Evaluation of the effects of the Advanced Paediatric Life-Support course

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Evaluatie van de effecten van de Advanced Paediatric Life-Support Course

(met een samenvatting in het Nederlands)

Proefschrift

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Contents

Introduction

1

Zorg voor een pakkend begin[1]

It is widely recognized that doctors are generally unacceptably poor at resuscitation and this has been shown to lead to unnecessary mortality.[2-7] Training at both undergraduate and postgraduate level has been found to be suboptimal in this area. This problem has been a potent stimulus for the development of structured resuscitation training in the form of life-support courses.[8-11] These courses have become very popular in the Netherlands and abroad, are widely advocated, and involve a large investment of time and money - but are they really effective?[12-17]

Before one can answer this question, it is important to pose another – what is meant by effectiveness? Ultimately, life support courses should contribute to the overall well-being of human beings, specifically by reducing mortality and morbidity from acute life-threatening illness. However, the courses cannot directly improve mortality but can only do so by affecting the behaviour of the practitioners they train, either in terms of direct patient care or of the organisation of that care. In order to have a positive effect on patient care the doctor needs to possess the necessary knowledge and skills and the appropriate attitude to use these in practice. A useful question in assessing the effectiveness of life-support courses is then: do the courses improve doctors' knowledge and skills and do they foster the right attitude, or, put another way, do doctors learn useful competencies on these courses? Of equal importance are the questions of whether doctors subsequently use these competencies in clinical practice and whether this contributes to the improvement in patient care and ultimately in patient outcome?

This relationship between life-support training and patient outcome is illustrated in the figure 1.1. Using this figure as a framework, it can be claimed with some justification that there is a fair amount of evidence that life-support courses are associated with improvements in knowledge and skills.[16;18-22] However, a considerable proportion of the newly learned knowledge and skills is quickly lost – in other words there is a problem of retention.[5;23-25] There is also evidence that doctors do change their behaviour after following life-support courses and also make potentially beneficial organisational changes.[26] Some research has also suggested that patient outcome can improve after doctors have followed life-support courses, but it has not been shown that this improvement correlates with changes in the doctors' behaviour.[27-33]

The effects of life-support courses on attitudes has been less well studied. Participants' reaction to life-support courses is generally very positive, but this does not mean that they have learned attitudes which are useful in clinical

[1] Start by gaining attention – advice and assessment criterion of the SHK and ALSG-NL instructor training course, acknowledging Gagne[1]

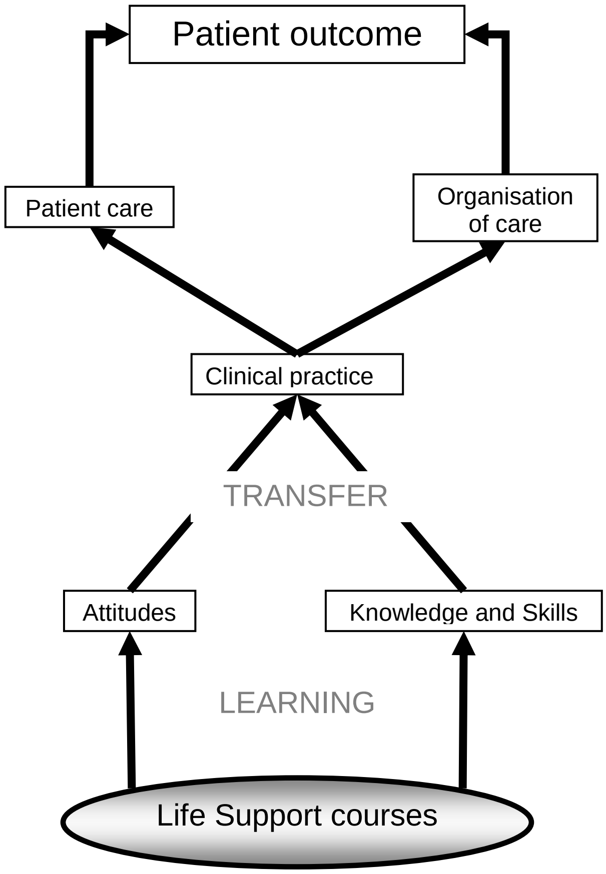

Figure 1.1: *Mechanism by which life-support courses can influence patient outcome.*

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practice.[18;34-36]

The potentially important role of attitudes in fostering transfer of new knowledge and skills to clinical practice has been largely left unstudied. One factor which is believed to be a determinant of behaviour and which can reasonably be regarded as an attitude is self-efficacy – a person's belief in their ability to deal effectively with situations.[1;37] Self-efficacy can be influenced by training and might be an important factor in transfer.

Of all the interesting research questions which arise from the preceding short discussion, this thesis will focus primarily on the issues of self-efficacy and retention as factors in the effectiveness of life-support courses. The five original investigations presented focus mainly on the Dutch Advanced Paediatric Life-Support (APLS) course. The first two studies concentrate on the measurement of self-efficacy, and the effect of the APLS on self-efficacy. The second two investigations look at the relationship between self-efficacy, performance and behaviour during a simulated resuscitation. The fifth study investigates a method of improving retention of factual and conceptual knowledge after a life-support course for medical students.

The rationale for choosing self-efficacy and retention as the focus for these studies will be presented in the next section of this introduction, in order to focus the reader's attention and whet his or her appetite for what follows. At the end of this chapter a theoretical model is presented which underlies and links the separate studies conceptually.

Many of the concepts mentioned in the next section will be explained in more detail subsequent sections which present relevant background information on the issues addressed in the studies and the general discussion. These are: the characteristics of training in emergency medicine; the particular importance of retention of knowledge and skills to emergency medicine; the characteristics of life-support courses; the principles of evaluation of educational interventions, and the social cognitive theory, in particular the construct of self-efficacy.

These sections have been kept deliberately broad because the thesis has been written to be of interest both to practicing clinicians involved in specialist training and continuing medical education in emergency medicine, and to those cognisant with the more theoretical aspects of medical education. In order to orientate this eclectic audience, the background information is presented, before the theoretical model is expounded.

Rationale for choosing the study objectives

Self-efficacy and retention are important issues in emergency medicine in general, and in life-support courses in particular. Both are significant determinants of what the doctor actually does in practice and have direct implications for patient care. Importantly, both self-efficacy and retention can be modified during and after life-support training with the aim of improving the doctor's competence and, ultimately, the patient's outcome.

Despite its importance to emergency medicine, self-efficacy has been little researched in this context and is worthy of further study for several reasons.

Firstly, the construct of self-efficacy is a predictor of behaviour. An individual with a stronger sense of self-efficacy for a particular task or procedure is more likely to perform it. Fears have been raised that children in particular might not receive prompt resuscitation because potential rescuers fear causing harm.[38] This problem might in part be related to a relative lack of self-efficacy and illustrates the potential importance of the construct to resuscitation.

In educational terms, self-efficacy is likely to be a predictor of transfer of techniques learned on the life-support courses to clinical practice. Whether a particular technique or task is actually carried out during a resuscitation attempt depends therefore on at least four factors: knowledge of the task (both procedural knowledge and background knowledge); physically ability to perform the task (skill); willingness to perform the task (preparedness) and sufficient belief in one's ability to dare to perform the task (self-efficacy) (figure 1.2).

Figure 1.2 also illustrates an important point of terminology which will be followed throughout the thesis. The ability to perform a specific professional task to the required standard is referred to in this work as a *competency*. This conceptualisation of a competency corresponds approximately to the concept of *behavioural capability* of social cognitive theory, and is distinct from the task itself which can be better described in other terms, such as those of *entrustable professional activities*.[39-41] Whether a doctor possesses a particular

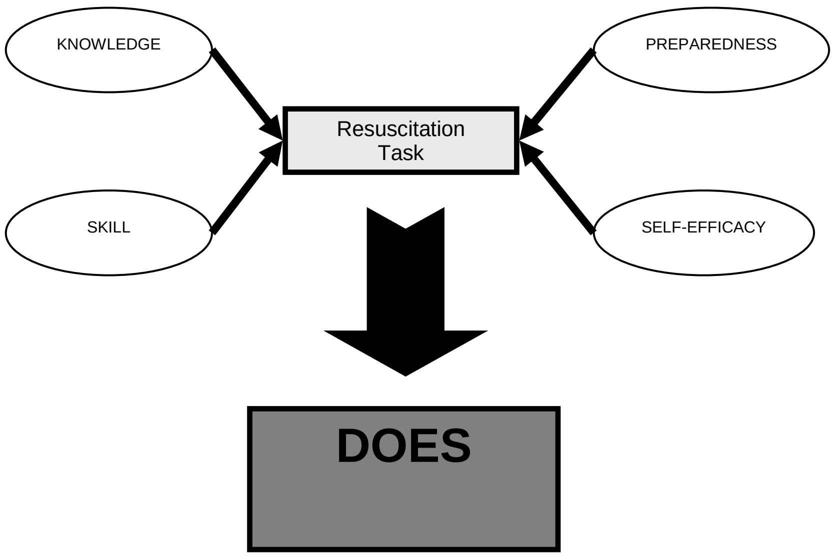

Figure 1.2: *Factors influencing whether a resuscitation task is performed.*

relevant task in a test situation. The term *competence* is reserved for that competency can be measured by assessing his or her performance on the attribute of professionals which is measured in terms of their actual performance in the course of their normal professional activities, which necessarily involves a range of professional tasks. Competence is a combination of ability and the satisfactory completion of actual tasks. It takes more than a set of competencies to become a competent practitioner in an emergency situation – attributes such as judgement, prioritisation, willingness and daring are also necessary. A clear distinction needs to be made between the immeasurable attribute of competence and its measurable expression in terms of performance.[42]

According to social cognitive theory, and as illustrated in the model in figure 1.2, lack of self-efficacy, even in presence of the other factors, could lead to a potentially beneficial procedure not being performed, which will have consequences for patient-outcome.

The second reason for studying self-efficacy in emergency medicine is that the relationship between self-efficacy and self-assessment has not been previously studies in this context. Self-efficacy might be found to correlate with quality of performance of resuscitation tasks and might therefore have a role in self-assessment of resuscitation ability.

A third motivation for self-efficacy research is related to the finding that a person's strength of self-efficacy correlates with the likelihood that they will engage in and persevere with deliberate practice.[37] In the next chapter an argument is made that complex skills are difficult to learn in the short time available on a life support course. Continued practice after the course is therefore essential if the relevant procedures are to be fully mastered.[43] Increasing self-efficacy might therefore improve learning subsequent to the course through its effect on perseverance.

A fourth reason for studying self-efficacy concerns attitudes in general. Despite the great importance placed on attitude learning in medical education, changes in attitudes have been relatively little studied in relation to life-support courses. An attitude can be defined as "a persisting state that predisposes an individual's choice behaviour"[1] and can be assessed either by behavioural observation or by self-reporting and this definition can be reasonably considered to encompass the construct of self-efficacy.[44] The study of self-efficacy as an attitude may open the door to research into the influence of resuscitation training for both professionals and lay-people on other attitudes. such as a person's readiness to respond to an emergency or their willingness to assume the most appropriate role for themselves during a resuscitation.

The fifth and final reason for studying self-efficacy is that many of the factors which have a positive effect on self-efficacy, such as verbal persuasion, modelling and simulated mastery experiences, are also believed to contribute to a good learning environment.[45-49] The learning environment is believed to have a beneficial effect on learning at various levels of education from school to post-graduate medical education. In addition, the environment is one element in the triadic reciprocal model in social cognitive theory (see figure 1.5). There is good reason to suspect that the learning environment might also be an important and modifiable factor in learning on life-support courses and the study of self-efficacy may shed some light on this.

The second main theme of this thesis is the issue of retention of knowledge and skills after training which is an extremely important aspect of emergency medicine. Although life-support courses are effective in terms of learning in the short-term, retention times are often short. However, emergency situations, particularly in children, are infrequent and optimal performance requires that essential knowledge and skills be immediately retrievable, if optimal patient care is to be given. Any intervention which has the potential to improve retention is worthy of investigation.

There are many ways to improve retention including; frequent practice, retraining, mastery learning and mental rehearsal.[43;50-53] Another way of doing this is by the use of spaced testing, a method which is based the *testing effect*.[53-57] This involves simply testing the learned material, without giving feedback, and has been shown to improve retention. In chapter seven a study is presented in which the testing effect is explored during the follow-up phase of a life-support course.

Characteristics of training in emergency medicine

Emergency medicine can be defined as *that branch of the [medical] profession concerned with an individual's resuscitation, transportation and care from the point of injury or beginning of illness through the hospital or other emergency treatment facility*[2]. Although this definition encompasses both the acute and the subsequent phases of injury and illness, this thesis will concentrate on the training of doctors in patient management during the early acute phase of severe illness or injury, - a period which is often referred to as the "Golden Hour".[58] In this phase, timely and appropriate intervention, often within minutes, can have a significant effect on the patient's long-term outcome.[59] Emergencies in which such intervention is required occur less frequently than many other clinical presentations. This is particularly true in general paediatric practice where acute life-threatening emergencies occur several times a year, but too infrequently to lead to ingrained and habitual behaviour in the doctors involved.[60] Thus, emergency medicine differs from other fields of medicine in that the doctor is required to act quickly in performing non-routine but potentially life-saving procedures at infrequent and sometimes quite long intervals.

[2] Descriptor of the PubMed MeSH term "Emergency Medicine"

Emergency medicine can be considered as a *chain of survival* in which different rescuers with varying amounts of experience and skills are active.[61] Lay-rescuers are active in the first link in this chain; all other areas are the domain of the professional health-care provider. The patient's prognosis is heavily influenced by the quality of care at each point on the chain. The chain can be strengthened by educational interventions which teach the competencies required at each link.[62] This thesis will concentrate on one link in the chain and only one member of the care team – the doctor. This is in no way intended to belittle the importance of other healthcare professionals in the chain, whose contribution is essential to the provision of adequate patient care.

Training in emergency medicine has been found to be inadequate at all levels of medical education.[2-7;63;64] Training of specialist-trainees and continuing education of specialists in emergency medicine can take many forms including workplace training, portfolios, computer-based learning[65] and life-support courses, which are the main focus of this thesis.

Training in emergency medicine, especially paediatric emergency medicine, is fraught with problems.[66] Firstly, the learner must acquire a wide range of skills of varying complexity together with the knowledge and judgement to apply them appropriately. Maibach et al give an idea of the range of competencies required in terms of cognitive, affective and psychomotor aspects and social skills (table 1.1).[66] Secondly, these skills will need to be applied in practice in difficult and often chaotic circumstances, in which the consequences of inadequate performance can be fatal, and which cannot always be simulated accurately during training. Thirdly, competencies need to be maintained despite infrequent opportunities to use them. Retention of knowledge and skills is therefore an important issue which will be discussed in some detail in the next section.

Retention in relation to emergency medicine[3]

The infrequency of medical emergencies and the need for rapid intervention means that retention of knowledge is an important factor in training in emergency medicine. Optimal medical care requires that the doctor has the ability to retain the necessary knowledge, skills and attitudes over a long period of time. In this context retention refers to the ability to perform the necessary task to the required standard after a defined period of disuse.[53] In emergency medicine, the required standard often includes being able to perform the task within a limited time.[59]

According to the cognitive view, information is stored in the long-term memory as organized units known as *schemata* or *knowledge-representation and*

[3] Part of this section has been adapted from a previous publication[67]

Cognitive aspects Knowing how to perform each procedure and skill well Assessing patient status accurately and applying the correct procedure(s) in response Evaluating accurately the role and performance level of other CPR team members Believing in the effectiveness of the procedures Believing in one's own capacity to implement the procedure in an appropriate and timely fashion (self-efficacy)
Affective aspects Controlling one's emotions Striking an appropriate balance between type 1 errors (saving a patient who is likely to be persistently vegetative) and type 2 errors (ceasing resuscitation in a patient who could have recovered) Willingness to subordinate one's ego or agenda for the well-being of the patient by giving and taking orders
Psychomotor aspects Skilled conduct of all procedures Ability to apply all the required skills and procedures appropriately Ability to refrain from unnecessary or unwarranted procedures
Social skills Communicating effectively Directing and coordination the efforts of other team members

Table 1.1: *Domains and characteristics of cardiopulmonary resuscitation (CPR) proficiency (from Maibach[66])*

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retrieval structures. Remembering involves accessing these schemata by retrieval systems and their transfer to the short-term memory.[68] Forgetting a piece of information by a person with a normally functioning brain, can involve two processes. Firstly, the information is lost irrevocably from the long-term memory. The second mechanism, which is believed to be the most common, involves a defect of retrieval. Here the problem can lie with the information itself which has not been stored in such a fashion as to be distinctive and easily found by the retrieval system, or because it has subsequently become confused by other similar information. Alternatively retrieval failure can occur because the retrieval system is adequate for the search, for instance, because it contains too few cues to the information being sought.[69]

Retention can be improved by ensuring that the information is stored distinctly such that it can easily be discriminated from other information, and by elaborating the information in order to link it with information in other schemata.

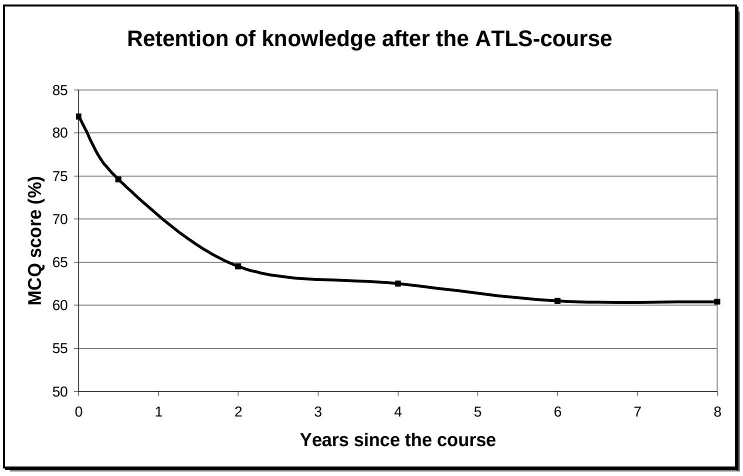
Retention of a practical procedure is dependent on both recall of the procedural steps required and the degree of attrition of the necessary psychomotor skills. If a procedure is not regularly performed or practiced, the quality and speed of performance declines. This has been well illustrated by White in a study of paediatric trainees' resuscitation skills after the PALS course.[63] Although most trainees were eventually able to perform the resuscitation skills tested, the time to completion of the skill was often unacceptably long. As survival in emergency medicine sometimes depends on the speed with which an intervention is performed - for example the relief of an obstructed airway – delay may be as deadly as not intervening at all. Thus the paradigm of retention in the context of paediatric emergency medicine should include the notion of *speed* of retrieval.

Retention of knowledge and psychomotor skills ability after training in emergency medicine is poor.[24;70-73] The global finding from many studies is that knowledge and performance decline rapidly after a life-support course, following which they remain relatively stable for a period of years. Figure 1.3 contrasts the findings of a typical study of retention following a life-support course with the classical forgetting curve first described by Ebbinghaus in the nineteenth century.[24;74] Ebbinghaus found that retention of nonsense syllables decreased rapidly shortly after learning, following which the rate of loss declined.

In contrast to Ebbinghaus, more recent research on the long-term retention of meaningful information has suggested that retention reaches a true plateau phase during which no further information is lost.[75;76] This plateau phase has been dubbed by Bahrick "immunity to forgetting", during which the information remains unchanged in a memory *permastore*.[77] If such a phenomenon exists for knowledge learned on life-support courses, the challenge will be to ensure that the most important information is retained in the permastore.

Retention of resuscitation competencies can be improved by regular spaced practice, for instance by regular simulation-training in the workplace.[53;78]

Retention is also improved by use of mastery learning in which students are required to obtain a given level of competency regardless of the amount of training required.[43] The retention-interval of knowledge, including procedural



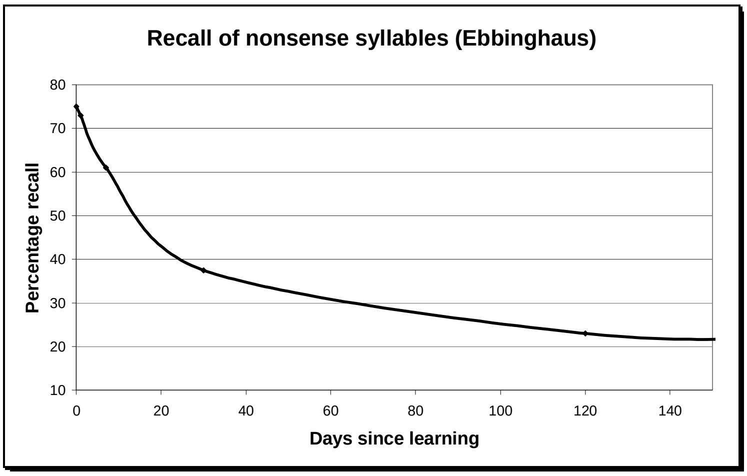


Figure 1.3: *Retention of factual knowledge after the Advanced Trauma Life Support course (modified from Ali[24]) compared to the classical retention curve of Ebbinghaus[74].*

"desirable difficulties" into the learning programme[79] and spaced testing.[53-56]

These approaches are based on the idea that re-activation and re-elaboration of knowledge leads to better retention by ensuring that the information is ultimately better stored and linked to other information.[53] Spacing the re-elaboration results in more efficient learning and improved retention, than using massed distribution of re-elaboration.[57]

Testing is also believed to improve learning by requiring re-elaborating of existing memory traces and their cue-target relationships and by increasing the number of retrieval routes to stored information.[56] This is the basis of the so-called *testing effect* which refers to the observation that testing of the material to be retained leads to more efficient retention than restudying the material.[56] Restudying and retraining can also improve retention of factual and conceptual knowledge and of motor skills, however, teaching the knowledge or skills may not. This has been shown for life-support courses where teaching skills which the instructor does not use regularly in practice has been shown not to improve retention.[28;34;70]

It has been suggested that learning in context improves retention, although this has also been disputed.[80;81] It may be that retention and transfer are optimally facilitated by deliberate learning in several different contexts.[53] If this is indeed so, then it would be an argument in favour of deliberately situating training in emergency medicine in the various contexts such as those of the workplace and of life-support courses.

The optimal interval for retraining after life-support courses is unknown and different authors have suggested intervals ranging from 3 to 6 months up to 8 years.[24;71;82;83] However, there is likely to be great inter-individual variation and the optimal interval will vary between practitioners. One factor which seems likely to play a role in this variation is exposure or the amount of opportunity to use the knowledge and skills in practice.[24] Other variables such as sex, age and specialty have been shown to be less important.[73]

In summary, training in emergency medicine, including life-support courses, should aim not only to facilitate the learning of the required competencies but also to maximize their retention. This will involve setting mastery criteria not only in terms of acquisition, but also in terms of retention. Learning objectives should therefore be described which include an element of retention – it is not adequate to define what is to be learned, but also to state how long, and at what level, it is to be retained.[53] Systematic research into retention is badly needed if training in emergency medicine generally is to be optimalised. This applies also specifically to life-support courses which are the subject of the next section of this introduction.

Life-support courses

A large number of short, highly structured training courses in various branches of emergency medicine for doctors and other health-care professionals have become available in the Netherlands in the last 15 years under the name *life-*

support course. These include the Advanced Life Support (ALS®), Advanced Trauma Life Support (ATLS®), Advanced Paediatric Life Support (APLS®), European Paediatric Life Support (EPLS®), Pre-hospital Trauma Life Support (PHTLS®), Pre-hospital Paediatric Life Support (PHPLS®), Battlefield Advanced Trauma Life Support (BATLS®), Emergency Management of Severe Burns (EMSB®), Management of Obstetric Emergencies and Trauma (MOET®) and the Newborn Life Support (NLS®) courses. Each of these was originally imported from an English speaking country and all have international links in several different countries.

One impetus for the growth of life-support courses has been the criticism that training in resuscitation and emergency medicine at undergraduate level has been inadequate.[2;3] Another stimulus has been increased acceptance of the need for continuing medical education (CME) in crucial areas – particularly those areas where rapid intervention is necessary. CME should address the needs of the practitioners in bridging the gap between their current practice and their desired practice.[84] This may involve reactivating atrophied knowledge of the management of infrequently experienced emergency conditions. It might also involve presenting a new (and hopefully better) approach to a familiar and frequently encountered problem. Both these needs can be addressed by life-support courses.

Life-support courses worldwide are big business. More than ten years ago it was estimated that in the USA alone 3 billion dollars were already being spent annually on resuscitation training.[17] Since then the popularity of life-support courses in many countries – including the Netherlands – has progressively increased. Currently most UK consultant paediatricians and essentially all trainees have followed an advanced life-support course.[85] In the Netherlands, the Advanced Trauma Life Support course, which was introduced in 1995, currently trains 500 doctors a year, whereas the Advanced Paediatric Life Support course, introduced three years later, current trains 200 doctors a year. This amounts to an annual turnover approaching one million Euros for these two courses alone. Taking into account the fact that there are at least eight other similar life-support courses each lasting from one to three days aimed at doctors[86], and numerous other courses for other health-care professionals, it is clear that vast amounts of time and money are invested in this educational activity. This consideration alone justifies a systematic attempt to evaluate the effects of these courses.

Life-support courses are claimed to be designed using the principles of adult education, taking account of such factors as relevance, active involvement, clearly defined goals, positive feedback, varying teaching methods and reflection.[87] Instructors for the courses are required to follow a training course, usually followed by a period of supervised teaching practice and often by regular peer-assessment and self-reflection. The educational philosophy of life-support courses has been described indirectly by Davis and Conaghan who reviewed a British instructors' training course.[88] They describe the educational design of the course in terms of four theoretical perspectives: experiential learning[89], group dynamics[90], reflective practice[91] and situated learning[92]. However, while many of these educational approaches may well have been consciously employed in the original design of life-support courses, they are seldom if ever explicitly referred to either during instructor training or during the courses themselves.

As far as course content is concerned, all life-support courses present a simplified and highly structured system for the assessment and management of acutely, severely ill or injured patients. The basic principle is frequently expressed using the aphorism "*treat first what kills first*" and a methodology based on the A-B-C-system (airway – breathing – circulation) is virtually universal. Although this system is at odds with the way medicine is traditionally taught, the "life-support course formula" has become so ingrained that new courses in fields other than emergency medicine are being developed using it.[33;93]

It is useful to explain the intended meaning of the term life-support course as used in this thesis in some detail for three main reasons – firstly to orientate the reader; secondly to delineate the scope of the discussion and, thirdly, to justify the validity and the limitations of drawing conclusions about life-support courses generally from the research to be described which was carried out largely in the context of one particular course.

