01 Introduction

Introductory remarks
Cardiac arrest affects hundreds of thousands of people worldwide each day. To reverse this cause of sudden death, early basic life support (BLS) is necessary.
BLS refers to maintaining airway patency and supporting breathing and circulation, without the use of equipment other than a protective device.\(^1,^2\) BLS includes recognition of signs of sudden cardiac arrest, cardiopulmonary resuscitation (CPR); and defibrillation with an automated external defibrillator (AED).\(^3,^4\) Early BLS refers to BLS administered by bystanders and can double survival rates compared to situations where treatment is delayed until professional ambulance crews start life support.\(^5-^9\) In this thesis education in BLS is defined as education in CPR and AED use.

Utstein Formula of Survival
The ‘Utstein Formula of Survival’ underscores that survival after cardiac arrest depends on medical science, education and local implementation.\(^10\) Medical science provides evidence-based data for the best way to deliver rescue breathing and chest compressions, the optimal energy and electrical wave-form for defibrillation, and the most effective drugs to restore or maintain blood circulation. Education refers to providing lay rescuers and professional healthcare providers with the skills they need to provide effective resuscitation and make life-saving decisions. Local implementations refer to the local dispatch and Emergency Medical System (EMS), the facilities in the receiving hospital and the local level of education.

![The Utstein Formula of Survival](image)

*Figure 1.*
The Utstein Formula of Survival.\(^10\)
(Reproduced with permission of Laerdal Medical AS)
Chain of Survival
A second concept, and the core issue in resuscitation, is the ‘Chain of Survival’.\textsuperscript{11-18} (Figure 2) The Chain of Survival describes for the actions needed to manage a case of circulatory arrest in terms of links in a chain. This concept addresses the interdependencies of the actions. The first link is related to the pre-event phase and to the first action in cardiopulmonary resuscitation. As a pre-event component, it focuses on prevention of cardiac arrest through early recognition of the symptoms such as chest pain and the need for rapid activation of the EMS. The second link addresses the rapid start of basic life support, especially CPR, and the third link addresses prompt defibrillation. The fourth link refers to advanced life support (ALS) and the post-resuscitation care provided by professional health care providers at the scene of the event, subsequently, in hospital where a large variety of therapies and resources are available to resuscitate and stabilize a patient following circulatory arrest. The chain of survival is only as strong as its weakest link. The chance of survival is low if a bystander does not recognize the symptoms of cardiac arrest, if there are no trained BLS providers (lay rescuers) immediately available, or when the EMS is not able to start ALS in time. All links need to be present in order to optimize the chances of survival; if even one of the links in the Chain of Survival is absent or ignored, survival rates plummet to next to zero. This thesis focuses on the second (CPR) and third (defibrillation) links. More specifically, it focuses on the educational aspects of CPR and early defibrillation by lay rescuers with an AED.

Figure 2.
\textit{Chain of survival.}\textsuperscript{18}
(Reproduced with permission of Laerdal Medical AS)
In a study by Waalewijn et al. (2001) in the suburbs of Amsterdam it was shown that when resuscitation was started after arrival of the EMS, survival was 6%, whereas when resuscitation was started immediately by bystanders (lay people), survival was 22%. If lay people can also provide early defibrillation survival rates can increase to 48%.\textsuperscript{19,20} (Figure 3)

Defibrillation became a real option for lay rescuers after the introduction of the automated external defibrillator (AED) in the 1990s. An AED is a computerized medical device that can recognize potential lethal cardiac arrhythmia’s and administer a defibrillation shock to restore normal rhythm. Voice prompts, lights and text messages guide the rescuer through the steps for defibrillation, and advise the rescuer that a shock is needed. These devices have become increasingly popular and widespread since their introduction. The exact number of AEDs in The Netherlands is unknown, but distributors estimate that there are more than 30,000 within the country.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3}
\caption{Calculated survival as function of time to first defibrillatory shock; the large difference in survival between shockable (plain lines) versus nonshockable initial rhythm (dashed line) is shown. There is a more rapid decrease in survival when basic CPR is not started (bold line) and a less rapid decrease when basic CPR is initiated after 0, 2, 4, 6, 8 min (thin lines) is shown.\textsuperscript{*}}
\end{figure}

\textsuperscript{*}Reprinted from Resuscitation 2001;51, Waalewijn RA, De Vos R, Tijssen JGP, Koster RW. Survival models for out-of-hospital cardiopulmonary resuscitation from the perspectives of the bystander, the first responder, and the paramedic, 113—22, copyright 2001, with permission from Elsevier.
Changing training concepts

The first CPR training courses for lay rescuers took place in the 1950s. Health care professionals, mainly anaesthesiologists, ran these courses for fire-fighters, the unemployed and even to prisoners. (Figure 4)

