was an urban setting defined as having a population density of 340/km2.
Interventions	EMS services were offered on a 3-tier system (BLS-D, ALS-Paramedics, and ALS MD's).
Outcomes	The ALS MD service had the highest survival to hospital discharge rate in both urban and rural settings. A psychological evaluation and cerebral function test were performed on long-term survivors, and 11 control subjects. Patients with more intensive pre-hospital treatment (ALS MD) had the best survival to hospital discharge rate and best cerebral function.

Ma et al 2007

Methods	Prospective cohort study
Participants	All adult (≥18 years), OHCA that activated EMS were included in the study. Traumatic injury patients and those for whom resuscitation was not attempted were excluded.
Intervention	At the onset of the study ALS Paramedic services were being introduced into an area consisting of 12 smaller regions which previously only had BLS-D services. Only two of the 12 study regions introduced ALS Paramedic services. Existing BLS-D services performed CPR and defibrillation. ALS services offered in addition to BLS-D services, tracheal intubation and administration of IV medication.
Outcomes	ALS Paramedic services had a 9% higher ROSC, but only a 2% higher rate of survival to hospital discharge, compared to BLS-D services. Bystander CPR was a positive predictor for survival to hospital discharge. ALS Paramedic services provided better outcomes for patients who initially did not receive bystander CPR or had asystole.

Olasveengen et al 2009

Methods	Prospective cohort study
Participants	All patients older than 18 years old with non-traumatic OHCA of all causes.
Intervention	The patients were retrospectively categorized into three groups: 1- those treated by the ALS MD group, 2- those treated initially by an ALS EMT/Paramedic group followed by the ALS MD group, and 3- only ALS EMT/Paramedic groups (non-PMA group).
Outcomes	The ALS EMT/Paramedic group had a slightly higher rate of ROSC and hospital admittance, while the ALS MD group had a 2% higher rate of survival to hospital discharge. ALS MD groups also defibrillated more often than ALS EMT/Paramedics.
Note	For the final analysis, only comparisons between the 1^{st} and 3^{rd} group were offered. The second group was not included in the final analysis since it was felt to be a highly selective subgroup, and was only utilized when the ALS EMT/Paramedic group called in requesting backup.

Soo et al 1999

Methods	Retrospective cohort study
Participants	All patients in the catchment area of one ambulance service who experienced OHCA from verified or suspected cardiac etiology. Exclusions included drug overdoses, suicide, drowning, hypoxia, exsanguinations, cerebrovascular accident, subarachnoid hemorrhage, trauma, ruptured aortic aneurism, and pulmonary thrombosis.
Intervention	BLS-D, ALS EMT/Paramedic, and ALS MD units were all available during the entire length of the study. Additionally, there were interventions performed by EMTs only, without the assistance of Paramedics, and Paramedic only units. Intervention was not attempted when no bystander CPR had been performed for at least 15 minutes, or if the patient already had rigor mortis.
Outcomes	ALS MD groups had the highest rate of survival to hospital discharge followed by the ALS EMT/Paramedic group, and lastly the BLS-D group. There were also Paramedic only groups (see note below) which had higher odds of survival compared to the EMT only group, BLS-D, and ALS EMT/Paramedic groups.
Notes	During the study period there was a large increase in the number of qualified paramedics, as opposed to EMTs. Over a 4-year period the number of Paramedics increased from 22 to 116. This resulted in an increased proportion of patients receiving Paramedic care, versus the other treat groups. For the final analysis in this review Technician only, Paramedic only, and Technician and Paramedic groups were all combined into one group, BLS-D, since this matches the original treatment group definitions.

Stiell et al 2004

Methods	Before-After prospective cohort study
Participants	All individuals 16 years or older who experienced OHCA and resuscitation was attempted. Reasons for exclusion include being younger than 16 years of age, determined to be dead upon EMS arrival, patient had traumatic injury, or had disorder which clearly had a non-cardiac etiology.
Intervention	The first phase of the study includes only care provided by BLS-D units for a one year period of time. The second phase includes the introduction of newly trained ALS EMT/Paramedic groups for a three year period.

Outcomes	There was no distinguishable difference in survival to hospital discharge in either group.

Woodall et al 2007

Methods	Retrospective cohort study
Participants	All individuals 18 years or older who experienced OHCA and for whom resuscitation was attempted. Exclusion criteria included anyone who was not of age, or if cardiac arrest was not felt to be of primarily cardiac etiology. Cardiac etiology was assumed in men greater than 40 years of age and women greater than 50 years of age when determination of other etiology was not possible.
Intervention	The study included care provided by BLS-D and ALS EMT/Paramedic units during a three year period. ALS EMT/Paramedic are automatically dispatched first for OHCA calls. BLS-D units responded only when ALS EMT/Paramedic units were not available.
Outcomes	ALS EMT/Paramedic treated individuals had a higher probability to survive to hospital discharge compared to BLS-D units (chi squared 6.70 and 4.66 $p = 0.03$). Authors hypothesize that the ALS EMT/Paramedic units may have had a better score since they were more efficient in choosing which patients should receive resuscitation and/or be sent to the hospital for further treatment.

Yen et al 2006

Methods	Prospective observational study
Participants	All patients experiencing OHCA of non-traumatic origin who were transported to a hospital for further care. Patients were limited to those in the catchment area of the nine participating major medical centers.
Intervention	Care was provided in eight hospital centers by ALS MD units. In the ninth hospital, ALS EMT/Paramedic units were dispatched to OHCA calls. ALS-MD units were dispatched only when ALS EMT/Paramedic were not available (already fully engaged).
Outcomes	The ALS EMT/Paramedic units had a better survival to hospital discharge compared with the ALS MD groups.