As there is no universally accepted definition of the term life-support course, it is necessary either to derive one; to identify common characteristics of the various courses or, to describe the courses using an established classification. A definition, however, may be unnecessarily restrictive. In an early review of the effectiveness of life-support courses, Jabbour et al avoided this problem and defined the scope of their analysis been taken by other authors who have compared or surveyed more than one course.[60;85] Jabbour et al also claimed that there was sufficient similarity between different life-support courses to justify grouping them together for statistical purposes.[28] If this is true, it should be possible to describe life-support courses by identifying their common characteristics. An attempt to do is shown in table 1.2, which is based on published descriptions of various courses and personal experience with these and others.[8-11]

The intended educational outcome can not be used as a feature to characterizelife-support courses as not all courses have defined their outcomes in the same way. Descriptions of the course-aims fall into two groups – those in which an improvement in survival is claimed as the ultimate aim[28;29], and those in which some form of learning is claimed as the desired outcome[97;98] - although one course describes its aims in terms of the teaching process.[99]

Universal characteristics	Frequently encountered characteristics
o Discrete courses lasting from one to several days	o Situated away from the workplace
o Focus on one area of emergency medicine – although not necessarily restricted to resuscitation	o Tendency to focus on medical treatment rather than a holistic approach to the patient as a person
o Tendency towards information gathering rather than interactive problem-based learning (PBL)[95], although PBL is an element of certain sessions on certain courses	o Multidisciplinary and / or multiprofessional, aimed at various groups of clinically active health-professionals
o Employing several different, alternating teaching methods	o Compulsory pre-course study and pre-course test
o Much use of interactive small group teaching	o Formal summative assessment and certification
o As far as doctors are concerned, aimed at both specialist trainees (compulsory in some countries[13;96],) and specialists (recommended in some countries[12;16])	o Tendency to focus on training of the individual rather than the team, although team training is a prominent feature of some courses[8;94]
o Lesson plans are supplied by the course organisers; instructors are allowed little leeway with the course-content	o Instructors are selected from participants using criteria which are supposed to predict teaching ability
o Compulsory training for instructors presenting a simplified "ABC"-type approach to didactics	o Presentation of one, simplified method of treatment ("ABC"-approach) with the emphasis on structured, prioritised care
o High instructor-learner ratio (usually 1 instructor to fewer than 4 learners)	o Instructors are unpaid volunteers, whereas participants are charged a fee
o play Instructors are trained to focus on the individual learner, but the course is largely teacher controlled	o Claim to be competency-based education, although not all course define outcomes in terms of competencies
o Highly intensive (usually >8 hours/day)	o Mentoring of participants
o Much use of simulation, role-play and models for skills-teaching	o Little follow-up, except an invitation to attend a refresher course several years later, and essentially no follow-up in the workplace

Table 1.2: *Characteristics of life-support courses in the sense in which the term is used in this thesis.* [8-11]

A third approach to the problem of explaining the term life-support course is to describe their features using an established classification system. As life-support courses are at least in part intended as continuing medical education activities for specialists, a suitable classification might be the CRISIS-criteria defined by Harden and Ladilaw.[100] The CRISIS-model describes seven dimensions along which a CME activity can be graded from good to less good: Convenient, Relevant, Individual, Self-assessment, Interesting, Systematic and Speculative. In the following paragraphs an attempt is made to describe life-support courses as CME using these dimensions. In doing this a number of area for further research will be brought to light.

1 <u>Convenience (in terms of place, pace and time):</u>

Although some life-support courses are organised in the participant's own institution most are essentially residential courses which may take place at a considerable distance from the participants' usual workplace. This may decontextualise the content and might generate a less effective learning environment for professional development. On the other hand learning in different contexts, such as the life-support course and the workplace, might improve retention[53;101]

In terms of time, life-support courses are not always convenient. Participants generally have to attend the course when it is offered, and during the course are not available for clinical work. Modular courses in which the whole course is given in a series of smaller sessions over a longer period (usually several weeks) have been developed for some life-support courses and may improve convenience for some.[94] There might also be theoretical advantages to modular courses as these offer spaced learning, which it is believed to improve retention more than massed learning.[57] However, concerns have been raised that the learning environment of a modular course might be less conducive to learning than that of the whole course given in continuity over several days.

The pace of most life-support courses is generally not adjustable for slower or faster learners. Few attempts have been made to adopt a mastery learning approach.

2 <u>Relevance</u>

All life-support courses are intended to be very relevant to practice and are designed with the intention of concentrating on common clinical problems and those conditions in which rapid intervention can improve the prognosis. Unfortunately their relevance does not seem to have been systematically studied by assessing the specific needs of participants before the course and to what degree these have been addressed after it.

Making the course more relevant has been shown to improve learning in a study of military doctors.[102] It would be fairly straightforward to tailor the content of a course to the needs of the participants by using a pre-test to analyse these needs.[103] Whether such an investment of time and effort would improve learning is uncertain, as there have been no studies comparing such "tailored" courses with standard courses.

3 Individualised

Life-support courses which concentrate on different aspects of emergency medicine are available (for example trauma, children, burns etc.) and the individual participant can choose the courses which are most relevant to his or her practice. However, most individual courses offer a standard programme and there is little or no room for variation which might better address individual learning needs.

4 Self-assessment

Although many courses use a pre-course self-assessment test, this is often not discussed and participants are not usually informed of their scores on individual questions. Thus a rich opportunity for feedback is often missed. The use of self-assessment is however increasing – for example in the UK APLS-course where participants are required to follow a computer based preparatory programme containing self-assessment questions and immediate feedback before they attend the course. A similar self-study and self-assessment programme has been developed in the USA.[35]

5 Interesting

Analysis of course-evaluations and of participants´ reactions to the course suggest that life-support courses are generally perceived as being interesting.

6 Systematic

All life-support courses employ a highly systematic approach to the management of medical emergencies, which is considered to be one of their great strengths.[9] However this approach has been criticized as over-simplistic as discussed in the next paragraph.

7 Speculative

Speculative is the most perceptive of the CRISIS criteria, but it is the area in which life-support courses fare worst. According to Harden and Laidlaw, clinicians have the most difficulty with "grey-areas" in their practice and this is where their greatest learning needs tend to lie.[100] However, on life-support courses controversial issues are very rarely addressed in an open manner. There is usually little room for discussion of situations in which the use of professional judgement to select from a range of alternative approaches might be more appropriate than strict adherence to the proscribed procotol.[9] Often instructors will terminate such discussions by overtly presenting the standard approach to a clinical problem, as presented by the course content.

Although this almost over-simplistic approach is considered by some to be a weakness[104], the presentation of a very simply systematic approach to emergency medicine is considered by others to be one of the great strengths of the life-support course formula. Participants do not seem to experience a problem in this area as lack of a speculative approach rarely emerges as a criticism during course evaluations.

There is considerable evidence that life-support courses can increase participants' knowledge, at least in the short term, and that doctors can acquire fairly simple competencies on the course, such as the insertion of an intraosseous device for vascular access during resuscitation. But clearly, life-support courses can have no effect on a doctor's competence or on patient outcome unless transfer of new knowledge to the work-place takes place, regardless of how many new skills he or she has learned on the course. Studies on transfer or behavioural change after following a life-support course show mixed results while research into the effect of courses on patient outcome is difficult and has been inconclusive.

Because of the enormous popularity of life-support courses and the degree to which great health-care services invest in them, it is important that the course should be properly evaluated. Chapter 2 of this thesis presents an attempt to do this, while the following section of this introduction presents a discussion of some generally principles of educational evaluation.

Evaluation of educational interventions

The evaluation of an educational intervention such as a life-support course involves a judgement of its worth, generally in terms of both the teaching methods employed (the process) and the effectiveness (the outcomes).[105] Over the last forty years the evaluation of the extent to which an intervention reaches its predetermined aims has been increasingly recognized as a more useful approach than one focusing on the comparison of different teaching methods.[106]

There are many reasons to undertake evaluation and these have been grouped into three main categories: to guide the development of the intervention: to demonstrate its effect and worth for reasons of accountability, and to generate knowledge and understanding for research, policy and educational purposes.[107] All of these three categories are relevant to the evaluation of life-support courses, but much of the published research tends to focus on the issue of accountability – attempting to justify the expense and organisational effort of the courses in terms of their outcomes.

Evaluation needs to be distinguished from assessment which generally refers to attempts to measure what has been learned by individual students.[108] Learner assessment clearly yields important information for a course evaluation, but there are many other approaches to evaluation, and these have been reviewed recently by Goldie in two articles.[108;109] Much of the following discussion is derived from these reviews.

Fundamental to a discussion of evaluation are two points. Firstly, the realisation that both assessment and evaluation necessarily involve a value judgement which carries an inevitable degree of subjectivity. Even evaluation according to strict criteria can never be entirely objective, as value judgements are made in the choice of those criteria and their weighting. Secondly, evaluation need not necessarily be restricted to analysis of the outcomes of an intervention. Evaluation aimed at the process of the intervention or even at the input may also be justified. For instance Wilkes and Bligh have described four levels of evaluation of which the first level – structural issues – specifically includes attendance, which can be considered an input parameter. However, most of the evaluative literature on life-support courses has focused on outcomes.

There are numerous approaches to evaluation and Goldie presents several classifications systems for these.[109] These include Stake's eight non-overlapping dimensions, House's monodimensional spectrum and Worthen's categorization of orientation of approach. Goldie goes on to place more than twenty educational evaluation systems into Worthen's categories. Wilkes and Bligh describe four approaches to evaluation on the basis of their orientation: Student-oriented using information from students' assessments and their reaction to the intervention; Programme-oriented comparing the course to its objectives; Institution-oriented, being often part of an accreditation process, and Stakeholder-oriented focusing on the interests of its commissioners.[108] Hutchinson explains that both experimental and naturalistic methods have a place in educational evaluation.[110]

There are therefore so many approaches to evaluation that choosing the most appropriate one can be made as complex as the investigator wishes. In order to evaluate life-support courses an evaluation system is required with which not only the direct effects of the courses on individual doctors, but also their indirect effects on the quality of health-care and patient outcomes can be included. Bearing in mind the emphasis in the published literature, an outcome-orientated system which accommodates multiple evaluation methods, including historical and retrospective approaches, would do the most justice to the published data. Kirkpatick has described such a system.

Kirkpatrick's model

Kirkpatrick has popularized a simple classification of levels of evaluation for training programmes (figure 1.4). Although originally designed for use in business training, the model, sometimes in modified form, has established itself in the medical education literature to such an extent that its use has even described by Dornan as *"a core BEME methodology".*[110-114] Apart from the authors of BEME-reviews[4], Wilkes and Bligh have also described a similar evaluation model to that of Kirkpatrick and consisting of four levels: structural issues such as attendance, and adherence to objectives; before and after testing of knowledge; assessment of competence, and evaluation of the benefit of the intervention to society.[108]

The four levels in Kirkpatrick's model - reaction, learning, transfer and results –were originally depicted as a pyramid, but are shown in figure 1.4 as a triangle for simplicity.

Reaction refers to what the participants thought of the course. The underlying assumption, literally expounded by Kirkpatrick, is that a positive reaction will

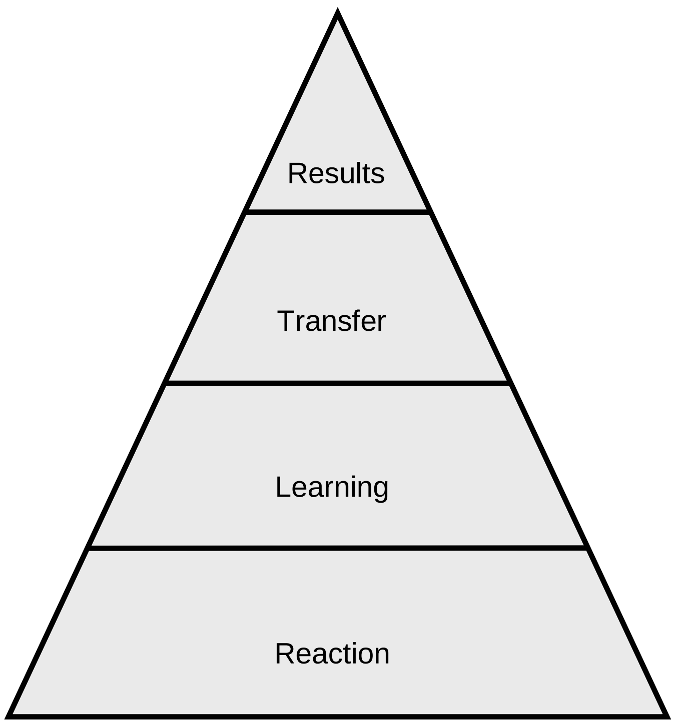


Figure 1.4: *Kirkpatrick's model for evaluating training programmes.*[115]

[4] BEME = Best Evidence Medical Education, an international collaboration of medical educators

facilitate learning. Reaction is usually measured using a course evaluation form, which is compulsory for accredited CME-activities in the Netherlands, and which is widely used on life-support courses. Participants' reaction can be assessed more systematically by using an instrument to measure the educational environment, many of which are available for undergraduate and postgraduate medical education.[46;49;116] A supportive educational environment is generally regarded as a prerequisite for optimal learning, and there is some evidence for this.[117;118] There is as yet no validated instrument for measuring the educational environment of life-support courses.

In the second level of the model, *learning* refers to what the participants learned on the course in the widest sense including factual information, conceptual knowledge, practical and problem-solving skills and attitudes. The term *transfer* is used in its educational sense to mean the positive or negative effect of learning in one context on a related performance in another context.[119] Kirkpatrick adopts a slightly simpler approach to the concept of transfer in level three of his model and focuses on whether the participants changed their behaviour as a result of following the training.

The highest level of the hierarchy refers to *results* and is the most important for society at large. Kirkpatrick originally described this level in terms of company results such as costs, profits and personnel issues. Within the context of healthcare, results can be considered to refer to two distinct outcomes: the effect of the training on the quality or organisation of healthcare, and its effect on patient outcomes.

These two outcome domains at the highest level of Kirkpatrick´s model have been specifically distinguished by the authors of BEME-reviews. The model has also been modified by other authors, either by adding levels or by subdividing one or more of the existing levels. Curran and Fleet have suggested an additional level at the bottom of Kirkpatrick's model which is concerned with the uptake of the educational intervention.[111] Both Dornan and Issenberg differentiate at the level of learning between the acquisition of knowledge and skills and that of attitudes.[112;113] Both authors also subdivide the level of results by identifying benefit to patients as a subset of this level. However, whereas Dornan describes a second domain within the level of results in terms of *changes in the organisation and delivery of patient care*, Issenberg describes *changes in professional practice* as the second domain.

Apart from additions and subdivisions, there are also different interpretations of Kirkpatrick's model. Although Kirkpatrick himself is said to have originally intended the model to be no more than a classification of possible effects[114], more recently, he and others have implicitly or explicitly implied a hierarchical association between the four levels.[112;115;120] This hierarchy is easy to trace: patient outcome can be improved with better patient care, which involves a behavioural change on the part of the doctor; behaviour can only change if new skills are learned and are transferred to the workplace; and optimal learning of these skills is facilitated if the learner reacts positively to the course.

In the last section of this introduction the underlying theme of this thesis is explained using a model based on Kirkpatrick's hierarchy. However, before presenting this model, it is necessary to discuss the concept of self-efficacy in a little detail, as this features prominently in the model.

Social cognitive theory and self-efficacy

Social cognitive theory emerged in the 1970's from the earlier social learning theory and is founded on two premises.[40;121] Firstly that a person is not a passive respondent to environmental stimuli but a cognitive being, able to interpret reality, self-regulate, make judgements and choose his or her actions. The second premise is that the person, his or her behaviour and the environment bear a triadic reciprocal relationship to each other which is shown in figure 1.5. Personal factors interact with environmental factors and both influence and are influenced by the person's behaviour. Similarly, environmental factors and the behaviour of the individual also influence each other. In respect of these two premises, the social cognitive theory was, when first described, a major departure from the then prevailing school of behaviourism.[122]

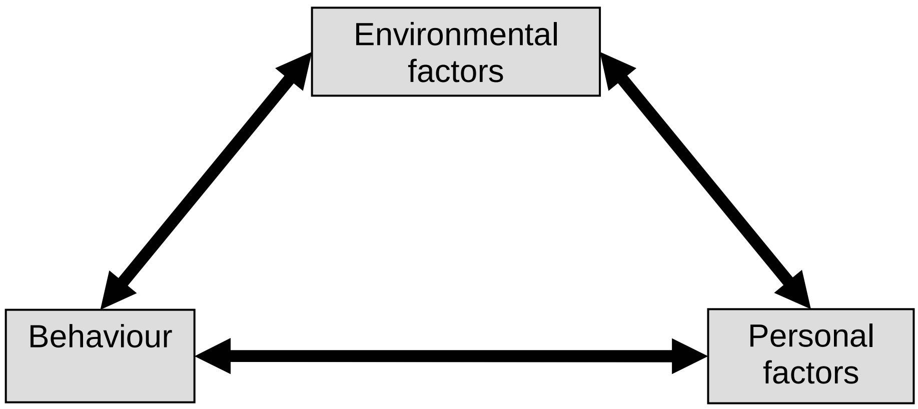


Figure 1.5: *The triadic reciprocal relationship between behaviour, environment and personal factors (from Bandura[37]).*

Central to social cognitive theory is that environmental influences do not act directly on the individual but are mediated by mental processes. It is a person's perception of the environment which influences behaviour and this perception is often termed the *situation* to distinguish it from the real environment. Key to mental processing and of pivotal important to the social cognitive theory is the concept of *self-efficacy* which is defined as "a person's belief in their capabilities to organise and execute the courses of action required to produce given attainments."[37] Self-efficacy influences choices of behaviour, the degree of effort and perseverance invested in a task, a person's resilience to impediments and also thought-patterns and emotional reactions (figure 1.6).

Self-efficacy has been shown to correlate with behaviour in many different contexts.[39] Whether a particular behaviour is expressed – whether a person chooses to undertake a particular task or not – is partly dependent on their self- efficacy beliefs relating to that task. It is generally not enough to merely posses the necessary knowledge and skill to perform a given task (behavioural capability), a certain degree of self-efficacy is also required and a self-efficacy threshold, below which the individual is unlikely to attempt the task in question, has been found in some contexts.[39] It should be emphasized that self-efficacy is only one of many factors which determine behaviour and that the relationship between self-efficacy and performance operates probabilistically.

The influence of self-efficacy on thought patterns and emotional reactions can

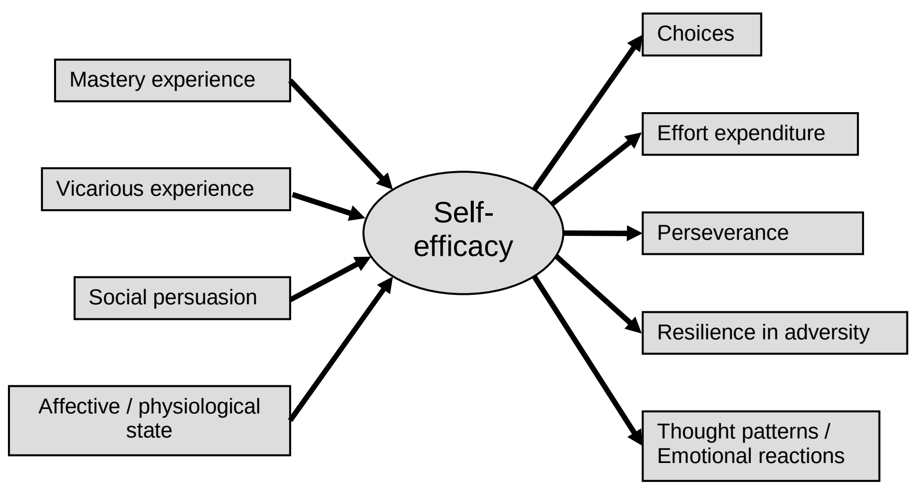


Figure 1.6: *Factors influencing, and influenced by, self-efficacy*

take several forms.[66] A strong sense of self-efficacy encourages positive thinking allowing the individual to visualize successful performance and control such as anxiety, high self-efficacy also promotes analytical thinking in stressful situations.

Self-efficacy is derived from four sources: mastery experience, vicarious experience, social persuasion and affective and physiological state (figure 1.6).[37] Mastery experience refers to a person's own experience with a particular behaviour or task and has the greatest effect on self-efficacy of increase self-efficacy whereas a perception of failure will reduce it.

Vicarious experience corresponds to the notion of observational learning and is a weaker, but nonetheless significant, influence on self-efficacy beliefs[66]. It has the greatest effect when the observer can identify with, or has a high regard for, the person modelling the behaviour. Self-efficacy for a particular task will tend to increase if a peer is perceived by the observer to succeed at that task. Perceived failure in others will tend to undermine self-efficacy beliefs. Social persuasion includes verbal and non-verbal sources of information and judgements from others. In order to be effective at increasing self-efficacy, this information must be credible. Somatic and emotional states also provide the individual with information which is used in the construction of efficacy beliefs. A high degree of anxiety when confronted with a given task is likely to be associated with reduced self-efficacy.

Self-efficacy needs to be distinguished from the concepts of self-esteem, outcome expectancy and self- confidence. Self-esteem is a judgement of self-worth which, unlike self-efficacy, tends to generalise across many contexts. Self-esteem, but not self-efficacy, tends to correlate with locus of control beliefs – that is, beliefs about whether the responsibility for and choice and control of events is internal or external to the individual.

Outcome expectancy can refer to physical, social or internal self-evaluative outcomes and its nature is compared to that of self-efficacy in figure 1.7. The outcome an individual expects can have a significant influence on self-efficacy, but the two concepts are distinct entities.

Self-confidence is more difficulty to define as the term is familiar in the everyday language and its use is seldom operationalised. Self-confidence is most often considered to be a general personality trait which refers to the strength of belief in one's ability to cope with a wide range of situations. This differs from self-efficacy which is task specific.[123]

Self-efficacy is conceived as having three dimensions: strength, level and generality.[37] Strength of self-efficacy is the degree of certainty of an individual's belief in their ability to perform a specific task, whereas level refers to the magnitude of the task to which that belief refers. Generality is the degree to which self-efficacy beliefs for different tasks are related within a

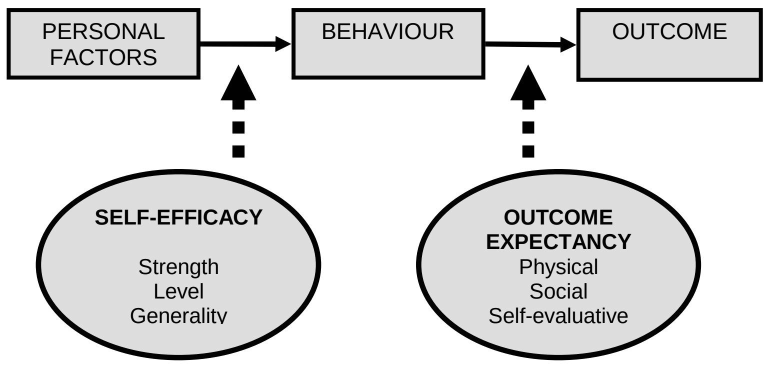


Figure 1.7: *The relationship of self-efficacy to outcome expectancy (from Bandura[37])*

behavioural domain, across domains or across time. To illustrate this consider a recently qualified trainee in anaesthesiology who may have a strong belief in her ability to intubate a normal healthy young adult endotracheally. She has a strong sense of self-efficacy for this task. She may however not feel at all strongly that she is able perform endotracheal intubation in older patients or children, whereas her more experienced colleagues experience no such feelings. Her level of self-efficacy for intubation is therefore relatively low. If we now compare her self-efficacy for a similar but distinct task such as endobrochial intubation, it is possible to assess the degree of generality of self-efficacy for these two related procedures. The limits of generality can be explored by choosing tasks which are increasing distinct from the original task.

<u>The relevance of self-efficacy to life-support courses and paediatric resuscitation</u>

As self-efficacy is probabilistically related to the likelihood of action, it is an important concept in the training and practice of resuscitation. This issue has been little researched, but Maibach et al have reviewed the relevance of self-efficacy to resuscitation and much of the following discussion is taken from their paper.[66] Based on theoretical considerations, case reports and a review of the limited literature they conclude that:

> *"Even clinicians who are knowledgeable and skilled in resuscitation techniques may fail to apply them successfully unless they have an adequately strong belief in their capability."*

During an actual resuscitation a strong sense of self-efficacy for resuscitation tasks should not only increase the likelihood of those tasks being successfully and timely accomplished, but will also reduce negative thought patterns and counterproductive emotional reactions, thereby facilitating access to cognitive information and skills required for optimal care. In other words, stronger self-efficacy will tend to reduce stress and allow the doctor to think more effectively. A negative outcome of a resuscitation attempt would be expected to reduce self-efficacy, although this has not been reported in the literature. This may have a detrimental effect on a doctor's performance at subsequent resuscitations.

During and following resuscitation training a strong sense of self-efficacy is likely to increase a doctor's motivation to improve his or her resuscitation competence. According to social cognitive theory, doctors with weaker self-efficacy are less likely to engage in and to persevere with deliberate practice, and should therefore be less likely to achieve competence in resuscitation, although, again, this has not been demonstrated in the context of life/support courses.[43]

Maintaining or increasing self-efficacy should therefore be a specific aim of both resuscitation training and of debriefing after a real resuscitation. There are several ways of doing this on a life-support course, involving personal and vicarious experience and social persuasion, and many such methods are employed extensively on life-support courses, but without explicit reference to self-efficacy.[8;10;33] Despite the lack of specific attention to the construct, there is evidence that life-support training can increase a person's belief in their resuscitation ability.[124;125]

Providing mastery experiences in a simulated setting is a key feature of all life-support courses. These exercises are almost invariably allowed to lead to a successful or at least neutral outcome. The simulated patient is never allowed to die! This, combined with positively expressed feedback should in theory increase self-efficacy, although this has not previously been demonstrated. Continued frequent practice in varying situations both during and after the course will tend to increase competency and self-efficacy further. Maibach et al also suggest mental rehearsal as a potential method of increasing self-efficacy, but present no evidence to support this.

It is important to realise that the effect of a mastery experience on self-efficacy is mediated by a person's subjective impression of that experience rather than the objectively measured performance itself. This effect can therefore be modified by social persuasion using appropriate feedback. Feedback on life-support courses is usually given according to the so-called Pendleton rules[126], and although this method has been criticized[127], it does have the advantage of emphasizing positive aspects of a mediocre performance which will tend to increase self-efficacy. Feedback has the most effect on self-efficacy if the ability of the individual is praised rather than their degree of effort.[128] Also, the credibility of both the feedback and its provider is an important factor in the influence of feedback on self-efficacy.