Course design has changed dramatically over the years. In the Netherlands, the instructor:student ratio in the Netherlands changed from 1:10 in 1982\textsuperscript{22}, to 1:15 in 1989\textsuperscript{23} and finally 1:6 in 2000.\textsuperscript{24} Early courses lasted 6 hours for CPR\textsuperscript{22} and 12 hours for the use of an AED.\textsuperscript{25} By contrast, a combined CPR and AED training currently lasts 4 hours.\textsuperscript{26} Teaching materials have also progressed from flip-over charts and projected slides to PowerPoint presentations. Manikins have become more sophisticated, but the style of student/learner manuals has only changed as a result of new guidelines.\textsuperscript{27-31}

A Consensus on Science is reached every five years, based on the most recent scientific evidence. This procedure is co-ordinate by the International Liaison Committee on Resuscitation, and each participating Council formulates Guidelines based on this Consensus on Science. For Europe the European Resuscitation Council (ERC) publishes European Guidelines for Resuscitation.\textsuperscript{32} Course contents changed along with guidelines for resuscitation.\textsuperscript{2,33,34}

The emphasis of BLS training has changed from lecture-based training to hands-on training,\textsuperscript{35} but the courses have remained instructor-based throughout. The role of the instructor is to teach the students what to do and how to improve resuscitation skills through direct feedback, correction and demonstration. In recent years there has been a growing tendency towards other methods training lay rescuers in resuscitation techniques. For this thesis the current ERC Guidelines were those of 2000 and 2005.\textsuperscript{2,33,34} Those of 2000 for the studies in Chapters 4 till 6, and those of 2005 for the studies in Chapters 3 and 7.
The educational problem of teaching CPR and AED
Cardiac arrest is an uncommon situation for a lay rescuer to encounter. However, the lay rescuer has to recognize the acute nature of the situation immediately and to recall skills and knowledge within seconds. The transfer of the knowledge from simulated situations to real action has to take place during and immediately after training. It is important that the skills learned in the classroom can be applied during real life events. Although millions of lay rescuers have been trained in CPR and AED, many studies have concluded that CPR skill retention is very poor.36-42
There is therefore a great need to identify and develop better educational methods to increase skill retention in lay rescuers. Improving training efficacy might be one way to solve the problem of poor skill retention, but another way might be to change the training method. This thesis aims to contribute to an improved quality of education of cardiopulmonary resuscitation and the use of automated external defibrillators.

Definition of the problem
Each year millions of lay rescuers all over the world are trained and retrained in BLS during instructor based training to groups of 4-8 students. It is important to investigate the efficiency of this trainings. It is even more important to investigate if alternative methods of training can be applied. These alternative training methods should result in increased retention or faster retrieval of skill knowledge.

Outline of the thesis
The next chapter of this thesis (Chapter 2) describes the conceptual framework: some basic assumptions about education in general and about education in CPR and use of the AED in particular. Based on the assumption that learning environments will be subject to fewer restrictions of time, place and method, and that less sophisticated teaching materials will be needed, a study was developed to compare different training methods with the help of a DVD, featuring inflatable small manikins and a generic ‘mouse pad’ AED device (Chapter 3).
Chapter 4 assesses the relationship between learning skills during training situations and the application of these skills in a real event. This study aims to test whether skills learned in the classroom will in fact be applied in real-life events. Evidence that CPR and AED skills can and will be used, and that education is, therefore, useful, will serve as a basis for exploring new training methods.
The next chapters focus again on education (Formula of Survival) in CPR and AED (second and third link of the Chain of Survival) techniques, using materials ranging from posters sophisticated manikins, AED trainers (Chapters 5 and 6), to just a computer screen without any additional training materials (Chapter 7). Chapter 8 discusses the results of the studies and the potential consequences for evidence-based insights in education. One important conclusion is that the classical method of analyses of training results (ANOVA, Kruskal Wallis test, Mann-Whitney test) is not appropriate and that a non-inferiority design, common in pharmaceutical research but uncommon in educational research, is more appropriate.

**Conflict of interest**
During the study described in Chapter 4, Wiebe de Vries was working for The Orange Cross as Head of Development and Education, and for the Dutch Resuscitation Council as Secretary. He had no conflicts of interest with regard to the distributors of the AEDs. During the studies described in Chapters 3, 5, 6, and 7, he was working as an educator for Doczero, a company involved in web-based design, including web-based training. The web-based program described and shown in Chapter 7 was developed by this company. The participants were working for a company that is part of the same parent company as Doczero, with a different core business (consultant and ad interim management). There were no direct professional or personal links between him and this company. Doczero did not interfere in any way in the design, analysis or presentation of the results of the studies.

The study materials described in Chapter 3 (MiniAnne’s®) were made available without any restrictions to the researchers by Laerdal Medical AS. The training poster described in Chapters 5 and 6 were developed by Wiebe de Vries during his employment at The Orange Cross, without any restrictions or orders from third parties. After Wiebe de Vries had left The Orange Cross, the organisation decided to outsource the production and distribution of the poster to PhysioControl/Medtronic. For purposes of the studies, the posters had to be obtained via regular commercial order by the hospital and lifeguard organization. The manuals in Chapter 5 and 6 were published by ThiemeMeulenhoff in collaboration with the European and Dutch Resuscitation Council, and also obtained via regular commercial order.
References