Status is even more important for the effect of observational learning on self-efficacy than for feedback.[129] Life-support courses make extensive use of observational learning during demonstrations and practice sessions for fellow-learners, during which instructors or peers act as models for the observer. The most effective models in observational learning are those with whom the observer can identify socially and yet possess a higher degree of competency.

For maximum effect on self-efficacy complex procedures are best modelled using a step-by-step approach and invisible but crucial steps in the procedure, such as thought processes, need to be verbalised. The effect on self-efficacy is greater if both correct and incorrect performances are modelled. Modelling of incorrect performances is, however, rarely employed on life-support courses, and is explicitly discouraged on most courses.

The importance of reducing learners´ stress and anxiety by attention to physical and social comfort and regular, encouraging feedback is emphasized during the training of instructors for life-support courses.[87] By putting this into practice the detrimental effect of these negative emotional reactions on self-efficacy can be minimised. In some cases the individual learner may benefit from instruction in techniques for dealing with stress in emergency situations.

Improving and maintaining self-efficacy with regard to real-life resuscitations is somewhat more problematic than is the case during training. Resuscitation attempts are more likely than not to be unsuccessful especially in paediatrics and a negative outcome, despite competent treatment, is therefore common.[130] Such experiences are likely to tend to reduce self-efficacy unless methods are employed to prevent this. One recommended method is to organise systematic debriefing of all resuscitation attempts.[131] During the debriefing, positive aspects are emphasized and suboptimal performance and counterproductive emotional reactions are discussed and a method to deal with these is decided.

The opportunities for increasing competency and self-efficacy by observational learning at real resuscitations is limited by their infrequency and unpredictability. Nonetheless, efforts can be made to encourage unobtrusive observation of expert performance by less experienced doctors – provided that the resuscitation is attended by experts. However, traditionally, resuscitation has often been delegated to more junior members of the health-care team. Respected members of the team can also contribute to the improvement or maintenance of self-efficacy by avoiding destructive verbal and non-verbal communication during the actual resuscitation.

Self-efficacy is therefore an important dimension to resuscitation training and practice which deserves to be given more explicit attention on life-support courses by, for instance, incorporating the construct into specific affective learning objectives for the course, and by addressing the issue explicitly during instructor training. Self-efficacy is an important component of the theoretical model which underlies the theme of this thesis and which is presented in the following and concluding section of this introduction.

Theme of the thesis – a theoretical model of the effects of life-support courses

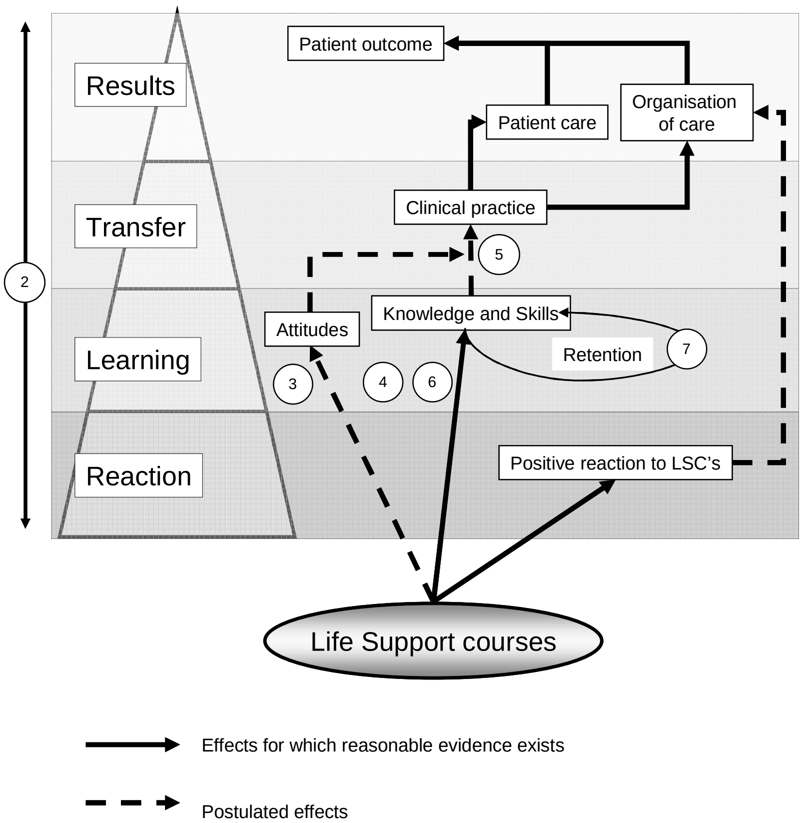
This thesis is based on a theoretical model of the effectiveness of life-support courses as presented in figure 1.8. In this model the mechanism of effect of life-support courses on patient outcome, via the doctor's learning and behaviour, from figure 1.1 is combined with Kirkpatrick's hierarchy. The numbers refer to the different studies presented in this thesis and the key to these is found at the end of this section. Effects for which reasonable evidence exists are represented by solid arrows; postulated effects by broken arrows.

The word "knowledge" is used in the model in a wide sense which incorporates three of Gagné's five categories of learning outcomes (i.e. intellectual skills, cognitive strategies and verbal information) but omits motor skills and attitudes, which are considered separately.[1] The reason for this division is firstly, that that much research into the effects of life-support courses has examined motor skills separately; and secondly, the effect of life-support courses on attitudes has not been subjected to extensive systematic study. This differentiation between the acquisition of knowledge and skills and that of attitudes has been used previously by others.[112;113]

There is reasonable evidence that life-support courses generate a marked positive reaction in their participants.[34;96;132;133] Whether this positive reaction to the course can itself be considered useful attitude learning, as some have claimed[18], is a matter of debate, as it does not directly influence clinical practice and has been found in some cases to bear little relationship to learning in other domains.[23] However it is one factor which determines the popularity of life-support courses and therefore probably contributes to their impact. A positive reaction may, however, also generate increased awareness and a desire, on behalf of members of the care team, to improve the working environment and its organization such that application of new learning is facilitated. This postulated effect is represented by a broken arrow in figure 1.8.

There is also reasonable evidence that life-support courses can lead to learning in the sense of increasing knowledge and motor skills.[18-22;22;34] This can lead to competency in certain fairly simple tasks, but complex tasks may be difficult to learn in the limited time available during the course.[34;63] However, assessment of doctors´ knowledge and motor skills after life-support courses, using written tests, objective structured clinical examinations (OSCE's) and simulated patient tests, has almost universally demonstrated poor retention.[5;23-25]

Poor retention may mean that a piece of knowledge is not lost, but the speed of its retrieval is severely compromised. This is potentially a more serious in emergency medicine than in other fields, as patient outcome may depend on the rapidity with which a medical intervention is performed.[59] A major focus of educational research in emergency medicine should therefore be to investigate



*Fi**gure 1.8:** Theoretical model underlying the theme of this thesis. The circled numbers refer to the chapters of this thesis where the relevant research is described* ways of improving retention, and this thesis contains an investigation of one method of doing this using spaced testing.

The effect of life-support courses on attitudes has not yet been deliberately and systematically researched. Therefore the postulated relationship between learning and attitudes is represented in figure 1.8 by a broken arrow. According to the model, attitudes modify choice behaviour and a task is only likely to be undertaken in practice if the doctor has knowledge, skill and a predisposing attitude towards it.

Transfer after having followed a life-support course can be considered as the application of new knowledge in clinical practice, and is highly important if a life-support course is to have an effect on patient outcome. There is evidence that newly learned skills are often, but not always, transferred to clinical practice.[36;134-138] According to the model, transfer depends upon both competency and attitudes, including self-efficacy, but as the relationship between these three phenomena is uncertain, they are linked by broken lines in figure 1.8. A large part of this thesis deals with the related questions of the effect of life-support courses on self-efficacy and its relationship to transfer.

At the highest level of the model, patient outcome is represented as being dependent upon direct patient care and the organisation of that care.[112] Although this relationship is more often assumed than demonstrated, it has been shown that application of the guidelines taught on life-support courses, and implementation of organisational changes recommended by them, can improve outcome.[29;139]

To summarise, life-support courses have been shown to increase knowledge and skills, but retention times are often short. Their effect on self-efficacy and other attitudes has been little studied but attitude learning is assumed to be essential to transfer. Transfer is essential if life-support courses are to influence patient care, and subsequently patient

outcome. In this thesis aspects of self-efficacy and retention in relation to life-support courses are explored. The studies presented are outlined below.

<u>Content of this thesis</u>

The relationship of the research presented in this thesis to the model, and the content of each chapter, is represented by the following numbers in figure 1.8:

② Chapter 2 presents an overview of the research to date into the effectiveness of life-support courses, structured according to

Kirkpatrick's four levels of evaluation.

③ Chapter 3 presents the development and validation of a simple method of measuring self-efficacy using a visual analogue score, which was used in subsequent studies.

④ In chapter 4 the effect of the Advanced Paediatric Life Support course on self-efficacy and skills-use is demonstrated in a survey of all participants over a period of fifteen months.

⑤ In chapter 5 the relationship between self-efficacy, behavioural decisions and quality of performance in paediatric resuscitation is explored in an experimental study using simulation.

⑥ Chapter 6 presents the effect of APLS on self-efficacy and competency in the longer term as assessed experimentally by an unannounced test in a clinical context.

⑦ In chapter 7 the use of unannounced spaced telephone testing to improve retention after a life-support course by is presented.

Finally chapter 8 contains a general discussion in which the result of these studies is critically appraised

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2

Evaluating the Effectiveness of Life-Support Courses: a Review of the Literature

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Summary

Aim

Life support courses are widely advocated, very popular and increasing in number but their effectiveness has been little studied. This paper presents a qualitative review of the evaluation literature of life-support courses over the last fifteen years.

Method

Kirkpatrick’s hierarchy of the effect of educational interventions was applied as a framework to summarize the available literature. This hierarchy distinguishes four effect levels: (I) reactions in the learners, (II) learned knowledge and skills, (III) transfer: observed change in actual behaviour and (IV) outcome effects in patient care as a result of behavioural change. Publications on the evaluation of life-support courses for doctors were reviewed and the results were categorized in this framework.

Results

Most literature was qualitative in nature, and did not permit quantitative conclusions on effects. On level I (reaction) generally positive results are reported. A learning effect (level II) is often found, but the retention of acquired skills has been less well studied and seems to be generally poor. Studies on transfer or behavioural change (level III) show mixed results. The effect of life-support courses on patient outcome has not adequately been studied.

Conclusion

While life-support courses are probably a necessary and valued approach to the acquisition of life-support skills in doctors, enhancement of the long term retention of those skills needs further attention. Educational research tools must be developed to investigate better behavioural change leading to improved patient outcome, which can be considered the most important effects of life-support courses.

Introduction

It has been commonly reported that the level of competence in resuscitation and emergency medicine of doctors, including paediatricians, is inadequate and life-support courses have been widely advocated to improve this.[1-6] There are estimated to be 250,000 resuscitation attempts annually in the USA, and lack of training has been show to have a negative effect on survival.[7;8] Thus even a modest percentage improvement in survival as a result of training can have a very considerable human impact.

With this in mind, resuscitation training by means of life-support courses has been widely advocated and has become big business. It is estimated that 3 billion dollars were spent on life-support courses in the US alone in 1995.[9;10] In the Netherlands there are currently at least nine life-support courses available to doctors, including four paediatric courses (table 2.1). Paediatric life-support courses are a compulsory part of training in several countries and in some they have even been given a legal status.[11;12] In other countries life-

Paediatric Courses

APLS: Advanced Paediatric Life Support
NLS: Newborn Life Support
PHPLS: Prehospital Paediatric Life Support
EPLS: European Paediatric Life Support
(Formerly PALS: Paediatric Advanced Life Support)

Adult or Mixed Courses

ATLS: Advanced Trauma Life Support
BATLS: Battlefield Advanced Trauma Life Support
ALS: Advanced Life Support
ACLS: Advanced Cardiac Life Support
ILS: Immediate Life Support
MOET: Management of Obsetric Emergencies and Trauma
ALSO: Advanced Life Support in Obstetrics
PHTLS: Prehospital Trauma Life Support
EMSB: Emergency Management of Severe Burns

Table 2.1: *Examples of life support courses for doctors currently offered in the Netherlands, including a key to the abbreviated names mentioned in the text*

support courses are highly recommended – for example the APLS has been officially described identified as useful by the Dutch Inspectorate for Health.[13-16] It is widely held that following a life-support course improves patient care and is advantageous to professional development.[17;18]

Life-support courses have been described in elsewhere.[19-22] Their common features have been discussed in the previous chapter of this thesis and include: courses of one or more days' duration, located away from the workplace with a focus on life-threatening conditions, use of diverse, alternating learning methods with many practical sessions, and peer-teaching by instructors selected from previous participants (table 1.2). The educational philosophy of life-support course has been described in terms of four theoretical perspectives[23]: experiential learning[24], group dynamics[25], reflective practice[26] and situated learning.[27] The "life-support course-formula" has become so ingrained in postgraduate medical education that it has been adopted by new interventions in fields other than emergency medicine.[28]

Although there is a general impression that adult patient care has improved since the introduction of life-support courses and it is widely held that paediatric life-support courses should be able to improve survival, the courses have been criticized on the grounds of being expensive, bureaucratic, resistant to change, inconveniently located, limited in scope, propagating protocols which are only partly evidence-based and placing the emphasis on the individual rather than the team.[29-33] In addition, the conviction that life-support courses can improve patient care has lead to ethical issues to the extent that providing an emergency service without such life-support training may be considered substandard care, and using a untrained control group in a comparative study might be considered unethical.[8;34]

The evaluation of life-support courses is of necessity qualitative. It is difficult to conduct a randomized controlled trial of learning after life-support courses as many factors which might influence learning and retention are unquantifiable or uncontrollable and there is no single standardized method of measuring performance. This last difficulty applies especially to the performance of practical skills, although some scoring systems for isolated skills have been used by several different authors.[35; 37;38] The heterogeneity of life-support courses and of their participants makes comparison between different studies difficult and statistical analysis unsound. Investigating patient outcomes is equally difficult.[36] A systematic review of quantitative evidence on the effectiveness of life-support courses is therefore difficult, and two attempts at this were inconclusive.[39;40]

Method

A search was performed of the literature published in English, Dutch or

German in medical and educational publications since 1992 relating to life-support courses. A search was made of PubMed using the following as key-words and text words: "life-support", "education", "APLS", "PALS", "ATLS", "ACLS". This yielded over 400 articles which were assessed by the main author on the basis of abstracts. Only articles relating specifically to the evaluation of life-support courses for doctors were selected for further analysis. A subsequent search of the Educational Resources Information Centre (ERIC) revealed no additional articles. In total 69 papers were reviewed, and all of these are included in the reference list at the end of this chapter

Evaluation

The evaluation of educational interventions has been discussed in some detail in the previous chapter. Over the past decades education, including specialist medical training and continuing medical education (CME) of specialists, has been increasingly outcome-based. As a result educational interventions are increasingly evaluated on the basis of their effectiveness. There are essentially two approaches to evaluation – naturalistic and experimental.[41] Experimental designs are hampered by the complex, multifaceted nature of education, by difficulty in obtaining a sufficiently large representative sample and by the selection of outcome measures. Much naturalistic evaluation is not rigorous enough in terms of reliability and validity to be regarded as research, but can, nonetheless, yield useful information to guide educational improvements.

A simple evaluation-system which lends itself to either an experimental or a naturalistic approach makes use of the model of Kirkpatrick (figure 1.4).[42] Life-support courses have not previously been analyzed using this model. In the model the effect of an intervention is considered at four levels, which, in the context of life-support courses can be described as:

1 *reaction* – what the participants thought of the course;

2 *learning* – what they learned on the course, in the widest sense: information, problem-solving and practical skills and attitudes;

3 *transfer* – how the participants changed their behaviour as a result of following the course; and

4 *outcome* – the effect that having followed the course had on patient outcome, either directly or indirectly.

The four levels are in a hierarchical relationship to each other: patient outcome can be improved with better patient care, which involves a behavioural change on the part of the doctor; behaviour can only change if new competencies are learned and are transferred to the workplace; and optimal learning can only take place if the learner reacts positively to the course.

Results and discussion

Virtually all of the research on life-support courses is published in the medical literature, as opposed to the (non-medical) educational literature. Much of the research identified focused on life-support courses in adult medicine, and this may not always be generalizable to paediatric courses. However, as there are relatively few studies of paediatric courses, a consideration of the literature on adult courses may be informative. The results are presented in four sections referring to the levels of Kirkpatrick's model.

Level I: Reaction

A positive reaction to an educational intervention is considered essential for subsequent learning.[42] A positive reaction to a life-support course may also have an indirect effect on patient care. A positive attitude may generate a desire within the care team to improve the work environment and organization such that transfer of new learning is facilitated, although this has yet to be demonstrated.

Participants' reaction to life-support courses is generally positive.[43] Reaction has been measured in terms of comfort or confidence which have all been shown to increase after life-support courses.[11;12;18;43;44] However a positive reaction does not correlate reliably with learning.[45]

Life-support courses can also have effects on non-participants. Nurses and surgical colleagues, who had not followed the course, have the impression that ATLS-trained doctors are better able to resuscitate and are more confident in managing trauma patients.[46]

Despite the positive attitude of attendees and others to life-support courses, they are not necessarily the most highly regarded learning opportunities available to doctors. In a survey of 1300 US surgeons, 55% of those who had followed the ATLS felt that they had learned at least a "fair amount" from it. This was similar to their reaction to reading journals, learning from colleagues and attending other educational courses.[47]

Thus, a positive reaction to a life-support course correlates poorly with other outcome measures and does not guarantee learning, but a negative reaction may impede learning. A positive reaction may stimulate organisational change with an indirect effect on patient care.

Level II: Learning

Life-threatening events in children are relatively rare and adequate management often requires immediate action, which means that the doctor will have to retain immediately accessible information and skills for long periods. Adult and paediatric life-support courses can lead to an immediate increase in both theoretical knowledge and practical skills.[11;12;46;48-50]. Unfortunately, this is often short-lived and performance can deteriorate alarmingly.[45;51-53] For these reasons evaluation of life-support courses at the level of learning should focus not on the immediate learning effect but on long-term retention.

Factual knowledge seems to be less well retained than conceptual knowledge or global performance during a simulated patient test.[51;54;55] Learning is greater for treatment protocols than for complex skills, and mastery of these skills is unlikely be achieved during the limited time available during a life-support course.[4;56]

Regular use of resuscitation skills improves retention but simply being an instructor on a life-support course does not guarantee it.[51;57] In fact instructors´ skills have in some cases been shown not to exceed those of candidates at the end of the course.[4;56]

Retention may be improved by more frequent refresher courses, improving teachers' teaching skills and understanding of educational principles and changing their attitude to teaching, making more use of modern learning methods such as computer-based and student-directed learning and adopting an interactive approach. [50;53] Another approach is to continue life-support training in the workplace using a similar educational strategy with the emphasis on simulation.[58-60] Mastery learning, in which learners are allowed to achieve learning objectives at their own tempo during a course of flexible duration, has also been advocated.[60] There has however been little systematic research on the effect of these methods on retention.

Life-support courses may have an indirect and general effect on learning even of doctors who do not attend the courses. This is nicely illustrated by a study in which trainee paediatricians were asked unannounced sentinel questions relating to paediatric emergency medicine in 1992 and in 1999.[1] Overall knowledge was much better in the later study. However, those questioned in 1999, who had *not* followed a life-support course, did better than the trainees questioned in 1992, before the introduction of life-support courses. Although many factors may have contributed to this, one possible explanation claimed is that the introduction of life-support courses led to an increase in general awareness of the importance of paediatric emergency medicine thus facilitating an increase in knowledge in all trainees. This explanation is plausible, but whether this would suggest that the development of life-support courses was a cause or a consequence of increased awareness of emergency medicine is unclear.

There is no clear answer to the question of how often a life-support course should be repeated in order to improve retention with maximum efficiency. The rate at which knowledge and skills decline varies between individuals and retraining at variable intervals, tailored to the individual doctor, is likely to be the most effective. A goal-directed approach to refresher course training has been adopted by Kaye who gave problems identified on a pre-course simulated resuscitation test the most emphasis during the course.[61]

It appears that life-support courses are effective in teaching the most essential concepts of emergency medicine and resuscitation and that this fundamental knowledge is well retained. Detailed knowledge and complex skills, however, tend to decline rapidly unless used regularly. It is uncertain to what extent patient outcome is influenced by loss of this detailed knowledge.

Level III: Transfer

Transfer after life-support courses can be considered as the application of newly learned knowledge in clinical practice and is acknowledged as the primary goal of many courses. Learning without transfer is redundant. Transfer is best studied by looking at actual clinical practice but has been more often studied in a simulated setting. The correlation between behaviour during actual and simulated patient management is unclear and is it not known whether this is influenced by the degree of realism of the simulation.

The assumption is that adequate transfer will lead to improved patient care although this remains unproven.[62] Improved survival after life-support course-training reported in some studies has not been correlated with behavioural changes.[63] However, survival of children with septic shock has been shown to improve when treated according to the guidelines of the US PALS-course.[64]

There is evidence that life-support courses can alter doctors' behaviour both directly and indirectly. Direct effects include the findings of Ali et al that, following the introduction of the ATLS-course into Trinidad and Tobago, many essential emergency procedures were performed earlier.[65] They also found that the incidence of endotracheal intubation decreased, which they attributed to better early resuscitation. An improvement in the timeliness, appropriateness and quality of thirteen interventions in trauma patients was also found following the introduction of the ATLS into the Netherlands.[66] At the same time, organisational changes were made to the emergency room environment which could have facilitated behavioural change and might be considered an indirect effect of the course. Organisational improvements were also reported in US paediatricians and family practitioners after a PALS-course, including the availability of Broselow tape and intraosseous devices.[67] Changes in practice has also been reported amongst obstetricians one year after following the ALSO course.[43]

Not all studies have demonstrated effective transfer. A survey of cardiac arrests over one year in an American hospital revealed no difference in compliance with guidelines between ACLS-certified and other doctors, and performance was generally poor.[68]

Redundant transfer may also occur in which behavioural change is unlikely to improve outcome. Following the ILS-course ward nurses remained reluctant to use their newly learned airway and defibrillation skills when they were the first responder at a cardiac arrest, preferring to wait for the arrival of the cardiac arrest team.[58] They were generally happy to use their ILS-skills to assist the team after arrival. Thus behaviour changed, but effective treatment was not instituted earlier and an opportunity to improve outcome was missed. The reasons for the reluctance to intervene early was not systematically explored and it is interesting to speculate whether self-efficacy played a role here.

The persistence of behavioural change after a life-support course has not yet been fully assessed, and may be influenced by the method used to measure it. Improved behaviour, as assessed globally on a patient simulator exercise, can be maintained for several years. However when individual interventions are assessed using a checklist, the improvement declines as early as six months after the course.[55]

Repeated spaced life-support training in the workplace can lead to an improvement in transfer, at least during simulated resuscitations[69], and has an additional effect on transfer compared to training in theory and isolated skills alone.[70]

<u>Level IV: Outcome</u>

The most important question relating to the effectiveness of life-support course is: do they actually improve patient outcome? Research in this area is fraught with difficulties. Reports are often uncontrolled, historical studies. Analysis of the effect of educational interventions on outcome is affected by a myriad of uncontrollable confounders. For example, in trauma care, patient outcome is influenced by: the (re-)organization of pre-hospital care, the introduction of mobile medical teams and trauma helicopters, the increased use of special trauma-protocols, the categorization of hospitals and the designation of trauma centres.[71] In addition, the level of training of non-medical staff is likely to have an important influence on outcome.[8]

Essentially life-support courses are only likely to be effective if local conditions including organisation of services and peer-pressure are conducive. Life-support courses are attended by individual doctors and it is often difficult to determine which patients were treated by life-support course-trained doctors, by a team including such doctors or by doctors who had not attended a life-support course. Correlating outcome to the life-support course-status of the individual doctor is often difficult and this has rarely been done.

It is also unclear what the optimal outcome measure should be. Morbidity from pre-arrest conditions may be a better index of patient outcome than mortality when looking at paediatric life-support courses, as the frequency of resuscitations is low.[67] Quan suggests that the early recognition of potentially life-threatening situations would be an appropriate measure, although this would be difficult to operationalize.[12]

Outcome is also heavily influenced by severity of illness – particularly in a heterogeneous disease like trauma. However, stratification systems for the severity of injury have been criticized which makes the use in attempts to control for this factor controversial.[72;73]

The degree of improvement expected from a life-support course will depend on the level of care before training, with the greatest improvements expected where this is lowest.[66] The care of medical emergencies can be seen as a chain of survival in a multiplicative process in which outcome is most significantly determined by the link in the chain with the highest mortality. Which link this is will vary between hospitals, healthcare systems and patient-groups. Identifying this link requires a careful and extensive needs analysis, including the development of a longitudinal database of quality of clinical care, cost-effective decision-making and patient and doctor satisfaction. Ideally, such information should be collected nationally or internationally. Presently, this information is, at best, patchy for paediatric emergency medicine.

Life-support courses which focus on the weakest link will be the most effective. However improving survival at *any* stage opens the door to other interventions which may subsequently improve survival at later stages and an intervention which improves mortality at an intermediate link in the chain, but not overall, should not be considered unhelpful. To illustrate this, overall mortality in two Dutch hospitals did not change after introduction of the ATLS, although mortality in the first hour after arrival did significantly decline.[63] In particular mortality from two types of preventable causes of early death which are specifically addressed on the ATLS-course - tension pneumothorax and cardiac tamponade - were only seen in the pre-ATLS period. ATLS training, with its focus on management during the first hour may only be able to influence this period and overall mortality may be determined by other weaker links later in the trauma care chain.[74] However, only patients who survive the first hour will have a chance of overall survival.

The above discussion explains why a Cochrane systematic review of the effectiveness of hospitals with an ATLS-trained trauma response system was unable to find any trials rigorous enough for inclusion.[40] Nevertheless some researchers have claimed a reduction in mortality after introduction of a life-support course. Early studies have been reviewed by Jabbour et al and include a reduction of mortality by 50% after the introduction of the ATLS into Trinidad and Tobago and into Canada, and improved pre-hospital survival after

ACLS training in the USA.[39]

The reduction in mortality seen after the ATLS, if real, may not be expected to apply to all life-support courses.[39] The advantages of early intervention, which are widely accepted in trauma care, are more difficult to demonstrate in paediatric emergencies.[75] Life-support courses in areas other than trauma therefore need to focus on areas where improved early intervention can improve outcome. Cardiac arrest due to acute rhythm disturbance is likely to be such an area and an improvement in initial resuscitation success and long-term survival after ACLS training of junior doctors and of nurses has been reported.[76] Patients discovered by an ACLS-trained nurse were nearly four times more likely to survive than other patients, and the ACLS-status of the nurse was the second most important factor in determining outcome.

Educational interventions other than life-support course may improve outcome, such as systematic review of video recordings of actual resuscitations.[77] However, comparative trials of life-support courses with other educational interventions were not found in the accessible literature.

General conclusions

The study of the effect of life-support courses is fraught with methodological difficulties and a naturalistic approach is often adopted.

The reaction of participants to life-support courses is generally positive. Learning in terms of knowledge and skills certainly takes place, but retention of infrequently used knowledge and skills is short unless measures are taken to follow up on this learning.

There is evidence that life-support courses can lead to a change in behaviour and patient outcome has been shown to increase after the introduction of life-support courses but the large number of potential confounders makes a causal relationship difficult to prove. The positive effect of life-support courses may owe more to indirect effects on the organisation of heath-care than to the skills acquired by individuals.

Nevertheless, a doctor’s life support skills are important and so far, the model of the life-support course seems the best planned educational intervention imaginable to supply the health care community with them. A continuous search for adequate evaluation tools is necessary to optimize our knowledge of the effects of life-support courses and the ways to improve them further.

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3

Validity of the visual analogue scale as an instrument to measure self-efficacy in resuscitation skills

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Summary

Background:

Self-efficacy is an important factor in many areas of medical education including self-assessment and self-directed learning, but has been little studied in resuscitation training, possibly due to the lack of a simple measurement instrument. We assessed the validity of a visual analogue scale linked to a single question as an instrument to measure self-efficacy in respect of resuscitation skills.

Design:

Comparison of the visual analogue scale with a questionnaire and known-groups comparisons.

Methods:

We developed questionnaires to measure self-efficacy for a number of resuscitation tasks and for computer skills. These were compared with visual analogue scales linked to a single question per task, using a multi-trait multi-method matrix. We also made known-groups comparisons of self-efficacy in specific professional groups.

Findings:

There was a good correlation between the questionnaires and the visual analogue scales for self-efficacy for specific resuscitation tasks. There was a less clear correlation for self-efficacy for paediatric resuscitation globally. There was no correlation between self-efficacy for resuscitation and for computer tasks. In specific professional groups measured self-efficacy accorded with theoretical predictions.

Conclusions:

A visual analogue scale linked to a single question appears to be a valid method of measuring self-efficacy in respect of specific well-defined resuscitation tasks, but should be used with caution for multifaceted tasks.

Introduction

Self-efficacy can be defined as a person's belief in their capability to organise and execute the course of action required to produce given attainments.[1] It is a familiar concept in psychology, and is believed to be an important factor in many areas of medical education, including resuscitation training.[2-6]

Self-efficacy is a task-specific predictor of behaviour. As such it differs from self-confidence which is a generalized personality trait, which does not predict behaviour significantly.[1] A strong sense of self-efficacy for a particular task is believed to influence an individual's behaviour by: 1) Influencing choices – making them more likely to attempt the task; 2) Determining effort and persistence – increasing the likelihood that they will persevere in the task and thus to attain a higher level of mastery; 3) Influencing thought patterns - promoting positive thinking and a better ability to deal with intercurrent problems and self-defeating thoughts; 4) Influencing emotional reactions – improving performance by reducing stress.[5] Therefore resuscitation training should specifically aim to increase self-efficacy with respect to the skills learned, and some resuscitation courses make use of techniques which are likely to do this, such as simulated personal experience, learning through observation of peers and perceived experts, verbal persuasion and close attention to the affective state of the learner.[7]

There has been relatively little research on the effect of resuscitation training on self-efficacy and one possible reason for this is the lack of a simple measurement instrument. Self-efficacy is generally measured using a carefully constructed questionnaire which includes a large number of questions on the component-steps of the task under study and impediments to its performance.[8;9] The resulting questionnaire is often quite lengthy and this may be a barrier to its use, especially when studying self-efficacy for several different tasks.

We examined the use of a visual analogue scale (VAS) for the measurement of self-efficacy in order to conduct a study of the effect of following the Advanced Paediatric Life Support course on self-efficacy in respect of paediatric resuscitation tasks.[10] The VAS is simple and quick to use and is familiar to most heath-care professionals, as it has been used extensively in the measurement of pain and of anxiety.[11;12]

The VAS has been used to measure self-efficacy before, but usually in combination with a lengthy questionnaire.[13;14] It was our aim to assess the validity of a visual analogue scale linked to a single question per task as a simple estimate of self-efficacy.

Methods

We investigated the concurrent validity of the visual analogue scale by comparing it with a questionnaire for each of a number of separate tasks. As we were unaware of any previously validated questionnaires for paediatric resuscitation skills, we constructed our own according to an accepted methodology and taking care to ensure face validity and internal consistency.[8;9]

We assessed construct validity using a multi-trait multi-method matrix (MTMM) of the correlations between self-efficacy for the various tasks as measured using the VAS and the questionnaire.[15] In an MTMM, all possible pairs of correlations between the variables under consideration are tabulated. The correlations between self-efficacy measured using different instruments (the questionnaire and the VAS) for each individual task form a diagonal line in the MTMM known as the monotrait-heteromethod line or the validity diagonal (see Tables 3.1 - 3.3). If both methods of measurement are valid, the correlations in this line should be the highest in the table. High correlations between unrelated tasks measured using different instruments (heterotrait-heteromethod correlations) would suggest that one or both of the instruments was invalid. There may however be a high correlation between self-efficacy for different but related tasks such as those resuscitation skills which are practised and performed together. In this case one would expect the correlation to be higher when the two tasks are measured on the same instrument (heterotrait-monomethod correlation) than when measured using different instruments (heterotrait-heteromethod correlations). Thus the MTMM shows the degree to which related tasks correlate (convergent validity), and conversely, the degree to which unrelated tasks do not correlate (discriminant validity).[16]

As further tests of construct validity we made known-groups comparisons of participants who, as a result of special experience and skills, would be expected to have a higher self-efficacy for particular tasks, and we also measured the effect of an intervention expected to increase self-efficacy (following a resuscitation course).

<u>Participants</u>

The pre-tests of the questionnaires were carried out in consultant and trainee paediatricians and anaesthesiologists, and paediatric intensive care and general paediatric nurses in six Dutch hospitals. For the comparison of the questionnaires with the VAS, the participants consisted of the same professional groups in two Dutch teaching hospitals, senior medical students at the University of Utrecht and all doctors and nurses following a national paediatric resuscitation course (APLS Recertification Course). Except for this last group, all participants were randomly selected from the relevant personnel lists. No participant participated in more than one part of the study.

Questionnaire design and pre-tests

We selected three specific paediatric resuscitation tasks to be studied, on the basis of clinical relevance: cardiac massage, bag and mask ventilation and insertion of an intra-osseous device (a method of obtaining vascular access in emergency situations). We also included paediatric resuscitation globally as a fourth domain. We subsequently designed separate questionnaires to measure self-efficacy in respect of these four domains.

In the first stage of the development of the questionnaires for the specific tasks, the main investigator and two other expert colleagues devised a list of the procedural steps involved in performing each task. Using this list as a guide a series of structured interviews with 20 doctors and nurses with varying amounts of experience in paediatric resuscitation was conducted in order to identify facilitating and impeding factors to performing each task and to ensure that the most relevant aspects of the tasks under consideration were included in the questionnaires. On the basis of this, preliminary questionnaires were drafted with a total of 72 questions. Each question was required to be scored on a scale of 0 to 100. The questionnaire relating to global paediatric resuscitation was modified from that previously used in a study of paramedics' knowledge and comfort about children.[17] The preliminary questionnaires were pre-tested in 20 participants for readability and clarity.

After textual adjustment the questionnaires were submitted to a second pre-test in 27 participants to estimate internal consistency. We aimed to restrict the length of the questionnaires and to optimalize their internal consistency as measured with Cronbach's alpha by using the SPSS® function "alpha if deleted". However, we also carefully considered which questions to eliminate in order not to reduce the scope of the questionnaires significantly. Twenty-two questions (31%) were eliminated at this stage, and these were fairly evenly distributed over the four domains.

Because the results of the second pre-test suggested a significant correlation between a number of different resuscitation skills, a fifth questionnaire with 21 question relating to a domain unrelated to resuscitation – using a computer – was added. This was modified from a previously used questionnaire.[18] All questionnaires were then subjected to a final pre-test among 45 participants.

Following the final pre-test Cronbach's alpha was calculated for each questionnaire and, using the criteria mentioned above, the questionnaire relating to computer use was reduced from 21 to 11 questions. The other questionnaires did not require further modification.

The questionnaires used for the comparative study contained in total 61 items.

All questionnaires were presented in Dutch (see appendix A).

Comparison of the questionnaires with the VAS

The self-efficacy questionnaires were combined in one document together with single questions relating to each of the five tasks under consideration (VAS-questions). These were of the form "Indicate how confident you believe yourself to be in performing each of the following tasks". Each of these VAS-questions required an answer on an enclosed 100 mm horizontal visual analogue scale with 5 mm vertical end-bars and anchor statements "not at all confident" and "extremely confident" at the left and right end respectively.

The questionnaires and the five VAS-questions were sent to a group of 150 participants (100 doctors and 50 nurses). Similar questionnaires and visual analogue scale questions were sent to 25 final-year medical students. The student questionnaires were limited to domains in which the students were likely to have some practical or simulated experience: cardiac massage, bag and mask ventilation and computer skills.

Questionnaires and VAS-questions on global paediatric resuscitation, bag and mask ventilation, insertion of an intra-osseous device and computer tasks, were sent to all 31 candidates following the APLS -Recertification Course (RCC) six weeks before and six weeks after the course. The change in self-efficacy as measured with each instrument was compared.

Data analysis

For each subject the individual scores for each question in each task-related questionnaire were averaged to give a mean self-efficacy score for that questionnaire. The VAS-questions were scored by measuring the distance in millimetres from the left-hand anchor bar.

For each task, the correlations between the VAS scores and the mean score on the questionnaire were calculated and a multi-trait multi-method matrix was constructed.

The self-efficacy scores measured using both the questionnaire and the visual analogue scale in respect of each task were compared separately for the nurses, doctors and students, and among the doctors for paediatricians and anaesthesiologists separately.

As the data were found not to be normally distributed (on the basis of tests of skewness and kurtosis), we used Spearman's rho to measure correlation. Similarly the Wilcoxon and Mann-Whitney tests were used to compare paired and unpaired data samples respectively in the known-group analysis. SPSS® version 10.1 was used for all statistical calculations. A p-value of ≤ 0.01 was taken to be significant.

Results

Questionnaires

Cronbach's alpha for the final questionnaires was: 0.95 for cardiac massage, 0.98 for bag and mask ventilation, 0.98 for insertion of an intra-osseous device, and 0.94 for computer skills. Cronbach's alpha for paediatric resuscitation globally was 0.77 for all participants (0.59 for nurses and 0.79 for doctors).

Response

Of the 175 questionnaires sent to participants in the comparative study, six were not received due to postal errors and these were excluded. One hundred and sixteen questionnaires (52 doctors, 41 nurses, 22 students, 1 unknown) were returned fully completed giving an overall response rate of 67% (82% for nurses, 55% for doctors and 88% for medical students). Of the 31 candidates following the RCC-course, 19 (61%) completed and returned both the pre-course and post-course questionnaire.

Correlations

The MTMM for all participants is shown in Table 3.1, and those for doctors and nurses separately in Tables 3.2 and 3.3. For all participants combined the monotrait-heteromethod correlations for self-efficacy for the specific tasks in the validity diagonals are high and are the highest correlations in their respective columns and rows. There are also reasonably high correlations between paediatric resuscitation globally and its component skills of cardiac massage and bag and mask ventilation, and also between these two skills. The monomethod correlations between these skills are generally higher than the heteromethod correlations. There is no correlation between computer tasks and any of the resuscitation tasks.

However, for all participants combined, there is no significant monotrait-heteromethod correlation for paediatric resuscitation globally. There is a reasonable monotrait-heteromethod correlation for global paediatric resuscitation for doctors and nurses separately, but the correlations between global resuscitation and specific resuscitation skills are in several cases higher.

Known groups analysis

The means of self-efficacy for the doctors, nurses and students for all tasks, as measured using the questionnaire and the VAS, are shown in figures 3.1a and 3.1b respectively. The two graphs show a similar pattern. Using both instruments doctors scored significantly higher than nurses for the insertion of an intra-osseous device (means (SD) VAS: 47.3 (31.2) and 27.0 (25.0),

		Visual analogue score					Questionnaire			
		Paediatric resuscitation	Cardiac massage	Bag/mask ventilation	Intraosseous device	Computer skills	Paediatric resuscitation	Cardiac massage	Bag/mask ventilation	Intraosseous device
Visual analogue score	Cardiac massage	0.91**								
	Bag/mask ventilation	0.56**	0.67**							
	Intraosseous device	0.32*	0.31*	0.37**						
	Computer skills	-0.05	-0.11	0.01	0.26					
Questionnaire	Paediatric resuscitation	**0.05**	0.10	0.31*	0.59**	0.29*				
	Cardiac massage	0.66**	**0.80****	0.52**	0.28*	-0.10	0.13			
	Bag/mask ventilation	0.38**	0.59**	**0.73****	0.30*	-0.06	0.31*	0.73**		
	Intraosseous device	0.26	0.27*	0.31*	**0.91****	0.25	0.58**	0.28*	0.32*	
	Computer skills	-0.14	-0.17	-0.08	0.21	**0.75****	0.41**	-0.19	-0.10	0.19

Table 3.1: *Multitrait-multimethod matrix for all participants. Values are Spearman's rho. * = p < 0.01 ** = p < 0.001. The correlations in the monotrait-heteromethod line (validity diagonal) are in bold type. (n = 116 except for paediatric resuscitation globally and intraosseous device where n = 94 as the medical students did not complete these sections.)*

		Visual analogue score					Questionnaire			
		Paediatric resuscitation	Cardiac massage	Bag/mask ventilation	Intraosseous device	Computer skills	Paediatric resuscitation	Cardiac massage	Bag/mask ventilation	Intraosseous device
Visual analogue score	Cardiac massage	0.89**								
	Bag/mask ventilation	0.68**	0.65**							
	Intraosseous device	0.60**	0.51**	0.32						
	Computer skills	0.17	0.15	0.20	0.22					
Questionnaire	Paediatric resuscitation	**0.60****	0.53**	0.30	0.56**	-0.02				
	Cardiac massage	0.73**	**0.82****	0.39*	0.62**	0.12	0.68**			
	Bag/mask ventilation	0.45*	0.49**	**0.53****	0.42*	0.16	0.45**	0.58**		
	Intraosseous device	0.52**	0.48**	0.24	**0.93****	0.14	0.64**	0.66**	0.49**	
	Computer skills	-0.05	-0.03	-0.17	-0.05	**0.62****	-0.16	-0.05	0.04	-0.11

Table 3.2: *Multitrait-multimethod matrix for doctors (n= 52). Values are Spearman's rho. * = p <0.01 ** = p < 0.001. The correlations in the monotrait-heteromethod line (validity diagonal) are in bold type.*

		Visual analogue score					Questionnaire			
		Paediatric resuscitation	Cardiac massage	Bag/mask ventilation	Intraosseous device	Computer skills	Paediatric resuscitation	Cardiac massage	Bag/mask ventilation	Intraosseous device
Visual analogue score	Cardiac massage	0.89**								
	Bag/mask ventilation	0.64**	0.66**							
	Intraosseous device	0.37	0.39	0.39						
	Computer skills	-0.04	-0.11	-0.03	0.18					
Questionnaire	Paediatric resuscitation	**0.55****	0.58**	0.38	0.42*	0.19*				
	Cardiac massage	0.55**	**0.57****	0.38	0.09	-0.01	0.63**			
	Bag/mask ventilation	0.38	0.45*	**0.55****	0.12	-0.08	0.52**	0.75**		
	Intraosseous device	0.34	0.31	0.36	**0.80****	0.18	0.30	0.02	0.01*	
	Computer skills	0.11	0.03	0.02	0.05	**0.77****	0.11	-0.02	-0.09	0.08*

Table 3.3: *Multitrait-multimethod matrix for nurses (n= 41). Values are Spearman's rho. * = p < 0.01 ** = p < 0.001. The correlations in the monotrait-heteromethod line (validity diagonal) are in bold type.*

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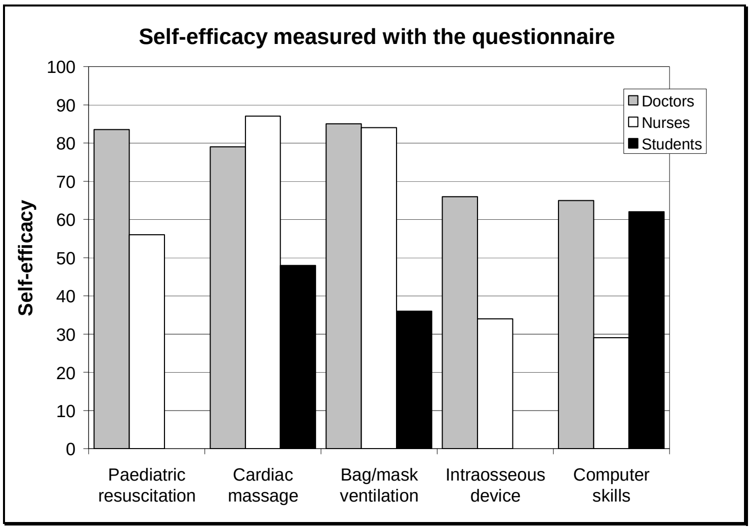
questionnaire: 57.1 (30.7) and 35.9 (27.1) respectively), but doctors scored significantly lower than nurses for cardiac massage (means (SD) VAS: 64.6 (20.7) and 75.7 (16.2), questionnaire: 77.0 (13.6) and 84.7 (10.0) respectively).

Both doctors and nurses scored significantly higher for bag and mask ventilation and cardiac massage than medical students. The students scored higher than nurses for computer tasks but the difference was only statistically significant for the questionnaire (questionnaire: $p<0.01$, VAS: $p = 0.14$).

For paediatric resuscitation globally, doctors scored significantly higher than nurses on the questionnaire (mean (SD) 80.3 (10.8) versus 54.7 (7.9) respectively). However, there was a significant difference in the opposite direction when the visual analogue scale scores were compared (doctors: 58.6 (20.3), nurses: 71.4 (16.8)).

Self-efficacy for bag and mask ventilation was significantly higher for anaesthesiologists than for paediatricians using both the visual analogue scale (mean (SD) 83.1 (13.3) and 73.5 (15.4) respectively), and the questionnaire



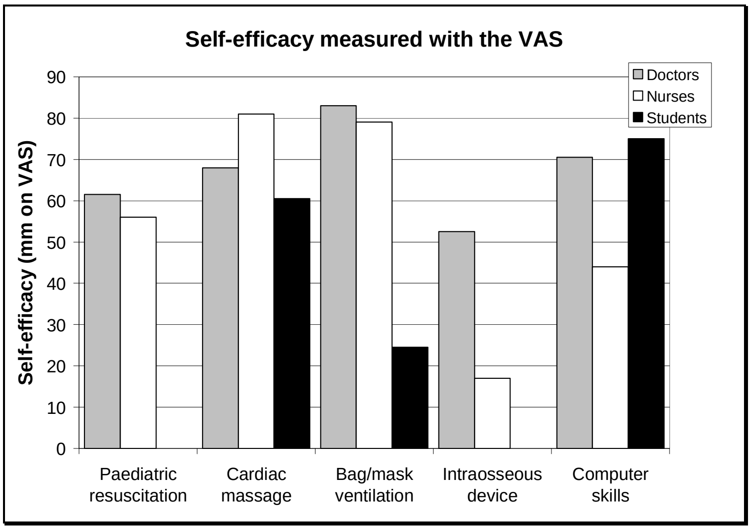


Figure 3.1: *Mean self-efficacy per task for doctors, nurses and medical students measured using the questionnaire (top) and the VAS (bottom).*

(mean (SD): 87.4 (9.3) and 78.4 (11.4) respectively).

<u>Recertification course data</u>

There was a significant increase in self-efficacy for all resuscitation tasks after following the recertification course for both the questionnaire and the VAS (mean (SD) questionnaire scores pre-post: Paediatric resuscitation globally 77.1 (13.0) - 83.6 (7.7); Bag-mask ventilation 78.2 (11.4) - 85.9 (6.3); Intra-osseous device 65.6 (20.3) - 81.8 (12.2). VAS pre-post: Paediatric resuscitation globally 59.7 (15.2) - 72.9 (16.3); Bag-mask ventilation 72.5 (12.6) - 83.8 (9.3); Intra-osseous device 52.0 (18.3) - 79.1 (11.4)). There was no significant change in VAS score for self- efficacy for computer skills after the course (pre-course 61.8 (21.1), post-course 65.8 (23.1)). However measured with the questionnaire, self-efficacy for computer tasks did increase significantly ($p = 0.01$) after the course (pre-course 49.2 (24.5), post-course 56.0 (25.1)).

Discussion

The use of the visual analogue scale offers a potential quick and simple measure of self-efficacy, which may stimulate research into various aspects of resuscitation such as the effect of training, the use of self-efficacy as a self-assessment tool and behaviour in resuscitation situations. The VAS is familiar to health care workers and, being much shorter than a self-efficacy questionnaire, it may improve compliance, especially if multiple measurements are used.

Our results show that there is evidence for the validity of the VAS as a measure of self-efficacy. The pattern of correlations presented in the MTMM suggests that the VAS-questions and the questionnaires are measuring the same construct. The known groups analysis shows that self-efficacy measured on the VAS is higher in groups where this would be expected theoretically and where it was confirmed using the questionnaire. These findings support the construct validity of the VAS measurement. The RCC-course makes extensive use of techniques to increase self-efficacy such as simulation to enhance personal mastery experiences and observational learning, verbal persuasion and attention to the affective state of the learner (5;7). The increase in self-efficacy for resuscitation tasks measured after following this course is therefore further evidence of the construct validity of the VAS.

The moderately high mono- and heteromethod correlations in the MTMM between self-efficacy for bag and mask ventilation and cardiac massage for all participants is not surprising as these skills are often learned, practiced and performed in close association. This leads to an association between self-efficacy for these tasks in a process described by Bandura as co-development.[1] The same process might explain the much stronger correlation of self-efficacy for insertion of an intra-osseous device with other resuscitation skills for doctors than for nurses, as this skill is often part of resuscitation training for the former group but not for the latter.

As the three resuscitation skills studied are component tasks of paediatric resuscitation globally, their correlation with self-efficacy for global paediatric resuscitation is also not unexpected. These findings, together with the predictable lack of correlation between resuscitation and computer tasks can be considered further evidence of the construct validity of the VAS.

There was no correlation between the questionnaire and the VAS for global resuscitation when all participants were included. However a reasonable correlation emerged when doctors and nurses were considered separately. This could be due to different interpretations by these two groups of their role during resuscitation. Both groups scored their self-efficacy in a similar range on the VAS, and are likely to have done this in reference to their perception of the maximum self-efficacy for their role during resuscitation. The nurses scored themselves significantly lower than the doctors on the questionnaire which contained questions on several resuscitation tasks which, in the hospital setting, are generally only performed by doctors. Therefore the questionnaire proved to be more discriminatory than the visual analogue scale and, as discussed by Bandura[1], it seems unlikely that a single question linked to a VAS could replace a multifaceted questionnaire when dealing with such a complex and imprecisely specified activity. We believe that the formulation and specificity of an unambiguous question targeted at a well-defined task in a specific group of participants is critical for the VAS to be a valid measure of self-efficacy.

Our study does have several limitations. Firstly, the questionnaire used to measure paediatric resuscitation globally was derived from one developed by Spaite et al for paramedics.[17] We found it to be internally reliable for use with anaesthesiologists and paediatricians, but less so for use with hospital nurses. This questionnaire was therefore possibly not an optimal self-efficacy measure for the latter group, and this may partially explain the less than ideal distribution of correlations in the MTMM for nurses for this domain. Secondly. we compared self-efficacy for two sample populations at one point in time. Self-efficacy is however a personal trait and large inter-individual differences probably account for some of the variability in our correlations. In order to quantify this it would be interesting to correlate the questionnaire and visual analogue scale in the same individuals over a longer period of time. Thirdly, the generalizability of our findings to other task or domains or to other individuals needs further investigation.

Conclusion

We conclude that there is evidence that the visual analogue scale linked to a single unambiguous question targeted at a well-defined task is a valid method of measuring self-efficacy for specific paediatric resuscitation skills, but is less robust as a measure of self-efficacy for complex multi-facetted or imprecisely defined tasks.

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The effect of the Advanced Paediatric Life Support course on self-efficacy and use of resuscitation skills

4

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Summary

Background

Perceived self-efficacy is a predictor of behaviour and therefore an important dimension of resuscitation training which may have consequences for patient care. The Advanced Paediatric Life Support (APLS) course makes use of techniques which would be expected to increase self-efficacy. We examined the effect of this course on self-efficacy in respect of resuscitation skills and on the use of these skills.

Design

A prospective descriptive study using a questionnaire.

Methods

Questionnaires were sent to all doctors following the course (the candidates) in the Netherlands over a period of 15 months and to a matched control group. Self-efficacy in respect of paediatric resuscitation as a whole and six of its component skills was measured on a visual analogue scale. Questionnaires were sent out before the course and at three and six months after it.

Findings

The candidate and control groups were not significantly different in terms of sex, specialty, grade or experience with children. Self-efficacy increased significantly ($p<0.01$) in candidates following the course for all skills and remained increased for at least six months. There was no significant change in self-efficacy in the control group. There was no change in skills-use or in the number of critically ill children seen, in either group.

Conclusions

The APLS-course does have an important effect on self-efficacy but this is not related to an increase in the frequency of use of the skills learned on the course, partly because the opportunity for increased use is lacking. Further work is needed to determine whether the quality of those skills is improved by the course.

Introduction

The Advanced Paediatric Life Support (APLS) course as given in the Netherlands is a three-day course in paediatric emergency medicine for qualified doctors which originated in the United Kingdom. Over 1000 doctors have followed the course in the Netherlands since its introduction in 1998. The course aims to teach the skills and knowledge required to treat children with life threatening illness or injury in the first hour after presentation.[1] The APLS employs various teaching methods including interactive lectures, skills training and simulated cases in a realistic setting, and places great emphasis on the educational environment and structured feedback.

Although there has been extensive descriptive and some experimental research of similar life-support courses aimed at various patient groups, there has been little attention paid to the APLS-course itself in the medical or educational literature. Life-support courses generally appear to be effective in increasing factual knowledge and problem solving skills within the context addressed by course, but retention generally is limited to a few months.[2-6] Certain practical skills such as insertion of an intraosseous device can also be learned on these courses but retention is short unless the skill is practised frequently.[7-9] As far as we can ascertain, there have been no studies looking at the use of the skills learned on an APLS-course.

One factor believed to influence the use of skills is perceived self-efficacy (hereafter referred to simply as self-efficacy) which is defined as a person's belief in their capability to organise and execute the course of action required to produce given attainments.[7] Self-efficacy is closely related to, but distinct from confidence. Confidence refers to a level of belief, whereas the construct of self-efficacy includes both the expected level of achievement and the individual's belief in their ability. Self-efficacy is a predictor of behaviour: an increase in the strength of self-efficacy with respect to a particular skill is likely to lead to an increase in its use, provided there is an opportunity to do so.[8;9] It is also possible that a threshold level of self-efficacy exists under which a skill is unlikely to be used in practice, regardless of the degree of proficiency. A course such as the APLS should aim to influence self-efficacy in respect of the skills required to provide adequate emergency care to critically ill children.

Maibach et al in a review of self-efficacy in paediatric resuscitation training have suggested methods to increase self-efficacy on resuscitation courses, many of which are used in the APLS-course. These include explicit mental rehearsal during skills training, role modelling, verbal persuasion and attention to the affective state of the learner.[10] The APLS course also makes use of other techniques which are believed to increase self-efficacy, such as observational learning from both peers and perceived experts.[7]

Maibach et al also emphasized the need for evaluative research on self-efficacy in resuscitation training, but as yet there has been little published in this area.

Two authors have specifically looked at the effect of resuscitation training on confidence. Spaite et al found that an educational programme focused on paediatric emergencies increased the "comfort" of ambulance personnel in dealing with these problems - a vague construct which may be related to self-efficacy.[11] Nadel et al found an increase in confidence in respect of both resuscitation skills and leadership in paediatric trainees after following a paediatric life-support course, however these authors do not define what they mean by confidence nor do they describe the method used to measure it.[12]

The aim of the present study was to assess the effect of the APLS-course on self-efficacy for resuscitation skills and its relationship to the frequency of use of those skills. Using a questionnaire, we compared self-efficacy and skills-use in doctors who followed the APLS course (the candidates) with a matched control group who did not follow it.

Materials and methods

<u>Subjects</u>

We included all 204 candidates who followed the APLS course in the Netherlands between October 2003 and December 2004. In order to control for natural changes of self-efficacy over time, we generated a control group by asking each candidate to nominate two direct colleagues who had not followed the APLS-course and were not registered to do so during the study period.

<u>Questionnaires</u>

We devised a series of questionnaires to measure self-efficacy in respect of paediatric resuscitation and six of its component skills: external chest compressions, bag and mask ventilation, endotracheal intubation, defibrillation, insertion of an intraosseous device and umbilical catheterisation, giving a total of seven domains. Subjects were also asked to indicate the number of times they had been involved in treating critically ill or severely injured children, or had used the skills, during the preceding three months.

The first questionnaire also contained questions on the candidate's sex, grade, speciality and amount of previous experience with critically ill and severely injured children.

We used a 100 mm visual analogue scale to measure self-efficacy, which we have found to be a valid instrument for this purpose, as discussed later.

<u>Procedure</u>

All candidates and control group subjects were sent a questionnaire at three time intervals: before the course (or at inclusion for the control group) and three and six months later. All questionnaires were made anonymous by a secretarial assistant before being analyzed by the researchers. Subjects who failed to respond to the first questionnaire were excluded from the study.

Analysis

We compared the controls with the candidates in terms of sex, grade, specialty and amount of experience with children.

We performed a non-responders analysis by comparing the respondents with all candidates who followed the APLS-course in the study period in respect of all the information on the non-responders available to us, namely: sex, grade and speciality and results in the course assessments of theory, practical skills and simulated patient (scenario) test.

We used the Mann-Whitney or Wilcoxon test to compare unpaired and paired non-parametric interval data respectively, the t-test to compare parametric data and the Chi-squared test to compare non-interval data. We considered a p value of <0.05 to be statistically significant.

Results

Response

The number of candidates returning the first, second and third questionnaires were 153, 112 and 83 respectively and 66 candidates responded to all three questionnaires. There was no significant difference between the responders to each of the three questionnaires and the total candidate group in terms of sex, grade, speciality or test results, nor was there a difference between the responders and the non-responders for these characteristics. There was no significant difference between the three groups of responders in terms of experience with children (years of experience with critically ill children) or current exposure to paediatric patients (children as percentage of all patients seen).

The candidates nominated 83 colleagues of whom 52 agreed to take part in the study and returned the first questionnaire. Thirty-three of this control group returned the second questionnaire, 29 the third and 19 subjects returned all three questionnaires appropriately completed.

We found no significant difference between the groups in terms of the measured characteristics when candidates and control group subjects who responded to all three questionnaires were compared (table 4.1). When the responders were compared for each questionnaire separately, a similar pattern was seen with no difference between the candidate and control groups.

	Control group	Candidates
N	19	66
Female: number (% total)	12 (63%)	43 (65%)
Trainee: number (% total)	11 (58%)	40 (62%)
Specialty: number (% total)		
Anaesthetics	2 (11%)	7 (11%)
Paediatrics	12 (63%)	45 (68%)
Emergency medicine	2 (11%)	10 (15%)
Surgery	2 (11%)	4 (6%)
Other	1(5%)	3 (9%)
Years of experience with critically ill children (mean)	6.7	7.1
Number of children seen (percentage of all patients seen)	70%	76%

Table 4.1: *Characteristics of the candidate and control groups compared*

Self-efficacy

There was no significant difference between the pre-course self-efficacy of the candidates and the control group subjects for any of the seven domains measured. This was true for both the subjects who returned all questionnaires and those who only responded to only one or none of the post-course questionnaires (figure 4.1).

Self-efficacy increased significantly ($p < 0.01$) for candidates in all domains at three and six months compared to the pre-course value. Figure 4.2 shows the change in self-efficacy for all candidates and control group subjects who responded to the questionnaire at these time points.

There was no significant change in self-efficacy over the study period in the control group for any of the domains. A similar pattern and level of significance is seen if the analysis is restricted to those subjects who completed all three questionnaires (figure 4.3).

Skills-use

The percentage of subjects involved in the treatment of a least one critically ill child or using one of the resuscitation skills at least once in the three months preceding the questionnaire is shown in figure 4.4. There was no significant difference in the number of critically ill children seen between the candidates

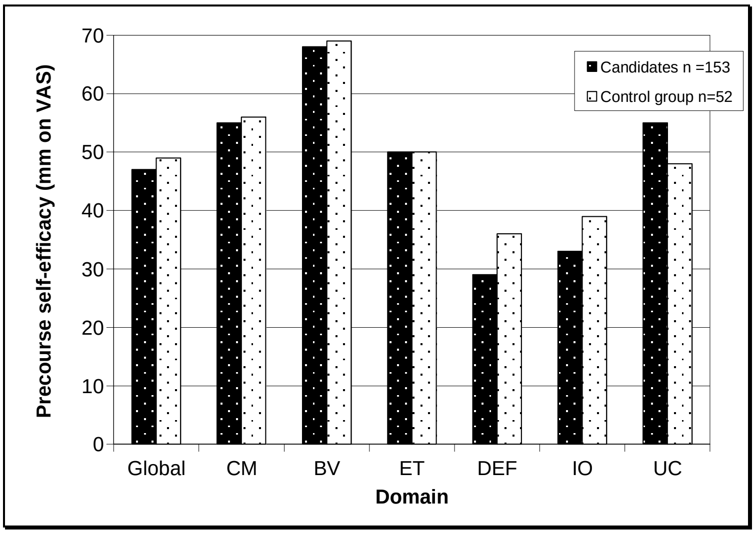

Figure 4.1: *Pre-course self-efficacy for the candidates and control group. (Global = Treatment of critically ill children, CC = External chest compressions, BV = Bag-mask ventilation, ET = Endotracheal intubation, DEF = Defibrillation, IO = Intraosseous device, UC = Umbilical catheterisation.)*

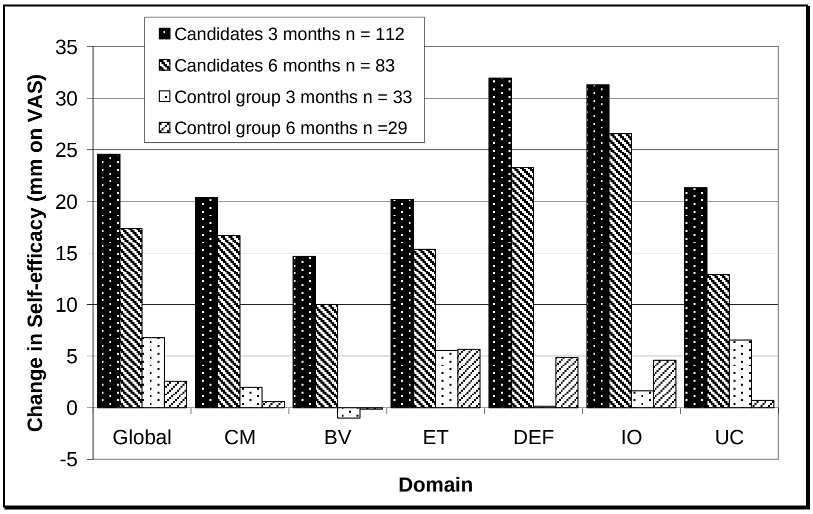

Figure 4.2 : *Change in self-efficacy VAS-score in the candidates and the control group at three and six months compared to pre-course. (Global = Treatment of critically ill children, CC = External chest compressions, BV = Bag-mask ventilation, ET = Endotracheal intubation, DEF = Defibrillation, IO = Intraosseous device, UC = Umbilical catheterisation.)*

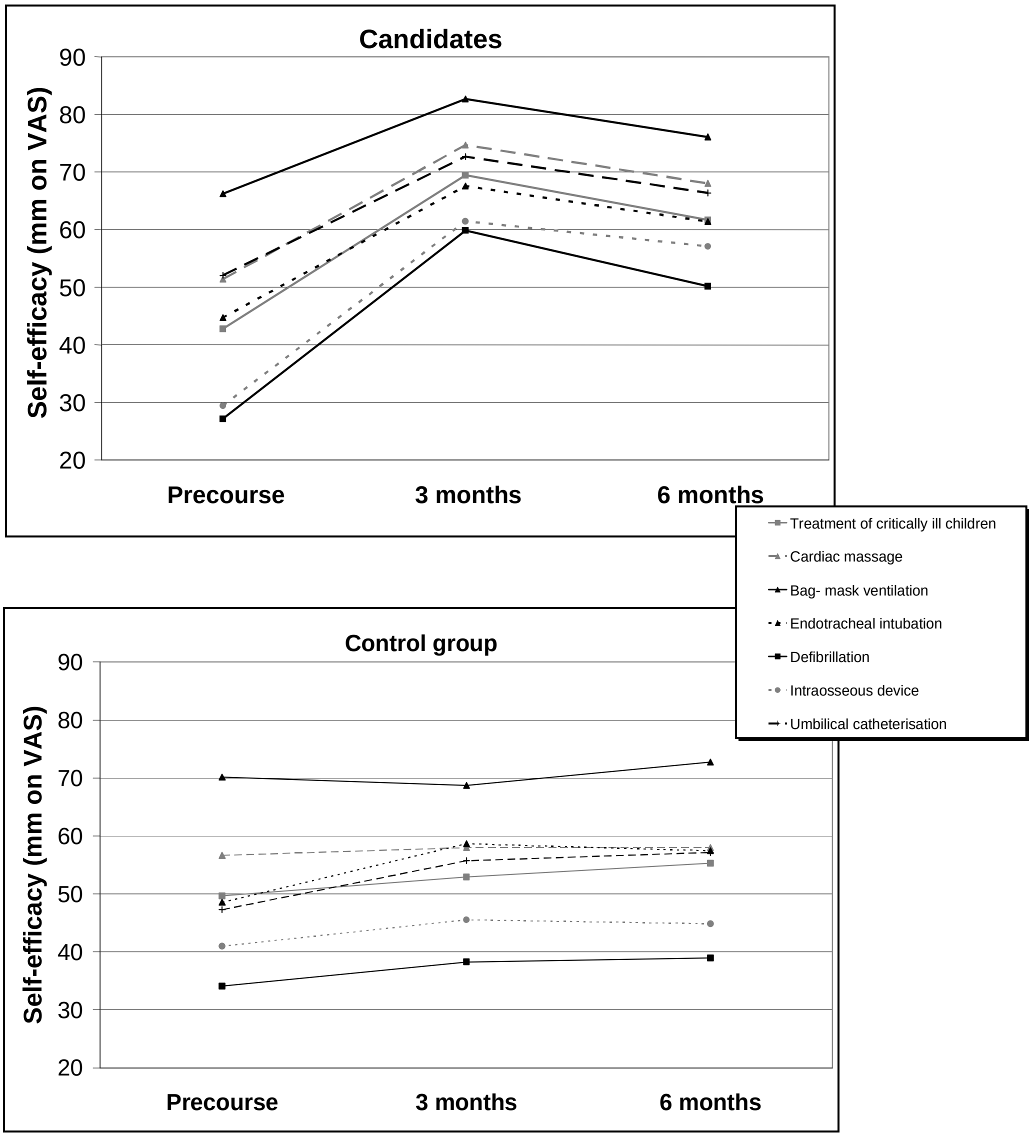

Figure 4.3: *Self-efficacy over time for each domain for candidates (top, n =66) and for participants in the control group (bottom, n =19) who responded to all three questionnaires.*

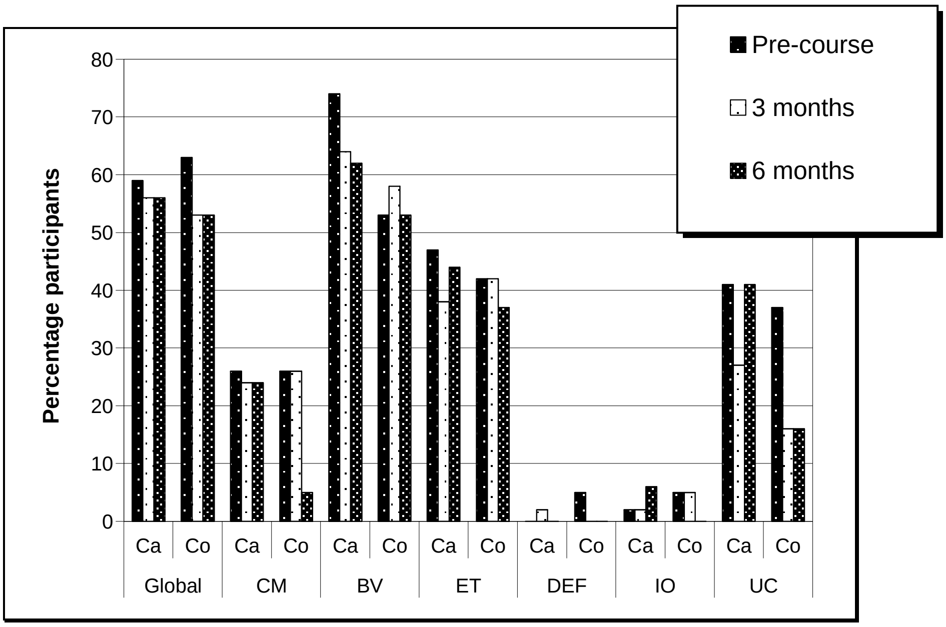

***Figure 4.4**: Percentage of candidates (n=66) and control group subjects (n=19) involved in the treatment of a critically ill child or using an emergency skill at least once before, and at 3 and 6 months after the course. (Global = Treatment of critically ill children, CM = External chest compressions, BV = Bag-mask ventilation, ET = Endotracheal intubation, DEF = Defibrillation, IO = Intraosseous device, UC = Umbilical catheterisation, Ca = candidates, Co = control group.)*

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and the control group or over the three time periods within each group. The use of the individual skills fluctuated over time but the differences did not reach significance for any emergency skill.

The majority of those performing external chest compressions or defibrillation or inserting an intraosseous device did so only once in the three time periods. Bag-mask ventilation and endotracheal intubation were most frequently used by anaesthesiologists. All doctors who inserted an umbilical catheter were paediatricians.

We were unable to detect any correlation between self-efficacy and frequency of use for any of the resuscitation skills at any of the time points.

Discussion

This study indicates that the APLS-course has a significant effect on self-efficacy as measured on a visual analogue scale, and that this effect remains for at least six months.

Self-efficacy has been shown to be a determinant of behaviour in widely differing domains and is an important dimension of skills learning which deserves specific attention during courses in emergency medicine.[8] It is not sufficient that a doctor merely gain the knowledge and practical skills required to intervene in an emergency. He or she also needs to have sufficient belief in his or her ability to dare to perform a potentially life-saving procedure. It is believed that many children do not receive adequate prompt resuscitation because potential lay-rescuers fear causing harm, and this problem may, in part, be related to insufficient self-efficacy.[13] Although it is by no means certain whether this reluctance also applies to health-care professionals, we believe that self-efficacy should be an important consideration in resuscitation training for both professionals and lay-rescuers.

Although little attention has generally been applied to self-efficacy in the training of instructors for life support courses, many of the teaching methods employed on these courses would be expected to increase it. These include the opportunity to perform a skill successfully and repetitively in a safe environment, peer modelling of successful performance and verbal persuasion through sensitive constructive feedback.[10]

We were unable to demonstrate an increase in skills-use following the course, which might be expected to follow an increase in self-efficacy. One probable reason for this is the lack of opportunity to use these skills, as the number of critically ill children presenting did not change. Most of the skills appear to be used by certain professional groups in a non-resuscitation setting e.g. anaesthesiologists using bag and mask ventilation in their daily work. Apart from external chest compressions, two exceptions to this are defibrillation and insertion of an intraosseous device, which are skills only used in an emergency situation and which were used very infrequently. As retention of a skill is related to the frequency of its use, this finding has implications for retraining.[14]

The intraosseous device is strongly advocated on the Dutch APLS-course for rapid vascular access in emergency situations. It is noteworthy that no change in its use was found following the course even though there was likely to have been an opportunity to use it - in 463 critically ill children reported by the subjects during the entire study period only 9 intraosseous devices were inserted.

We chose to include all candidates in the study in order to avoid a sampling bias, but one limitation of this study is the low response rate. However, the results of the non-responder analysis indicate that the responders were a representative sample of the total population of candidates following the APLS-course during the study period.

We included a control group to demonstrate that self-efficacy is relatively stable over time, in the absence of an intervention. The sample of control subjects was selected by the candidates themselves, however most respondents chose not to nominate colleagues for the control group, and the response rate among those nominated was low. Furthermore we are unable to state with certainty that this sample is representative of all those Dutch doctors who fall into the target group for the APLS-course but have not yet followed it, as we do not have access to statistical information on this group. However, we are confident that the sample is matched to the study group in terms of sex, specialty and experience.

We are also confident that the visual analogue score (VAS) is a valid instrument for the measurement of self-efficacy in respect of resuscitation skills in healthcare professionals. In a separate study (submitted) we found evidence for the concurrent validity of the VAS as a measure of self-efficacy in a comparison with a standard self-efficacy questionnaire developed according to the methodology of Bandura.[15;16] Correlations between these two instruments for doctors was high for individual resuscitation skills (r = 0.52 - 0.93 for various resuscitation skills) while correlations between different resuscitation skills were generally low, and there was no correlation between resuscitation and non-resuscitation skills. There was some correlation between different resuscitation skills, for example between external chest compressions and bag and mask ventilation (r =0.65), but this is not surprising as these skills are often learned and practiced together. This is a well known phenomenon referred to by Bandura as co-development.[7] As expected, self-efficacy measured using the VAS was higher for experts than for the less experienced – for example, self-efficacy for airway skills was higher in anaesthesiologists than paediatricians.

Although relatively stable over time, self-efficacy is known to be influenced by recent positive and negative experiences. Therefore the self-efficacy recorded by the subject on the questionnaire may not correspond to that pertaining during the management of a critically ill child. Furthermore the relationship between increased self-efficacy and improved *quality* of skill performance in the setting of emergency paediatrics is unclear and we are currently conducting a study to investigate this.

Conclusion

In conclusion, we have found that self-efficacy increases significantly after the APLS course, but were unable to show an associated increase in the use of the skills learned on the course. Further work is needed to determine whether the quality of those skills is improved by the course.

Conflict of interest

Two of the authors of this paper, Dr Turner and Dr Draaisma, are closely involved in the running and continuous development of the APLS-course, and are members of the board of directors of the foundation which organises the course in the Netherlands.

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5

The relationship of self-efficacy to behavioural decisions and quality of performance in paediatric resuscitation

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Submitted for publication

Summary

Aims

Self-efficacy for resuscitation skills may affect performance of resuscitation procedures. We investigated both the relationship between self-efficacy and behaviour during a simulated resuscitation and the use of self-efficacy as a self-assessment tool.

Materials and methods

Paediatricians and anaesthesiologists scored their self-efficacy for paediatric resuscitation skills before taking an unannounced simulated paediatric resuscitation and OSCE's of chest compressions and bag and mask ventilation. Performance during the simulation was scored by three separate expert judges and the OSCE's were scored using a modified Berden and ventilation penalty scores.

Results

Self-efficacy for the relevant skill was significantly higher in doctors choosing to give chest compressions, to intubate or to insert an intraosseous device during the simulation. There was a significant negative correlation between self-efficacy and time to deciding to intubate.

There was a moderate correlation between quality of performance during the simulation and self-efficacy for resuscitation globally. There was no correlation between self-efficacy for bag and mask ventilation or chest compressions and the score on the relevant OSCE. Quality of performance of individual skills during the mock resuscitation was not related to self-efficacy.

Conclusion

This study provides evidence that self-efficacy is predictive of behaviour during a simulated resuscitation but does not correlate with quality of performance of paediatric resuscitation skills. It may therefore be useful as a measure of the likelihood of transfer of learning into clinical practice, but cannot be recommended to (self-)assess competency or the need for retraining. We consider that life-support courses should specifically aim to increase self-efficacy.

Introduction

Self-efficacy can be defined as a person's belief in his or her capability to organise and execute the course of action required to produce given attainments[1] and is an increasingly recognised important factor in many areas of medical education, including resuscitation training.[2-5] Self-efficacy is highly task-specific and is considered to be a predictor of behaviour in that an increase in the strength of self-efficacy for a certain behaviour is associated under the right conditions with an increase in that behaviour.[6] A low level of self-efficacy might therefore lead to a doctor not performing a particular procedure which could benefit the patient, even if he/she possesses the necessary skills and knowledge to do so. For this reason, life-support courses should aim to increase not only knowledge and skills, but also self-efficacy and many courses employ learning methods which facilitate this.[5]

In a previous study we found that self-efficacy for paediatric resuscitation skills increases after following the Advanced Paediatric Life Support course.[7] We measured self-efficacy using a 100 mm visual analogue scale linked to a single question, which we have found to be a valid and practical method.[8] However, we were unable to find a relationship between self-efficacy and use of resuscitation skills, possibly because the opportunity to use them was lacking, as there were few paediatric resuscitations during the study period. In order to investigate the relationship further we designed the current study in which doctors were presented with a simulated paediatric resuscitation, which provides an opportunity to use the skills.

We were also interested to explore the relationship between self-efficacy and quality of performance of resuscitation tasks. The stability of self-efficacy over longer periods of time is uncertain and may vary under the influence of personal and vicarious experience, feedback from others and the physiological state of the individual, all of which might affect the relationship between self-efficacy and quality of performance.[1;9] Nonetheless, self-efficacy might show a sufficient correlation with quality of performance to be useful in diagnostic self-assessment allowing the doctor to identify individual educational needs.

In a recent systematic review Davis et al have described self-efficacy as a promising new approach to self-assessment for physicians.[10] If self-assessment using self-efficacy can identify specific educational needs this could help refresher life-support courses to become more individualized. Currently most courses advocate retraining after four to five years, although there is a large inter-individual variation in training needs.[11-13] This one-size-fits-all approach has led to dissatisfaction with recertification courses.[14] Improved individualisation through self-assessment could improve participation and lead to more efficient use of resources on life-support courses. Both individualisation and self-assessment have been advocated as important factors for successful continuing medical education.[15]

The research presented in this paper has therefore two aims. Firstly, to investigate whether self-efficacy is predictive for behaviour during a simulated resuscitation, in order to assess its importance in resuscitation training. Secondly, to investigate the correlation between self-efficacy for specific resuscitation tasks and quality of their performance in order to assess the value of self-efficacy in diagnostic self-assessment.

Methods

Participants

We presented a convenience sample of 55 consultant and trainee paediatricians and anaesthesiologists in three separate hospitals with an unannounced resuscitation test consisting of a simulated resuscitation and two objective structured clinical examinations (OSCE's). Explicit oral consent to the study and the recording and temporary storage of the video material and OSCE data was obtained from all participants immediately before the tests.

Measurement of self-efficacy

Immediately before taking the practical tests, participants scored their self-efficacy with respect to external chest compressions, bag and mask ventilation, endotracheal intubation, insertion of an intraosseous device and for paediatric resuscitation globally. Self-efficacy was measured on a 100 mm visual analogue score.[8] Using the same instrument we also measured participants' self-efficacy with respect to self-assessment for resuscitation skills. The participants' specialty and grade were also recorded.

Simulated resuscitation test

The simulated resuscitation was conducted in a realistic clinical setting, familiar to the participants, in which all the necessary resuscitation equipment and monitoring was available. All participants were given an identical clinical scenario of a 4 year-old child who collapsed after being admitted with a working diagnosis of septicaemia, and whose intravenous line has tissued. They were then asked to manage the case with the assistance of one ward nurse, played by a research assistant who was an experienced instructor on the APLS- or European Paediatric Life Support-course. The simulated resuscitations and the OSCE's were videoed for later analysis.

Three independent assessors, who were all APLS course directors and were blinded to the self-efficacy data, evaluated the participants' management of the resuscitation from the video recording using a checklist. The quality of procedures performed during the simulation were recorded as *not done*, *inadequate* (contributing nothing positive to the chance of surviving the resuscitation), *suboptimal* (making a positive contribution to the chance of survival but denying the patient some of the benefit of the correctly performed action) or *adequate.* The procedures considered were: giving rescue breaths, external chest compressions, continuing adequate ventilation, coordination between ventilation and chest compressions, inserting an intravenous cannula, inserting an intraosseous device and endotracheal intubation.

The times from the start of the simulation until starting chest compressions, intention to intubate and completion of intubation were also recorded. We defined the time of intention to intubate as the moment when the participant first stated the intention or asked, or reached, for intubation equipment. The duration of intubation was measured from insertion of the laryngoscope to the first ventilation following successful intubation. The duration of insertion an intraosseous device was measured from picking up the device or, if earlier, starting to identify the insertion site, to flushing the device after successful insertion.

After completing the checklist the assessors also assigned an overall Global Resuscitation Score between 1 and 10 for each participant’s performance and also stated whether they felt that the participant had resuscitated the patient adequately, such that the patient would have had a chance of survival if so treated. This decision was based upon the presence or absence of essential therapeutic manoeuvres which ensured adequate oxygenation and maintenance of an artificial circulation with adequate chest compressions and adrenaline.

<u>OSCE of external chest compressions and bag and mask ventilation</u>

The OSCE tests were conducted using a prototype child mannequin with built-in skills-meter with a length of 103.5 cm giving an estimated weight of 16.5 kg, and estimated age of 3.75 yrs according to the third Dutch growth survey.[16] The thoracic depth is 14.5 cm. Frequency and depth of external chest compression were recorded by the skills-meter and compression-relaxation ratio and incidence of incomplete release between compressions were calculated from the graphical output. Hand position was graded by the three assessors using the video recordings. Frequency and tidal volume of ventilation were also recorded by the mannequin, and the airway pressure was separately monitored using a pressure transducer.

Participants were asked to perform continuous chest compressions for a period of three minutes as if the patient were intubated and ventilated. Performance was assessed using a penalty score modified for paediatric resuscitation from that of Berden (Modified Berden Score, see appendix B).[17] Participants were subsequently asked to perform bag and mask ventilation for a period of three minutes as if the child were apnoeic without circulatory impairment. Performance was assessed using a Ventilation Penalty Score as described in appendix B.

Analysis

The means of normally distributed data were compared using the paired or unpaired t-test as appropriate. Other interval data were compared using the Mann-Whitney U-test. Nominal data were compared using the Chi-square test. P-values of less than 0.05 and 0.01 were taken to be significant and highly significant respectively. A Bonferroni correction was applied to analyses involving multiple outcome variables.

Correlations involving not normally distributed data were calculated using the Spearman correlation coefficient. In accordance with Cohen's guidelines, correlations with an absolute value between 0.30 and 0.50 were considered moderate, those in excess of 0.50 were considered to be high.[18]

Results

Participants

Fifty-six doctors were invited to participate and only one refused citing lack of time as the reason. The video recording of two participants, the thorax compression data for three participants and the ventilation data for one participant could not be evaluated due to equipment malfunction

Data distribution and reliability of assessment

The data for self-efficacy for resuscitation tasks, global resuscitation scores and modified Berden scores were found to be approximately normally distributed on the basis of skewness, kurtosis and Quartile-Quartile plots. Time interval data, the ventilation penalty score and self-efficacy data for self-assessment deviated significantly from the normal distribution.

The intraclass correlation coefficients for averaged values (ICC) for assessments made during the analysis of the simulated resuscitation videos are given in table 5.1.

Self-efficacy for self-assessment

The self-efficacy data for self-assessment for resuscitation tasks deviated from a normal distribution by being significantly skewed to the right. The median value was 61.0 (range 13.0 – 86.0) and the interquartile range was 22.0.

Intraclass correlation coefficients	
Individual actions	
Rescue breaths	0.561
External chest compressions	0.860
Continuing ventilation	0.703
Coordination chest compressions and ventilation	0.765
IV access	0.859
IO access	0.910
Endotracheal Intubation	0.893
Global resuscitation score	0.894
Adequacy of resuscitation overall	0.866

***Table 5.1**: Intraclass correlation coefficients (ICC) for averaged measures for assessments made during the analysis of the simulated resuscitation videos.*

Relationship between self-efficacy and behavioural decisions

Self-efficacy for chest compressions, intubation and insertion of an intraosseous device was significantly higher in those doctors who performed these procedures than other participants (figure 5.1). Self-efficacy for inserting an intraosseous device was significantly lower in those doctors who inserted an intravenous cannula. We found no significant difference between self-efficacy for bag and mask ventilation in doctors who gave rescue breaths and those who did not (n =3), but numbers were very small.

There was a high, significant negative correlation between self-efficacy for intubation and time to intention to intubate (table 5.2). Eighteen out of 21 anaesthesiologists and 8 out of 32 paediatricians chose to intubate ($p < 0.001$ Chi-squared).

There was no correlation between time of starting chest compressions and self-efficacy for chest compressions (table 5.2).

Relationship between self-efficacy and quality of performance

<u>Simulated resuscitation test</u>

There was a moderate and significant correlation between global resuscitation score and self-efficacy for resuscitation globally (table 5.2 and figure 5.2). The correlation was higher and significant for participants with a high score for self-efficacy for self-assessment (in the 3rd and 4th quartiles), but not significant for other participants.

Participants who resuscitated adequately according to the assessors had a mean self-efficacy for global resuscitation of 56.1 compared to 44.1 for other participants (p = 0.053).

<u>OSCE Bag and mask ventilation</u>

There was no significant correlation between self-efficacy for bag and mask ventilation and the ventilation penalty score (table 5.2), nor with the absolute deviation from the ideal of any component of it.

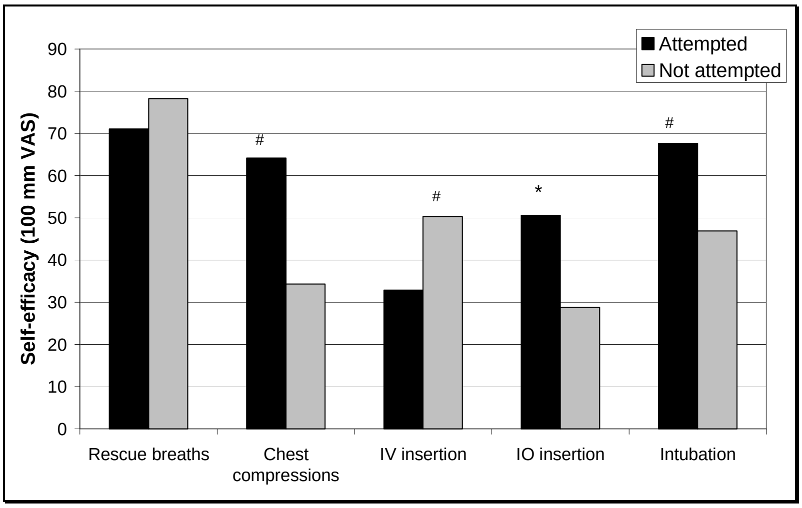

Figure 5.1: *Self-efficacy for resuscitation tasks in doctors who did or did not attempt those tasks. Data for the rescue breaths are self-efficacy for bag and mask ventilation; data for insertion of an intravenous (IV) cannula and for insertion of an intraosseous device (IO) are self-efficacy for insertion of an intraosseous device. (For the difference between the groups * = p<0.05; # = p<0.01).*

Self-efficacy for the named task	**Correlation coefficient**
Paediatric resuscitation globally vs mean global resuscitation score	
All participants	0.426**
Participants with a high score for self-efficacy for self-assessment	0.588*
Participants with a low score for self-efficacy for self-assessment	0.138
Chest compressions vs modified Berden score	-0.137
Mask ventilation vs ventilation penalty score	-0,131
External chest compressions vs time to starting compressions	0.123
Insertion of an IO device vs duration of insertion the device	0.030
Endotracheal intubation vs time to intention to intubate	-0.590*
Endotracheal intubation vs duration of intubation	-0.359

Table 5.2: *Spearman's correlation coefficients for self-efficacy (SE) for the relevant task and OSCE scores for external chest compressions and ventilation, global resuscitation score, time from the start of the simulation to decision to intubate and to starting chest compressions and time taken to intubate and to insert an intraosseous device. (SE = self-efficacy; IO = intraosseous; * p< 0.01; ** p< 0.001; $ for those participants who chose to perform this task (n= 31 for IO and n = 23 for intubation)*

OSCE External chest compressions

There was no significant correlation between score self-efficacy for chest compressions and the modified Berden (table 5.2), nor with the absolute deviation from the ideal for any of the components of it.

Adequacy of procedures during the simulated resuscitation

Self-efficacy for chest compressions, coordination of compressions with ventilation, ventilation during the resuscitation, insertion of an intraosseous device, and endotracheal intubation was not significantly different between those performing the procedure adequately and those performing inadequately or suboptimally (table 5.3).

There was no correlation between self-efficacy for endotracheal intubation and time taken to intubate or between self-efficacy for insertion of an intraosseous device and time taken to perform this procedure.

Discussion

In this study we found evidence that self-efficacy is predictive of behaviour during a simulated resuscitation but little evidence for a correlation between self-efficacy and quality of performance of individual resuscitation skills.

We consider our findings to be supportive of the theory that self-efficacy is a predictor of behaviour during paediatric resuscitation. A stronger feeling of self-efficacy seems to be predictive of choosing to intubate and to insert an intraosseous device. Each of these procedures can be considered optional during the first few minutes of resuscitation as the alternative interventions of ventilation without intubation and administration of drugs via an intravenous cannula are also compatible with a chance of survival. Therefore intubation and insertion of an intraosseous device are ideally suited to a study of the

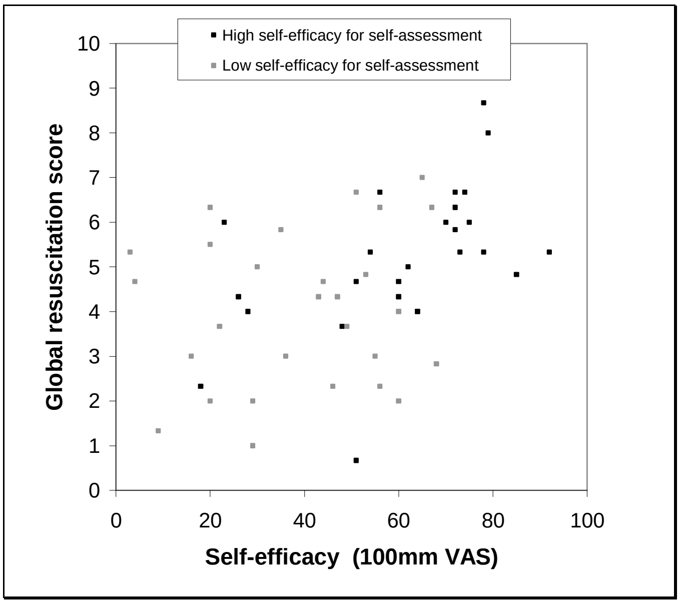

Figure 5.2: *Global resuscitation score versus self-efficacy for global resuscitation for participants scoring themselves high and low (above and below the median value) for*

self-efficacy for self-assessment.

Task and reported self-efficacy (SE)	SE if adequate	SE if inadequate or suboptimal	p
Rescue breaths (SE Bag and mask ventilation)	74.1 (n = 42)	55.2 (n = 8)	0.005
Chest compressions (SE chest compressions)	63.2 (n = 17)	64.8 (n = 30)	0.785
Coordination ventilation/chest compressions (SE chest compressions)	66.2 (n = 28)	61.5 (n = 19)	0.408
Ventilation (SE bag and mask ventilation)	70.2 (n = 47)	67.6 (n = 6)	0.495
IO insertion (SE insertion of intraosseous device)	57.2 (n = 13)	34.5 (n = 20)	0.140
Intubation (SE endotracheal intubation)	64.3 (n = 4)	68.3 (n = 22)	0.784

Table 5.3: *Self-efficacy for resuscitation tasks for participants performing the task adequately and for those performing it inadequately or suboptimally.*

effect of self-efficacy on behaviour as the most evident effects of self-efficacy are likely to be seen in situations where the individual has both a free choice of behaviours and an opportunity to perform them.[1]

Anaesthesiologists scored their self-efficacy for intubation significantly higher than paediatricians and were more likely to intubate. However we do not consider this to be a confounding factor, but rather to be further evidence that, in mixed groups of doctors, increased strength of self-efficacy – whatever its determinants may be – can be predictive of behaviour.

For inserting an intraosseous device, there was no significant difference between professions in the numbers choosing to do so, so a bias due to professional experience is less likely. We did not measure self-efficacy for inserting an intravenous cannula. However, it would be interesting to know whether this was low in the group who chose to insert an intraosseous device as the first choice of vascular access.

External chest compressions cannot be considered a free choice during resuscitation as survival without maintaining the circulation is unlikely. Nonetheless our data suggest that even behaviour in respect of chest compressions might be influenced by self-efficacy. Concern has been expressed that lay-rescuers may be reluctant to perform essential resuscitation procedures in children due to a fear of doing harm, which might, in part, be related to low self-efficacy.[19] Our data suggest that even doctors do not always initiate chest compressions when required to do so and that self-efficacy may help to predict this.

Although there was no evidence for a correlation between self-efficacy and individual resuscitation skills, there was a moderate correlation for paediatric resuscitation globally. It is known that global self-assessment is generally more accurate than self-assessment of specific tasks.[10] Participants who scored highly for self-assessment showed a better correlation between self-efficacy and quality of performance suggesting that they may indeed have better self-assessment skills.

The generally poor correlation between self-efficacy and both test performance and quality of skills performance during the simulation is not unexpected but has, to our knowledge, not previously been shown for individual paediatric resuscitation skills. White found no correlation between self-confidence for paediatric resuscitation globally and quality of performance of intubation and insertion of an intraosseous device.[20] Self-assessment for individual motor skills is generally unreliable and there are also conceptual reasons for considering that self-efficacy is not the ideal method of predictive self-assessment. Self-assessment of clinical skills has generally been found to correlate poorly with more objective measures, particularly when used to predict future performance. [21-24] Self-efficacy relates more to the relationship between performance and the individual's internal performance standards than to the level of performance itself.[6] Internal cognitive factors and personality traits such as self-esteem and global confidence are also likely to affect self-efficacy in the absence of any change in ability.[1;9] Self-efficacy affects performance reciprocally and it has been suggested that it better represents a self-fulfilling prophecy in determining behaviour than a passive assessment tool.[2]

A notable exception to our general findings of a poor correlation between self-efficacy and quality of performance but a significant relationship between self-efficacy and behavioural decisions, is our data on bag and mask ventilation. We feel that this should be interpreted with caution as the number of participants failing to give rescue breaths – three – was too small to reasonably expect a statistically significant difference to emerge. Also the interclass correlation coefficient for adequacy of rescue breaths was considerably lower than that for other procedures and this might have compromised reliability.

Our study has a number of limitations. Foremost is that behaviour in a simulated context may not correspond to behaviour during a real resuscitation due to such factors as performance constraints, ambiguity of task demands and performance (feedback) information, consequences of misjudgement and the influence of being observed.[25;26] Studying behaviour in a real-world context is however extremely difficult due to ethical considerations and the infrequency and unpredictability of paediatric resuscitations, and for these reasons we chose a simulation study.

We studied the relationship between self-efficacy and competence at the level of a group of participants, however self-efficacy is a trait possessed by individuals.[1] Inter-individual differences in self-efficacy and quality of performance were large, and it is possible that the correlation between self-efficacy and performance for individual doctors over time would be greater. We are considering a study to explore this.

The prototype mannequin used in this study has two major technical limitations. Firstly, the maximum possible depth of external chest compressions is 4 cm, making the detection of excessive compression depth unreliable. Secondly, the calibration of the measurement of tidal volume is difficult to verify, due to leakage around the airway, and this may have affected the reliability of the ventilation penalty score.

Despite these limitations, we consider two strengths of our design to be the use of a well validated self-efficacy measurement instrument and the fact that our tests were totally unannounced, although we acknowledge that the latter prevented us from using a randomized sample.

Conclusions

Self-efficacy appears to be a predictor of behaviour during a simulated paediatric resuscitation and may be useful as a measure of the likelihood of transfer of learning into clinical practice. For this reason we consider that life-support courses should specifically aim to increase self-efficacy. However, self-efficacy does not correlate with quality of performance of paediatric resuscitation skills and should therefore not be used unqualified to self-assess competency or the need for retraining in paediatric resuscitation.

Conflict of interest

Drs Turner, Lukkassen and Draaisma are closely involved in the running of the Dutch Advanced Paediatric Life Support course.

The mannequin used for the OSCE's was lent for the purpose of this research by the Laerdal company.

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6

The effect of the Advanced Paediatric Life Support course on self-efficacy and performance in a simulated paediatric resuscitation

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Summary

Aims

Self-efficacy for resuscitation skills may affect performance of those skills. This study investigates the long-term effect of the Advanced Paediatric Life Support (APLS) course on self-efficacy, resuscitation skills and resuscitation performance and also the effect of the death of a simulated patient on self-efficacy.

Materials and methods

In an observational study involving a control group, paediatricians and anaesthesiologists scored their self-efficacy for paediatric resuscitation skills before taking an unannounced simulated paediatric resuscitation in which half of the simulated patients were predestined to die. They also took objective structured clinical examinations (OSCEs) of chest compressions and bag and mask ventilation. Performance on the simulation was scored by three separate expert judges and the OSCEs were scored using a modified Berden and ventilation penalty scores.

Results

Self-efficacy for most resuscitation tasks and global performance in paediatric resuscitation were higher in those who had followed the APLS, but there was no difference in scores on the OSCEs of individual resuscitation skills. Death of the simulated patient led to a considerable decrease in self-efficacy.

Conclusions

The APLS has a positive effect on self-efficacy and performance on a simulated resuscitation which persists for several years. Death of simulated patient is a potent source of feedback and has more effect on self-efficacy than the quality of performance. Life-support courses should actively consider self-efficacy as a specific learning objective.

Introduction

The Advanced Paediatric Life Support (APLS) course is a three-day life-support course dealing with paediatric emergency medicine and resuscitation developed in the UK.[1] Training on life-support courses can lead to an immediate increase in theoretical knowledge, practical skills, attitudes and performance during a simulated resuscitation.[2-10] Unfortunately, these effects are often short-lived and subsequent performance can deteriorate alarmingly.[11-13] Core concepts and ability to resuscitate might be better retained than theoretical knowledge, but there is little published research into the long-term effect of the APLS-course on resuscitation performance.[14]

An important attitudinal effect of life-support courses is an increase in self-efficacy, which has been shown to increase in the short-term after the APLS-course.[15] Self-efficacy can be defined as a person's *belief in their capability to organise and execute the course of action required to produce given attainments*, and is considered to be a predictor of behaviour, under the right conditions.[16;17] Successful application of knowledge and skills may be impeded by low self-efficacy, and resuscitation training should aim to increase self-efficacy for relevant tasks.[18]

We previously found that self-efficacy for paediatric resuscitation skills increases after following the APLS-course, and remains high for at least six months.[15] We measured self-efficacy using a postal questionnaire which may not correspond to self-efficacy pertaining during a real resuscitation.[16;19] To study the effect of self-efficacy on resuscitation performance both should be measured at the same time.

It is an unwritten rule of the APLS and other life-support courses that the simulated patient must not be allowed to die, irrespective of the quality of simulated treatment. The theoretical basis for this rule has not been established but self-efficacy may play a role.

This research has therefore two aims: Firstly, to seek evidence for a long-term effect of the APLS on self-efficacy, resuscitation skills and global performance in a simulated resuscitation. Secondly, to investigate the effect of death of a simulated patient on self-efficacy.

Method

We presented a sample of 55 consultant and trainee paediatricians and anaesthesiologists in three separate hospitals with an unannounced resuscitation test consisting of a simulated resuscitation and two objective structured clinical examinations (OSCEs) of external chest compressions and bag and mask ventilation in a child of 4 years. Explicit oral consent to the study and the recording and temporary storage of the video material and OSCE data was obtained from all participants immediately before the tests.

Measurement of self-efficacy

Immediately before and after the practical tests participants scored their self-efficacy with respect to external chest compressions, bag and mask ventilation, endotracheal intubation, insertion of an intraosseous device and paediatric resuscitation globally. Self-efficacy was measured on a 100 mm visual analogue score.[20] The following information was also recorded: specialty and grade, whether and when they had followed the APLS, whether they had had in-house resuscitation training within the last year.

Simulated resuscitation test

The simulated resuscitation was conducted in a realistic clinical setting, with all the necessary resuscitation equipment and monitoring available. Participants were given a clinical scenario of a 4 year-old child who collapsed after being admitted with a working diagnosis of septicaemia, and whose intravenous line has tissued. They were then asked to manage the case with the assistance of one ward nurse, played by a research assistant who was an experienced life-support course-instructor. The simulated resuscitations and the OSCEs were videoed for later analysis. The clinical scenarios for all participants were identical except that each case was randomly assigned in advanced either to survive if adequately managed, or to die irrespective of the treatment received. This simulated clinical practice in which outcome of a resuscitation attempt is often determined by factors other than quality of treatment. Participants were blinded to the predetermined outcome and received no feedback during the tests but were allowed to observe a restoration of spontaneous circulation if appropriate.

Three independent assessors, all APLS course directors who were blinded to the participants' background information, evaluated the participants' management of the resuscitation using the video recording. The time of administering rescue breaths, checking the circulation, checking the ECG-rhythm and giving a first and a second dose of adrenaline was recorded as was the time to starting chest compressions and the completion of inserting an intraveneous cannula, intraosseous device and endotracheal tube. The assessors also assigned an overall global resuscitation score between 1 and 10 for each participant's performance and also stated whether they felt that the participant had treated the patient adequately during the resuscitation, such that the patient would have had a chance of survival if so treated. This decision was based purely up the presence or absence of essential therapeutic manoeuvres ensuring oxygenation and maintenance of an artificial circulation with chest compressions and adrenaline.

OSCE of external chest compressions and bag and mask ventilation

The OSCE tests were conducted using a prototype child mannequin with built-in skills-meter, resembling the Laerdal Junior®. Frequency and depth of chest compression were recorded by the skills-meter and compression-relaxation ratio and incidence of incomplete release between compressions were calculated from the graphical output. Hand position was graded by the three assessors using the video recordings. Frequency and tidal volume of ventilation were also recorded by the mannequin, and the airway pressure was separately monitored using a pressure-transducer.

Participants were asked to perform continuous external chest compressions for a period of three minutes as if the patient were intubated and ventilated. Performance was assessed using a penalty score modified for paediatric resuscitation from that of Berden (Modified Berden Score, see appendix B).[21] Participants were subsequently asked to perform bag and mask ventilation for a period of three minutes as if the child were apnoeic with a stable circulation. Performance was assessed using a Ventilation Penalty Score as described in appendix B.

Data analysis

Normally distributed data were compared using the paired or unpaired t-test or one-way ANOVA as appropriate. Other interval data were compared using the Mann-Whitney U-test. Nominal data were compared using the Chi-squared test. P-values of less than 0.05 and 0.01 were taken to be significant and highly significant respectively.

For the investigation of the impact of the APLS-course, the participants were split into to groups: an APLS-group: containing those who had followed the APLS-course and a No-APLS group for all other participants.

Results

Participants

Fifty-six doctors were invited to participate and only one refused citing lack of time. Due to equipment malfunction the data for six participants was incomplete and these were excluded. Of the 49 remaining participants, 18 had followed the APLS-course and none had followed an APLS-recertification course. The median time since the course was 3.0 years (range 4 months – 8 years).

	No APLS	APLS
Paediatrics (Consultant + trainee)	8 + 8	6 + 8
Anaesthesiology (Consultant + trainee)	1 + 14	3 + 1

Table 6.1: *Specialty and grade of participants*

There was no significant difference in the overall number of paediatricians and anaesthesiologists in the APLS and No-APLS groups, nor in the number of specialists and trainees in each group (table 6.1). However significantly more paediatric trainees had followed the course than anaesthetic trainees (p=0.01).

Data distribution and reliability

The data for self-efficacy, global resuscitation scores and modified Berden scores were found to be approximately normally distributed on the basis of skewness, kurtosis and Q/Q and P/P plots. Time interval and ventilation penalty score data deviated significantly from the normal distribution.

The intra-class correlation coefficients for averaged values (ICC) for assessments of individual actions made by the three assessors during the analysis of the simulated resuscitation videos were between 0.549 and 0.910 (mean 0.737). Those for adequacy of treatment and for global resuscitation score were 0.866 and 0.894 respectively (see table 5.1).

Self-efficacy and APLS

Pre-test self-efficacy for global resuscitation, external chest compressions

and insertion of an intraosseous device was significantly higher in doctors who had followed the APLS (figure 6.1). Self-efficacy for bag and mask ventilation and endotracheal intubation was not significantly different between the groups. Paediatricians analysed separately showed the same general pattern except that pre-test self-efficacy for intubation was also higher in the APLS group (mean (SD) 55.1 (21.9) and 31.9 (28.2) respectively p=0.019)

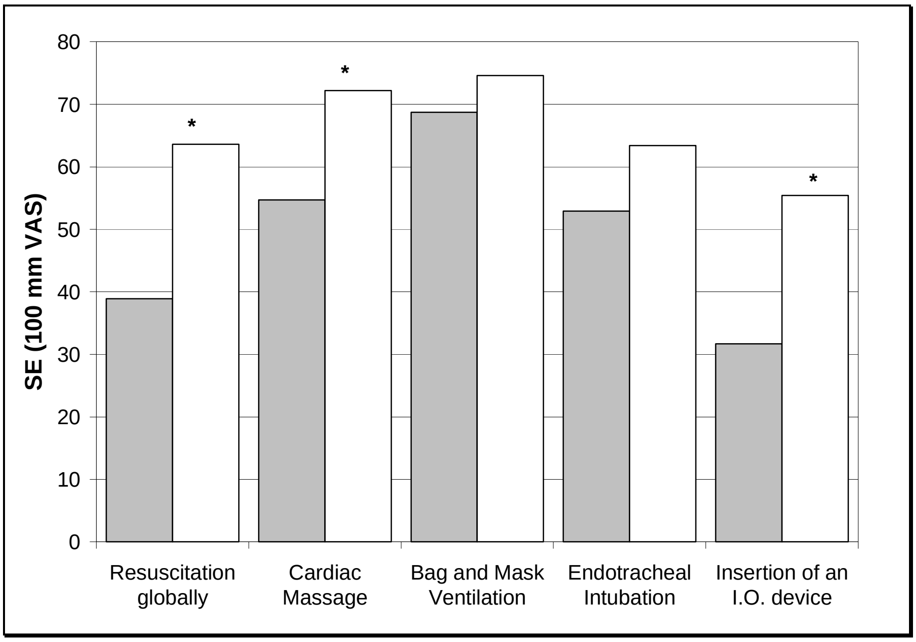

Figure 6.1: *Self-efficacy for resuscitation skills for participants who had or had not followed the APLS-course (open en solid columns respectively). * indicates p < 0.001.*

Effect of APLS on resuscitation skillsOverall performance on the practical tests

Sixty-seven percent of APLS-trained doctors treated the simulated patient adequately overall compared to 32% of other participants ($p = 0.020$).

The global resuscitation score was significantly higher for the APLS group (table 6.2).

Individual actions during the simulated resuscitation

The APLS group started chest compressions significantly later than the No-APLS group. However, there was no significant difference between the groups in time to stating chest compressions when only those participants who followed the ERC BLS protocol correctly up to that point were considered (table 6.2). Six participants, all in the No-APLS group failed to give chest compressions and five of these had had no resuscitation training in the last year. There was no significant difference in the time to performing other procedures.

Doctors in the APLS-group were more likely to perform the following procedures adequately: open the airway, continue ventilation, coordinate ventilation with thorax compressions, check the rhythm, insert an intraosseous device and intubate. They were also more likely to check the airway, give thorax compressions and give a second dose of adrenaline.

Performance on the OSCE tests

The modified Berden score and ventilation penalty score were not significantly different between the APLS and No-APLS groups (table 6.2).

Effect of death of the simulated patient on self-efficacy

Eleven of the 24 simulated patients predestined to die were treated adequately, compared to 13 of the 25 other patients. If the simulated patient died, post-test self-efficacy for global resuscitation fell significantly compared to the pre-test measurement, whether or not death was predestined. This was true for participants with self-efficacy above and below the median value.

	APLS (n= 18)	No-APLS n = 31	P
Global resuscitation score[1]	5.6 (1.8)	4.0 (1.7)	0.003
Modified Berden score[1]	27.2 (13.3)	30.6 (13.4)	0.673
Ventilation penalty score[1]	20.0 (11.25)	20.0 (20.0)	0.996
Failed to perform chest compressions	0	6 (19%)	0.046
Followed the ERC protocol	7 (39%)	7 (23%)	0.362
Time to staring chest compressions[2]			
all participants	125.3 (149.2)	57.9 (57.0)	0.001
those following the ERC protocol	89.3 (57.5)	79.3 (52.0)	0.768
Adequately resuscitated	12 (67%)	10 (32%)	0.020

Table 6.2: *Test results for the APLS and No-APLS groups. Values are number and percentage except, [1] = mean and standard deviation and [2] = mean and interquartile range*

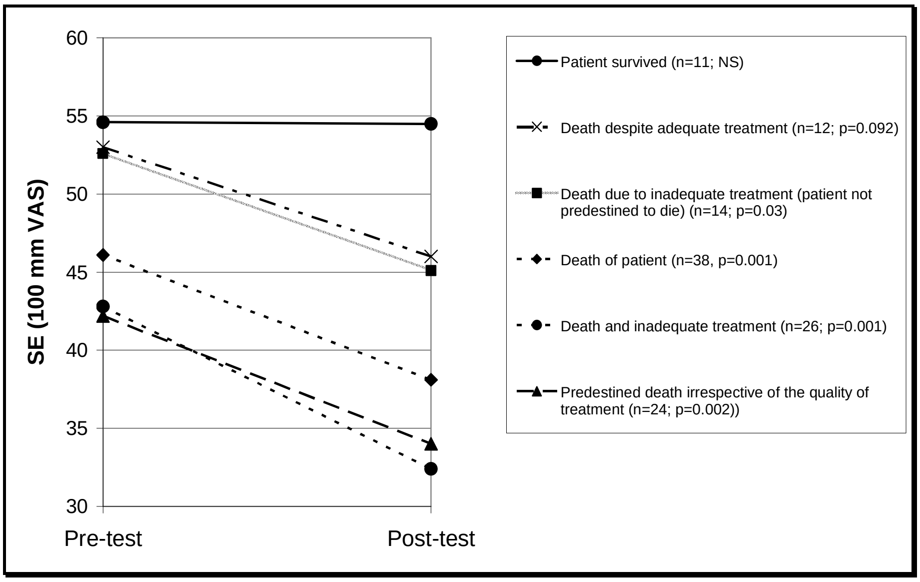

Figure 6.2: *Effect of the death of the simulated patient on self-efficacy in respect of global resuscitation.*

If the patient died despite adequate treatment, self-efficacy fell but not significantly. If the simulated patient survived, self-efficacy did not change (figure 6.2). Analysis using simple factorial ANOVA revealed that the death of the simulated patient had a significant effect on self-efficacy (p=0.046), while adequacy of resuscitation did not (p=0.637).

Discussion

We have previously demonstrated that self-efficacy for resuscitation tasks increases significantly after the APLS course.[22] In the present study we found that self-efficacy for external chest compressions, insertion of an intraosseous device and paediatric resuscitation globally was significantly higher in APLS-trained doctors several years after the course. We consider this to be encouraging evidence of a long-term effect of the course on self-efficacy. However, in contrast our previous study, we found less evidence for a persisting effect of the APLS-course on airway skills, which may have been related to the relatively high number of anaesthesiologists in the non-APLS groups, as their self-efficacy for airways skills is known to be high.[20]

The relationship of self-efficacy to behaviour is potentially crucial to effective resuscitation. Self-efficacy has been shown to be a determinant of behaviour in many areas and deserves specific attention during life support.[18] It is not sufficient that doctors have only the knowledge (*know*), practical skills (*able to*) and the right attitude (*prepared to*) required to intervene effectively in an emergency. They also need sufficient belief in their ability (*dare to*) to perform a potentially life-saving procedure.

APLS-trained doctors showed more competence in simulated resuscitation than their colleagues which may extrapolate to resuscitating a real child. However their performance on the OSCEs of individual resuscitation skills was not better than their peers. This dissonance between global performance of resuscitation and performance of individual skills has been previously reported for other life-support courses. Generally conceptual knowledge and performance during a simulated resuscitation are better retained after life-support courses than factual knowledge or complex skills.[23-25] We consider our results to be evidence that this also applies to the APLS.

Our finding that most doctors were unable to resuscitate adequate is worrying but not new. Resuscitation competence in paediatricians and trainees has often been found to be poor [26-31] and lack of training has been show to have a negative effect on survival.[32] However, the fact that even with APLS training doctors only commenced external chest compressions after an average of two minutes is a cause for concern. Although this delay was largely due to time invested in performing the actions recommended in the resuscitation protocol, it is nonetheless potentially clinically important. The fact that doctors in the No-APLS group commenced thorax compressions earlier is probably related to their not have first taken adequate steps to open the airway and ensure oxygenation. APLS-trained doctors who followed the protocol started thorax compressions earlier than others suggesting that the protocol itself is not the reason for the late start of thorax compressions. We feel that more attention should be paid on life-support courses not only to the correct sequence and performance of resuscitation skills, but also to the speed of their performance.

We found that death of a simulated patient decreases self-efficacy. This was true for participants with high and for those with low self-efficacy suggesting that this finding cannot be ascribed to a regression effect of the self-efficacy measurement. Self-efficacy beliefs are derived from four areas: personal experience (the most important source), vicarious experience, verbal persuasion and affective and physiological states.[16] In our study we eliminated vicarious experience and verbal persuasion by not giving feedback and attempted to standardise external influences on affective and physiological states by using an identical approach to all participants. We were therefore able to investigate the effect of personal experience in isolation.[16] Experience can only influence self-efficacy if individuals can assess their behaviour. Our results suggest that patient outcome, which is unequivocally observable, has a more powerful influence on self-efficacy than the quality of actions of the doctor, which is less easy to self-assess.

We consider that the effect of death on self-efficacy has two important practical consequences. Firstly, death of a real patient may reduce self-efficacy to a level at which behaviour is adversely affected, leading to less effective intervention in a subsequent resuscitation. Verbal persuasion following a death, in the form of an open case discussion, should be used with the specific aim of re-establishing self-efficacy. Secondly, our findings provide a theoretical basis for the unwritten rule of paediatric life-support courses that the patient should not be allowed to die.

Our study has a number of limitations. We chose to use a cross-sectional observational approach as other authors have done and which has the advantages of avoiding a possible test-retest effect and facilitating unannounced testing.[14] This approach may be less robust than a randomised, controlled before-and after study, and the validity of our findings rests on the assumption that the two groups (APLS No-APLS) were comparable. However, there are so many factors which can influence resuscitation competence that a truly controlled trial would be hard to envisage.

In explaining our results we have to consider a maturation effect. The APLS-course is very popular amongst Dutch paediatricians, and most follow the course during their training. Participants who had followed the course were therefore likely to have been more experienced. Furthermore, having followed the APLS course and being better able to resuscitate are not necessarily causally related. Doctors may chose to follow the course out of an interest in emergency paediatrics or under the influence of certain character traits which also make them more likely to be able to resuscitate. Even if a causal relation does exist, other biases may have affected our results such as familiarity with the technique of testing.

We attempted to run the simulations as realistically as possible on the basis that this would increase the validity of the self-efficacy data and allow a cautious extrapolation to real clinical practice. Therefore the experimental design did not permit us to investigate what would happen to self-efficacy if performance was poor but the patient survived. This unrealistic situation is often allowed to happen on life-support courses and needs to be investigated in that context. Further research should also concentrate on the influence of feedback and vicarious experience on self-efficacy for resuscitation.

Conclusions

There is evidence for a positive effect of the APLS on self-efficacy for resuscitation skills and on performance on a simulated resuscitation which persists for several years. We found no evidence for an effect on quality of individual resuscitation skills. Death of the simulated patient has a significant negative effect on self-efficacy. Death is a potent source of feedback for the learner and has more effect on self-efficacy than the quality of performance. We remain convinced that life-support courses should actively consider self-efficacy as a specific learning objective.

Conflict of interest

Drs Turner, Draaisma and Lukkassen are involved in the running of the Dutch APLS-course.

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Use of unannounced spaced telephone testing to improve retention of knowledge after a life-support course

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Summary

Background and aims

Life-support courses have been shown to improve knowledge and skills but attrition of factual knowledge is considerable. There is evidence that retention can be improved by spaced testing of the learned material. We investigated the effect of this on retention of knowledge in medical students after a life-support course, in a prospective controlled trial using stratified randomization.

Methods

Twenty final year medical students followed a half-day course on paediatric thoracic injuries involving a pre-course and end-of-course written test. They were subsequently assigned to an intervention group and a control group which were matched on the basis of their scores on the end-of-course test. The intervention group was given four unannounced spaced patient-management problem tests relating to paediatric thoracic trauma over a period of two months. The control group took only one similar test six weeks after the course. All students took a retention test including factual questions and patient management problems two months after the course.

Results

There was no difference between the two groups in terms of learning during the course. Students in the intervention group retained factual information significantly better than those in the control group. There was no difference in performance on the patient management problems.

Conclusions

Unannounced spaced testing seems to have a positive effect on retention of factual knowledge after life support courses. There was no evidence of an effect on clinical problem-solving ability. Spaced testing, which may also be achieved using internet or e-mail, offers a method of improving retention after life support courses.

Introduction

Retention of knowledge is a primary goal of medical education. In the practice of emergency medicine, optimal care involves the ability to act quickly in performing life-saving procedures at infrequent intervals which requires the retention of the necessary knowledge and skills over long periods. Training in emergency medicine often involves the requirement to follow short, discrete courses away from the workplace, such as the Advanced Trauma Life Support-(ATLS) or Advanced Paediatric Life Support (APLS) course.[1;2] Many studies have shown an improvement in knowledge and practical and problem-solving skills after such courses, however subsequent attrition of knowledge is considerable.[2-8]

Retention of knowledge after life-support courses can be improved in several ways. The amount of exposure to trauma patients has been shown to be an important determinant of retention in the management of trauma, and there is evidence that retention is also improved by continued simulation-training in the workplace after a life-support course.[9-11] Retention is also improved by use of mastery learning in which students are required to obtain a given level of competency regardless of the amount of training required.[12] These approaches are based on the idea that focused deliberate practice is an important factor in the acquisition and maintenance of skills.[13] However, repeated simulator training can be expensive and difficult to organize, and mastery learning can be time-consuming.

An alternative approach to improve retention is to use spaced testing. The effect of testing on retention (known as the *testing effect*) has been well demonstrated in psychological research and has been previously demonstrated in an educational context, but not in connection with a life-support course.[14-17] We designed a study to investigate the testing effect on retention in medical students who had followed a life-support course. Although this could be done by personal contact, e-mail or using the internet, we chose to use unannounced telephone contact in order to control the timing and amount of testing, and to reduce the possibility of collaboration during the test. The use of testing to improve retention should be distinguished from the use of reminder systems to modify clinical practice[18;19], which are intended to prompt actions in the short-term, rather than improve retention, and from mental practice which is intended to improve performance of specific motor-skills.[20;21] Spaced testing resembles spaced education in that both methods involve the practical application of the spacing effect - the finding that spaced distribution and repetition of educational encounters result in more efficient learning and improved retention, compared to massed distribution.[17]

Participants and methods

We offered a four-hour training in paediatric thoracic trauma to final-year medical students at the University of Utrecht on a voluntary basis. The training was based on the relevant parts of the APLS-course and designed to include the various teaching methods used on postgraduate life-support courses which have been described elsewhere.[1;22-24] The course consisted of a six-page preparatory text, two short lectures, a practical skill-station on needle thoracocentesis and pericardiocentesis, an interactive discussion on the differential diagnosis of immediately life-threatening thoracic injuries and two simulated patient exercises (scenarios) using mannequins and actual equipment in a real hospital setting. The training was given by certified APLS-instructors with a student:instructor ratio of 3.8:1.

Written informed consent to the study was obtained from all participating students. Students completed a pre-course questionnaire relating to experience and teaching of thoracic and paediatric trauma. They also completed a post-training course-evaluation form on which they were asked to rate the presentation, content and relevance of each session on a seven-point Likert scale (-3 = useless to +3 = excellent).

We administered an identical written test immediately before (pre-test) and immediately after the training (end-of-course test). This consisted of three specifically designed parts which were administered sequentially and consisting of the following: Part 1) Two open questions in which students were asked to state the five most immediately life-threatening thoracic injuries and the three most important clinical signs suggesting thoracic trauma; Part 2) Five short patient management problems[28] for which the students were required to supply the most likely diagnosis and the immediate specific treatment; Part 3) Thirteen open theory questions on the clinical presentation and treatment of immediately life-threatening thoracic injuries in children. The three parts of the test were administered consecutively and separately. Students were assigned marks for each correct response and no points were deducted for incorrect or irrelevant responses. All questions in parts 1 and 3 referred directly to factual information in the preparatory text. A group of 17 APLS-instructors were asked to supply independently the answers to the questions in part 2 of the test and reached an agreement of 95.3% for the diagnosis and 96.3% for the immediate treatment. The test-retest correlation for the whole test in APLS-instructors was 0.717. The test questions are shown in appendix C.

Following the training the students were randomly assigned to a intervention and a control group which were matched for the students' scores on part 1 of the end-of-course tests. The intervention group was subsequently telephoned unannounced four times with an intermediate retention test beginning on the evening of the training and at intervals of approximately two weeks for two months. During each of these calls students were presented with two previously unseen patient management problems, which we similar to those used in part 2 of the previous tests, and asked to supply the most likely diagnosis and to give a detailed description of their management of the case. All calls were made by the same two researchers (NT and RS) who had previously practiced the technique together to maximize methodological consistency. No feedback was given to the students at any time after the end of the training. The control group was telephoned only once, at the same time as the fourth call to the intervention group. Figure 7.1 gives a graphical representation of the methodology.

Two months after the training all students took a final retention-test which was presented by telephone and was identical to the written tests. The test was administered to all students over a period of two days. All students agreed verbally to treat all calls confidentially and not to discuss their nature with any

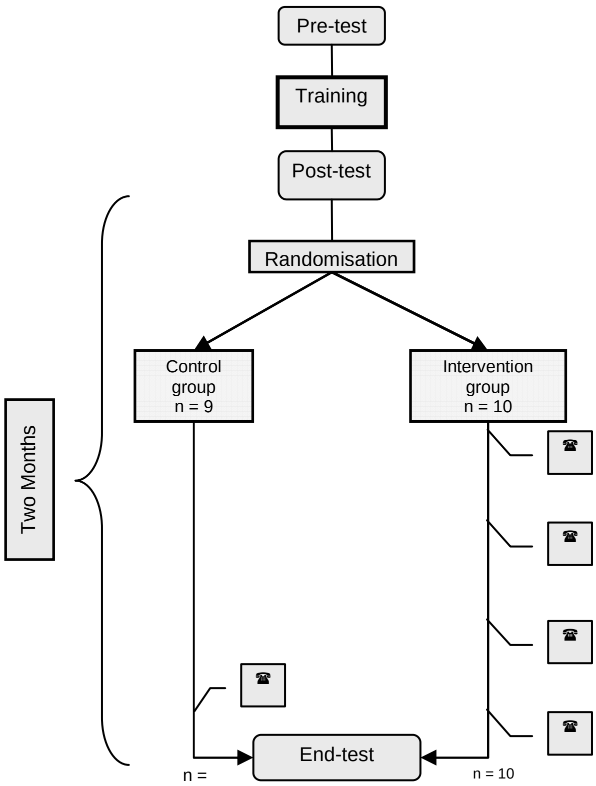

Figure 7.1: *Flow chart of the testing-scheme. ☎ = unannounced intermediate retention test.*

other student. Students were also asked to complete a final questionnaire on clinical experience and teaching during the study which was sent by post after the final retention-test.

Data analysis

We defined the use of the intermediate retention tests as the independent variable and the scores on the end-of-course-course and the final retention-test as dependent variables. The students´ test-results data were found to approximate to a normal distribution on the basis of visual inspection of histograms and tests of skewness and kurtosis. We used the paired and unpaired t-tests for comparisons of test-results and the Chi-squared test to compare background information on the students. SPSS® version 10.1 was used for all statistical calculations. A p-value of ≤ 0.05 was taken to be significant.

Results

Nineteen students completed the training and took part in the study. There were ten students in the intervention group and nine in the control group. Two students in the intervention group missed the fourth telephone call and another student in this group was unavailable for the final retention-test. The pre-course questionnaire and the course-evaluation form were completed by all students, however three students in the intervention group and one in the control group failed to return the final questionnaire.

There was no significant difference in the number of students returning the questionnaire in each group in terms of clinical experience of paediatric and / or thoracic trauma or teaching in these areas, either before or during the study (Table 7.1). The mean amount of self-study, on the basis of self-reporting, was 3.9 hours for the control group and 1.1 hours for the intervention group. This apparent difference was largely due to a single student in the control group who put in 10 hours of extra study, and the difference between the two groups did not reach statistical significance. This student's scores were within one standard deviation of the mean score for the control group for all parts of all three tests, except part 3 of the end-of-course-test which was 1.4 standard deviations lower than the mean. The average duration of the first four telephone calls was 13.5 minutes (s.d. 3.2 minutes).

There was a significant increase in score within both groups and for all parts of the tests between the pre-test and the end-of-course-test ($p<0.01$). There was no significant difference in the scores on any part of the pre- or end-of-course-test or on part 2 of the final retention-test between the intervention and the control groups. However, the intervention group scored significantly

	Control group	Intervention group
Number of students in each group	9	10
Previous teaching paediatric trauma	4	2
Previous teaching thorax trauma	8	9
Previous experience thorax trauma	3	3
Previous experience paediatric trauma	2	0
Extra teaching during the study[1]	0/8	0/7
Extra experience during study[1]	0/8	0/7

Table 7.1: *Clinical experience and teaching received in paediatric or thoracic trauma before or during the study. None of the differences was statistically significant (Chi-squared test). [1]Numbers on the right indicates the number of students who completed and returned the final questionnaire.*

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higher on parts 1 and 3 of the final retention test (figure 7.2). The scores in the control group fell significantly between the end-of-course-test en the final retention-test for part 1 and 3 of the test, but there was no significant change in the score on part 2. There was no significant change in scores in the intervention group between the end-of-course-test and the final retention-test on any part of the test. All students' scores for all parts of the final retention-test remained significantly higher than the pre-test scores. Figure 7.3 shows the percentage retention after two months of the gain in knowledge as a result of the course.

There was no correlation between the final retention-test score and the time that the test was taken, in relation to the first call on that day. There was also no significant difference between the scores achieved by students telephoned on the first day of retention-testing and those telephoned on the second day.

The average course evaluation for all session combined was 2.1 and none of the teaching session scored less than 1.7. The free comments on the training were generally positive and no student expressed an objection to the frequent telephone calls.

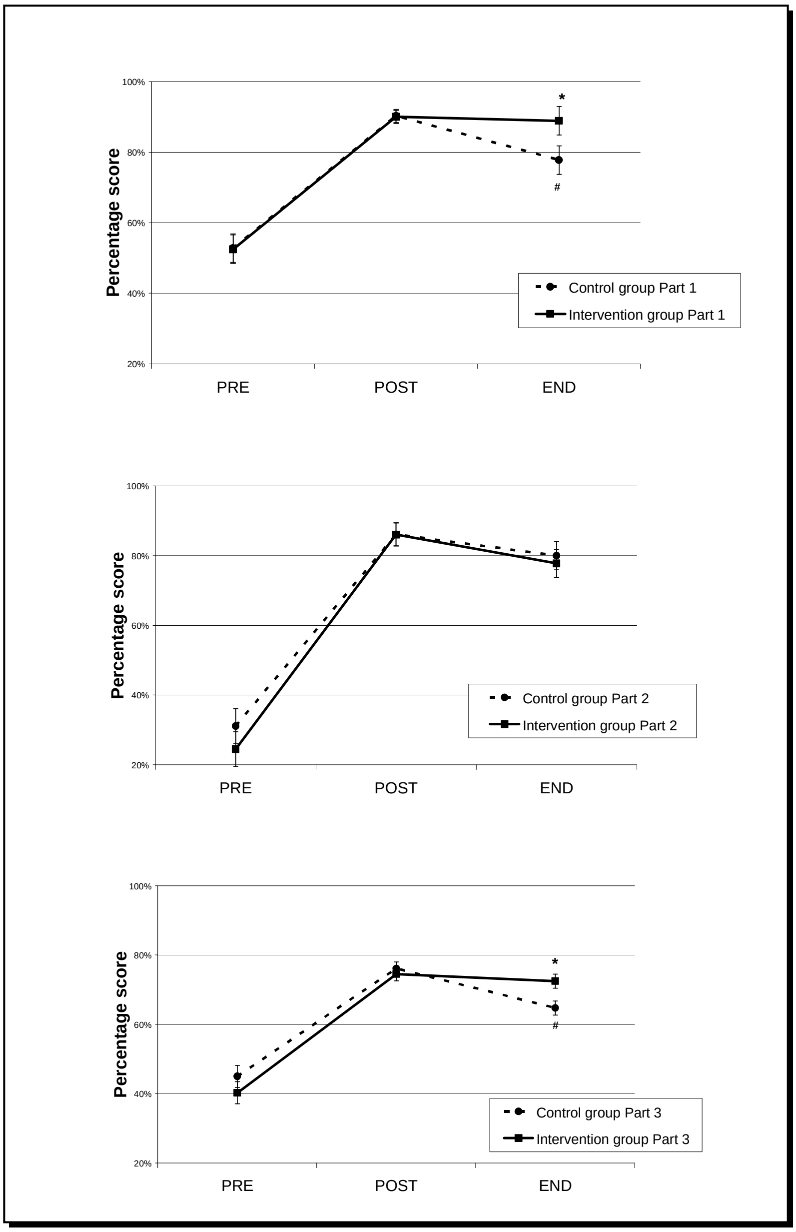

Figure 7.2: *Means test scores for the intervention (solid line) and control (broken line) groups on the pre-, end-of-course- and final retention-tests, for a) part 1, b) part 2 and c) part 3 of the test. Error bars indicate standard error of the mean. (*: p < 0.05 compared with the control group. #: p < 0.05 compared with the end-of-course-test).*

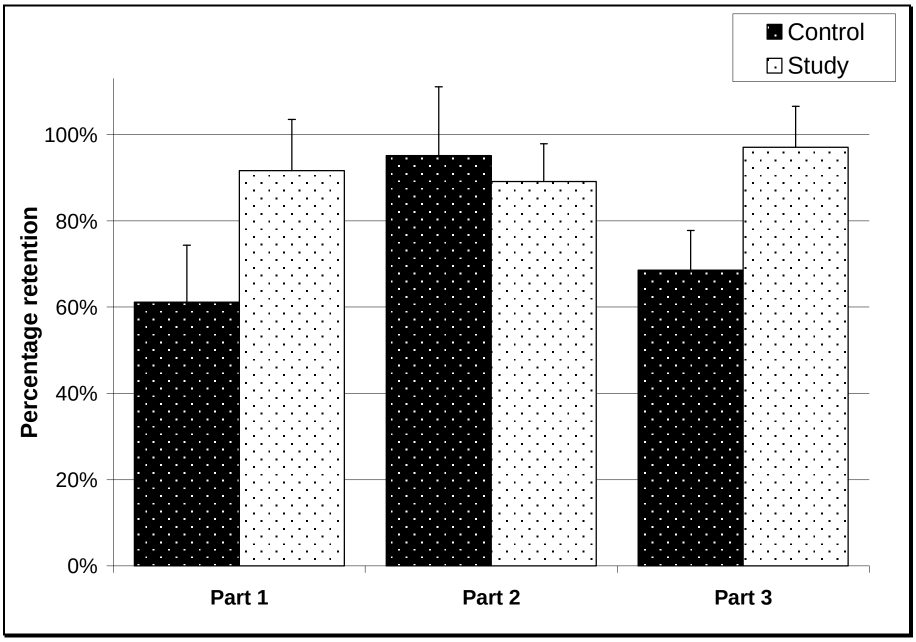

Figure 7.3: *Percentage retention of the new knowledge acquired during the training in the intervention and control group defined as (Final retention-test score – Pre-test score) / (End-of-course-test score – Pre-test score). Error bars represent standard error of the mean.*

Discussion

We interpret our results as evidence for an improvement in retention of factual knowledge after a life-support course as a result of spaced testing using patient management problems presented by telephone.

We postulate several mechanisms to explain this. Firstly, the telephone calls could have prompted the students to do more self-study, although we found no evidence of this. Secondly, the patient management problems could have provided students in the intervention group with extra factual information through the case-descriptions, although we were careful to keep this to a minimum. Thirdly, practicing patient management problems could have led to an improvement in test-performance without an overall increase in retention (retest effect).[14] However, if this were the case, students in the intervention group would be expected to show the most improvement in performance on patient management problems, which was not the case. Fourthly, a testing effect could have been responsible for our findings. In the testing effect solving the clinical cases leads to re-activation and re-elaboration of knowledge which in turn leads to better retention by ensuring that the information is ultimately better stored and linked to other information.[25] Testing is believed to improve learning by elaborating existing memory traces and their cue-target relationships and by increasing the number of retrieval routes to stored information. [15] We consider the last explanation to be the most plausible, and that our study is evidence for a testing effect on retention.

Interestingly we did not find any difference in performance of clinical problem-solving as assessed by performance on patient management problems, although this was the very activity which the intervention group practiced more than the control group. This finding is reminiscent of the work of Ali et al who studied a group of doctors who had followed the ATLS course and repeated an MCQ and a simulated-patient test at intervals for up to 6 years using a cross-sectional design.[8] They found that the MCQ-score started to decline between the end of the course and 6 months, reaching a plateau after 2 years. This level was below that considered acceptable for an end-of-course-test score for all candidates. However performance on tests involving clinical problem-solving of simulated cases declined less and doctors were still generally able to achieve a global pass for these tests even after six years. A separate study Ali et al demonstrated a similar dichotomy between the retention of trauma knowledge and maintenance of clinical ability at two years.[26] In a different context Conway et al found that concepts were better recalled than facts when studying the very long term retention of psychology graduates.[27] Our study is further evidence that clinical concepts and problem-solving skills are generally better retained than factual knowledge but also suggests that spaced testing is unable to improve the retention of clinical problem-solving skills further.

As we used the same test three times to facilitate the measurement of retention, it is possible that part of the improved performance on the end-of-course- and final retention-tests compared to the pre-test was due to the students remembering the answers to the test questions. However, any such retest effect would presumably also have been evident in the control group. Furthermore, Waisman found no evidence for a retest effect when repeatedly using questions in study of retention after the Pediatric Advanced Life Support course.[6]

Exchange of information between students could have affected our results. However, following the training all students rotated to individual clerkships and did not reunite as a group during the study period. Contact between students was therefore greatly reduced. Furthermore, students telephoned later in the evening or on the second day of testing did not score better than their colleagues. We can therefore find no evidence of cheating through exchange of information between students. The amount of study was self-reported and difficult to verify, however, the vast majority of students in both groups reported that they studied the material very little after the training.

The practical implications of our findings are open to debate. The educational significance of the improvement in retention of factual information which we found is difficult to quantify and the impact of this on clinical behaviour is uncertain. There are also practical impediments to implementation of spaced testing in health professionals who have followed an officially recognized life-support course who may be less open to, and feel more threatened by testing than medical students. We chose to use spaced telephone calls to stimulate recall in order to ensure that all students actually did work through the clinical cases. The total time investment per student was approximately one hour, and the students found this acceptable. However the technique was labour-intensive for the instructor and may not therefore be a practical method of improving retention following life-support courses. Alternative methods would be to present the cases either by post, e-mail or the internet, or a combination of these.[17;28] We are keen to investigate the use of an internet resource to improve retention after the APLS-course in the future.

It was not our intention to compare the use of spaced hypothetical clinical problems with other methods for improving retention, and we concentrated on cognitive knowledge rather than practical skills or clinical behaviour. We are uncertain as to the generalizability of our findings to other forms of learning or to contexts other than a life-support course. Furthermore we are cautious in our conclusions due to the small number of students involved in this study. To further investigate the effect of unannounced spaced testing in larger groups, it will be important to compare the effect of patient management problems with that of spaced simulator practice, to include assessment in other domains such as practical skills and behaviour, and to investigate the usefulness of spaced testing in other areas of medical education. Other means of presentation of the tests (e-mail, internet) as well as their optimal timing, interval and number, and the effect of feedback after each test also need to be investigated.

Conclusions

Knowledge declines after a life-support course and this attrition should be expected and planned for. We agree with Farr that learning objectives should include an element of retention – it is not adequate to define what is to be learned, but also to state how long, and at what level, it is to be retained.[25] We would suggest that this is highly pertinent to life-support courses. Course organizers should define objectives in terms of retention and consider ways of improving it. Spaced testing appears to be a potentially useful way of doing this.

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General Discussion

8

Possunt, quia posse videntur[5]

The primary motivation for writing this thesis came from two directions. Firstly, the evidence suggesting that doctors' management of critically ill patients is not always optimal and that this can lead to avoidable mortality.[1-8] Secondly, the impression that life-support courses might be a useful way of approaching this problem. Life-support courses can have effects at various levels leading to increased knowledge, technical and clinical skills and clinical decision-making in their participants – at least in the short-term. The courses can also have effects on attitudes which might, on occasions, be as important to the patient as the doctor's knowledge and skills.

The research presented in this thesis focused on two main themes of importance to the effect of life-support courses – self-efficacy and retention. As discussed in chapter 1, self-efficacy is a possible determinant of transfer of learning from a course to clinical practice and as such could be seen as playing a pivotal role in the effectiveness of training. Retention of factual knowledge and technical skills is arguably a greater problem in training in emergency medicine than in other areas of medical practice.

The research presented in this thesis had seven specific objectives which are related to the two main themes, and were incorporated into a model of learning in emergency medicine, structured around the hierarchy of Kirkpatrick. The objectives can be summarized as follows:

1. to develop and validate a simple measurement instrument for self-efficacy for resuscitation procedures;
2. to measure the effect of a life-support course on self-efficacy in both the short and the medium term;
3. to investigate the effect of a life-support course on the use of procedures taught on it in clinical practice;
4. to investigate the relationship of self-efficacy to behaviour during a resuscitation;
5. to investigate the relationship between self-efficacy and quality of resuscitation skills;
6. to investigate the effect of the outcome of a resuscitation on self-efficacy;
7. to investigate the effect of spaced testing on retention of knowledge and problem-solving ability in emergency medicine.

The extent to which these objectives have been addressed by the studies

[5] Virgil Aeneid V v 23. They thought they were able so they *were* able.

presented in this thesis, as well as their limitations, will be discussed in the next sections.

Critical discussion of the research findings

<u>The development and validation of an instrument to measure self-efficacy for resuscitation procedures.</u>

In **chapter three** the development and validation of a simple method of measuring self-efficacy was presented. The visual analogue scale (VAS) linked to a single question was found to be a reasonably valid method of measuring self-efficacy for resuscitation tasks. The validation of the use of the visual analogue scale is an important contribution to the study of self-efficacy in emergency medicine, and may encourage research and improve study-compliance. Self-efficacy is usually measured using a lengthy questionnaire which may be cumbersome to apply.[9] The VAS-instrument is very easy to use and may reduce questionnaire-fatigue and improve compliance especially when the measurement of self-efficacy for several different tasks is required. Research into self-efficacy and resuscitation may have been hindered in the past by lack of such a measurement instrument.

The visual analogue scale is, however, not intended as a substitute for more extensive measures of self-efficacy in all three of its dimensions, but only as a reasonably valid and simple technique which primarily measures the *strength*-dimension of the construct. The VAS-method does not lend itself so easily to the measurement of the *level* of self-efficacy, whereas questions which help to define the level are easily incorporated into a questionnaire. An example which was used in the validation study were questions referring to self-efficacy in respect of the increasing difficulty in canulating a vein in children of decreasing age. Similarly, the *generality* of self-efficacy could conceivably be addressed using the visual analogue scale if a series of questions were asked relating to progressively distinct but related tasks – for example hand-ventilation via a endotracheal tube, laryngeal mask or face-mask.However, if one were to do this in a detailed fashion, the resulting instrument would quickly come to resemble a questionnaire in which one could quite easily replace the visual analogue scale for each question with another scoring system.

The VAS-instrument was found to be more valid for the measurement of self-efficacy for specific-tasks than for more general ones, such as global resuscitation ability. This finding accords well with the task and context specificity of the self-efficacy construct. It is questionable to what extent one can cover the entire scope of complex tasks in a single question and what the value of such a self-efficacy measurement would mean. Therefore, the VAS-method might be best reserved for use with multiple specific well-defined tasks rather than for than for complex multifaceted tasks.

It is conceptually unsound to generalise self-efficacy too far. Task-specific and "general self-efficacy" might be different constructs.[10] The former is context-specific and predictive of performance and can be manipulated by educational interventions, whereas the latter is a decontextualised trait-like characteristic which may not bear a relation to functioning in any specific domain. "General self-efficacy" may therefore be more closely related to self-concept. The question is, how far can self-efficacy be generalised without loosing its meaning? The study presented in chapter five suggests that it might be reasonable to speak of self-efficacy for global resuscitation ability, as this did predict performance to a degree, and this conclusion will be discussed further in a later section in connection with the relationship between self-efficacy and self-assessment.

Various aspects of validity were addressed in the study. Concurrent validity was established by the favourable correlation between the VAS-instrument and a questionnaire, which was taken to represent the standard instrument. Construct validity was demonstrated by illustrating the predicted positive effect of following a life-support course on self-efficacy, and, in terms of divergent validity, by a know-group analysis.

However, the face validity of this method will depend on the individual's interpretation of the single question asked. Therefore the exact phrasing of this question is crucial. This was illustrated by the different regressions of the VAS-instrument with the questionnaire between doctors and nurses for global resuscitation ability, in which the nurses may well have interpreted their role differently from doctors and completed the visual analogue scale according to that interpretation.

The validation in this study was performed at group level. The VAS-method described should therefore only be used to draw conclusions relating to groups of individuals in cross-sectional or before-and-after studies. Furthermore, those groups should be, as far as possible, homogenous. The relationship between the visual analogue scale and the standard instrument in individuals over time has not been established, so the visual analogue scale should be used with caution in longitudinal or time-series studies.

The short term effects of a life-support course on self-efficacy and use of procedures taught on the course in clinical practice.

In **chapter four** the effect of the Advanced Paediatric Life Support (APLS) course on self-efficacy and skills-use was demonstrated in a survey of course-participants with a follow-up of six months. It was demonstrated that the APLS does increase self-efficacy for many resuscitation tasks significantly. This has not been demonstrated previously, but is of itself little more than an interesting observation. The important thing whether the doctor's behaviour changed as a result of the course – specifically whether his or her practice improved. Unfortunately, the results of this simple survey did not supply any evidence for a change in practice in terms of the frequency with which resuscitation procedures were carried out. This too is a new finding, as the extensive literature search for chapter two revealed no other published studies of the effect of the APLS on skills-use.

The apparent lack of effect of the APLS on clinical behaviour revealed by this study might, in most cases, have a very simple cause. Resuscitation skills can only be employed in practice if there is an opportunity to use them. It is to be hoped that, even before following the APLS-course, most doctors would have initiated thorax compressions to a child if they recognized a circulatory arrest (although evidence presented in chapter six suggests that this is not universal). Performing such procedures can therefore be assumed to be mandatory and will be directly proportional to the number of resuscitations encountered. Furthermore, many of the procedures used during a resuscitation, such as mask ventilation are more often employed in non-emergency situations, and the frequency of use of such skills might not be the best index of the effects of the course.

In order to evaluate the effect of a life-support course optimally, it is important to study procedures which are both "emergency" interventions and "optional", such as the use of the intraosseous device to gain rapid access to the circulation. For this reason this procedure was deliberately included in the study. The results were disappointing. There was no increase in the use of the intraosseous device after following the APLS, despite it being one of the procedures specifically targeted during the course. This cannot easily be ascribed to lack of opportunity as there appears to have been sufficient opportunity to perform the procedure during the initial management of more than 400 critically ill children included in the survey.

There was therefore a dissonance between the increase in self-efficacy and behaviour which is at odds with the social cognitive theory. An increase in self-efficacy should increase the probability that a particular task be attempted.[11] One possible explanation for this dissonance is that a threshold degree of self-efficacy exists of this procedure, as is known to exist for other tasks[10], and that APLS-training did not allow participants to attain this threshold level. Self-efficacy for the insertion of the intraosseous device did indeed remain relatively low compared to other tasks. Having said this, in the study described in **chapter six**, although self-efficacy for inserting an IO was higher in those who chose to do so, there was no clear suggestion of a threshold-effect – doctors with low self-efficacy also attempted the task, and some of those with very high self-efficacy did not. It would be interesting to know whether a threshold effect can be demonstrated in a study of individuals over longer time periods rather than of groups of individuals at one point in time.

A second possible explanation for the dissonance is the time-interval between the measurement of self-efficacy and the use of the skill resulting from the design of the study in chapter four. This could have led to a temporal disparity of self-efficacy and performance which is discussed in a later section.

The procedures chosen for investigation were all essential skills required for resuscitation from respiratory or circulatory arrest but investigating the frequency of use of these skills as a measure of the effectiveness of the APLS-course in general may be misleading. Furthermore, the study was only designed to look at the relationship between self-efficacy and skills-use. There is evidence that other life-support courses do lead to increased use of the techniques taught, and it would not be surprising if further studies revealed this to be the case with the APLS.[12-14] Cronbach suggested that educational interventions should be evaluated in terms of their stated aims[15], and the main focus of the APLS is on early intervention to prevent cardiorespiratory arrest, which, in children, has a very bad prognosis. Therefore, a more appropriate measure of the effect of the APLS might be the timeliness of interventions to prevent cardiopulomonary arrest such as the administration of oxygen and intravenous fluid.

Finally, one incidental finding of this study is potentially important for future studies. Self-efficacy for resuscitation tasks was found to be relatively stable over time in the control group. This is an essential finding if the effects of an educational intervention on self-efficacy are to be investigated and has not been described before

The relationship of self-efficacy to behaviour during a resuscitation.

In **chapter five** the relationship between self-efficacy, competency and behaviour in paediatric resuscitation was explored in an experimental study using simulation. Self-efficacy was found to be predictive of behaviour during a simulated resuscitation. This is a very important finding which is key to the belief that self-efficacy should be specifically addressed during life-support courses in particular, but also in medical education at all levels in general.

Self-efficacy for the relevant task was found to be higher in those doctors who chose to insert an intraosseous device or to intubate, and lower in those who failed to give thorax compressions. This last finding might have wide-reaching implications. Reluctance to begin resuscitation by lay-people is believed to be a significant public health issue.[16] Although there are likely to be many causes for this, self-efficacy might conceivably be an important factor which can be manipulated during training to increase bystander resuscitation and therefore have an impact on survival from cardiac arrest. The role of self-efficacy in this context therefore deserves further investigation.

The relationship between self-efficacy and quality of resuscitation skills.

The second objective of the study presented in **chapter five** was to investigate the use of self-efficacy measured on the visual analogue scale as a self-assessment tool. This revealed results which contrast interestingly with those presented in chapter three. There was no detectable correlation between self-efficacy and quality of performance with regard to the specific skills of thorax compressions and bag and mask ventilation, but self-efficacy for resuscitation ability generally did correlate reasonably well with the scores assigned by independent assessors. However, in the validation study described in chapter three, the measurement of self-efficacy for specific tasks was found to be more valid than that for resuscitation globally.

There is of course no real paradox in these findings, but the relationship between self-efficacy and self-assessment is slightly more complex than it might at first appear. As discussed in the introduction, self-efficacy and self-assessment of ability are two different constructs. Self-efficacy is related to the relationship between an individual's internal measure of his or her ability and their internal standards[17]; whereas the self-assessment is conceived of in terms of the relationship between this internal measure of ability and objectively measured performance (see figure 8.1).[18] Hence both self-efficacy

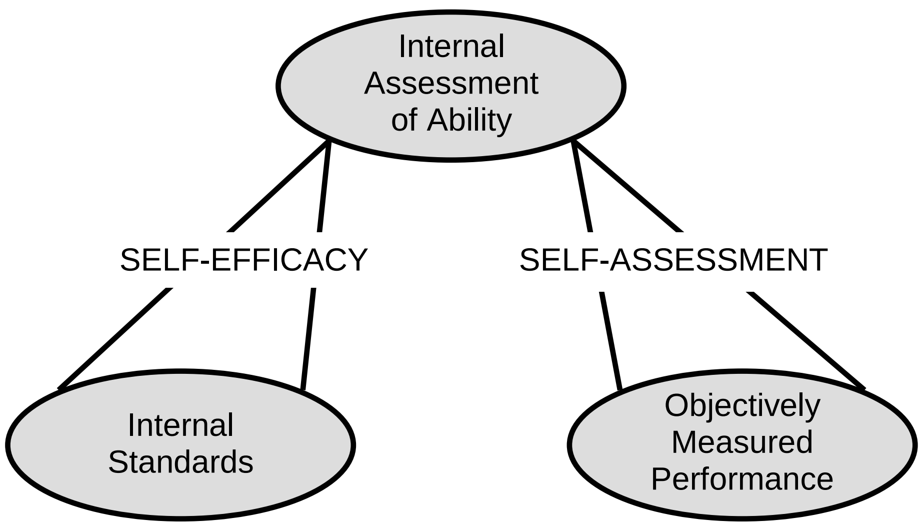

Figure 8.1: *Conceptual relationship of self-efficacy to self-assessment.*

and self-assessment involve the internal assessment of ability but are referenced to totally different, and variable, factors. Whereas self-assessment can be considered to be "anchored" in an objectively measurable factor, self-efficacy is entirely internal and its terms of reference are essentially subjective. Self-efficacy also bears a reciprocal relationship with events, being directly influenced by experience and influencing future performance. In the words of Bandura; "A*ctions are based more on beliefs than objective truths."*[19] Self-assessment, on theother hand is more related to outcome expectations. Thus self-assessment ability and self-efficacy are likely to vary independent of one another and a direct correlation between self-efficacy and quality of performance is conceptually unlikely.

As stated above, the more general a self-efficacy measurement is made, the more it resembles the measurement of self-concept. Gordon has concluded that "…*self-assessments are strongly influenced by global self-attributions and are perhaps as closely linked to self-concept as they are to previous performances."*[20] The finding that self-efficacy for global resuscitation ability, a more general measure, correlated better with objectively measured performance than more task-specific self-efficacy adds corroboratory evidence to this view.

Highly interesting in the light of this discussion are the findings relating to self-efficacy for self-assessment. It appears that doctors who rate their self-efficacy in relation to self-assessment highly, are indeed better able to self-assess. Although not new, this is an important observation with practical consequences. The self-assessment skills of doctors and medical students has repeatedly be found to be poor, and this has also been described for resuscitation skills.[18;21] However, self-assessment is a vital skill for members of a self-regulating profession.[22] Therefore anything which indicates which doctors have particular difficulties in assessing themselves would be of potential value, although much further research is needed to confirm this effect.

The visual analogue scale therefore appears to be better for the measurement of self-efficacy for more specific skills, but may have a role as a self-assessment tool for more general tasks, although this tentative conclusion needs verification in further research and in other domains. The VAS-instrument could be useful in self-assessing the need for retraining globally, but is unlikely to reveal much specific information on particular areas of weakness as it cannot be recommended for use in the self-assessment of individual skills. To do this a simulated-resuscitation test would be more useful.[23]

The findings of this study in respect of self-assessment, although new in the field of paediatric resuscitation training, confirm those of previous research. It is known that global self-assessment is generally more accurate than self-assessment of specific tasks.[22] Retrograde self-assessment of performance on a previous test is believed to be more accurate, but there was no evidence of this in our study.[24] Previous research has also shown that the ill-defined concept of "self-confidence", the measurement of which may contain an element of self-efficacy, does not correlate with performance of paediatric resuscitation tasks.[6]

<u>The effects of a life-support course on self-efficacy and quality of performance of procedures taught on the course in the longer term.</u>

Chapter six presents a study of the effect of the APLS-course on performance of resuscitation and self-efficacy in the longer term using an unannounced simulated resuscitation test in a clinical context. The most important, but well-recognized and depressing finding of this study was incidental to the study objectives – doctors are extremely bad at resuscitation (figure 8.2). Virtually

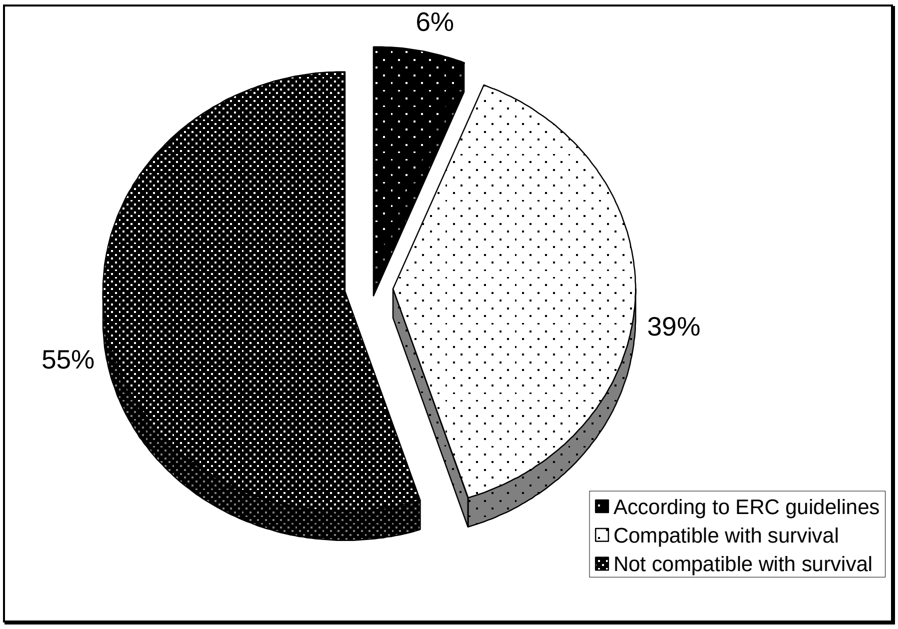

Figure 8.2: *Percentage of doctors who performed the resuscitation according to the protocol of the European Resuscitation Council, or such that the patient did or did not have a chance of survival.*

none of the participants followed the resuscitation protocol correctly. Even when the "acceptable" management was limited to the absolutely essential interventions to maintain the flow of oxygenated blood to the vital organs (ventilation, thorax compressions and adrenaline) less than half of the participants managed the simulated patient in such a way that he would have had offered him a chance of survival. This problem has been reported many times before[1-8], and although the political will to improve it has existed for some years[25-31], the situation remains unacceptable.

Chapter six does however add to the evidence that life-support courses can improve resuscitation ability – albeit not always to levels which can be considered acceptable. Two-thirds of doctors who had followed the APLS-course were able to manage the resuscitation such that the child would have had a chance of survival. However, the practical skills of thorax compressions and bag and mask ventilation of all doctors were generally poor and APLS-training appears to have little or no impact on this. The scoring system for thorax compressions was adapted for paediatric use from the adult penalty scoring system of Berden.[32] He considered 15 penalty points to be the cut-off point for acceptable performance. Only 20% of participants achieved this, and APLS-trained doctors were no better than their peers. APLS-trained doctors were however better able to perform certain other procedures during the simulation including the insertion of an intraosseous device.

Self-efficacy was also higher in doctors who had followed the APLS, even several years after the course, although numbers were too small to define the time-course of the change in self-efficacy. Combining these findings with those of chapter five it can be concluded that self-efficacy for resuscitation tasks is increased by following the APLS-course and this leads to an increased likelihood of performing those tasks, provided there is an opportunity to use them. However, self-efficacy does not correlate with quality of performance. These findings are what one would expect from a theoretical perspective but have not been previously described for the APLS-course and lend further construct validity to the visual analogue scale as a method of measuring self-efficacy.

<u>The effect of the outcome of a resuscitation attempt on self-efficacy</u>

The final finding of the study in **chapter six** is that death of the simulated patient has a significant negative effect on self-efficacy. It is an unwritten rule of paediatric life-support courses that the simulated patient must never be allowed to die, no matter how abysmal the doctor's management is. This is the only aspect of the teaching methods currently used on life-support courses which is specifically addressed in this thesis, but the results tend to support this "no-death" rule. This finding has consequences both for the course and for clinical practice.

Life-support courses should aim to increase self-efficacy and allowing the patient to die could be counterproductive to this aim. However, the death of the patient is only one source of feedback relevant to self-efficacy available during a simulation exercise. Apart from this (simulated) personal experience, there is also vicarious experience from watching others perform, social persuasion from instructors and fellow learners and internal influences from physiological and emotional states. During this study we eliminated both vicarious experience and social persuasion. During a course either or both of these might be able to compensate for the effect of the death of a simulated patient on self-efficacy to an extent. Therefore it would be rash to state that the "no-death" rule is totally vindicated. Furthermore, it would be useful to investigate further the effect on self-efficacy of the survival of a patient despite inadequate management, which is often encountered during life-support courses, but, by definition, unlikely during a real paediatric resuscitation.

As far as clinical practice is concerned, the findings suggest that death of real patient would also lead to a decrease in self-efficacy which, if persistent, might have repercussions on the doctor's later performance. The death of a patient, particularly a child, can have a demoralising effect on the health-care team, but the effect on self-efficacy for specific tasks, and the time-course of this effect, does not seem to have been studied and would be an interesting field for further research.

Limitations to the studies of self-efficacy and practical performance

The conclusions of the studies the effect of the APLS on self-efficacy and its relationship to skills-use and quality of performance need to be tempered by consideration of the limitations of these studies. Foremost amongst these are the technical limitations of the mannequin used for the study. This was a prototype version of the Laerdal Junior® mannequin kindly lent by the developer for the purpose of the study. The registration of thoracic compressions was generally adequate except that it was not physically possible compress the thorax more than about 4 cm. This corresponds approximately to the recommended depth of compression of one third of the thorax. It was therefore only possible to determine whether compression-depth was adequate or too shallow, but not whether this was too deep. This could have the consequence that some of those scoring less than 15 penalty points were actually pressing too firmly, which would mean that even fewer than 20% of participants had performed the procedure adequately.

Somewhat more problematic was the use of the mannequin to measure the quality of performance of bag and mask ventilation. The airway of the mannequin was not entirely air-tight which meant that the degree of thorax-expansion was influenced by the inspiration and expiration times and was not entirely accurate as a measure of the tidal volume. The air-leak was such that attempts to calibrate the measured tidal volume with a flow/volume-meter were unreliable. A second problem was the "wandering baseline" of the ventilation volume recording. It was possible to compensate for this but the accuracy of the volume-meter following this compensation could not be verified.

Apart from technical problems three experimental limitations need to be considered. First of these was the maturation effect which arises from the fact that those who had followed the APLS were generally older than others and which is discussed in chapter six.

The second major limitation is the issue of the relationship between simulation and reality. The pitfalls of drawing conclusions about self-efficacy from studies in simulated environments have been discussed by Stajkovic and Luthens.[10] They identified five elements which limit the validity of simulation when investigating self-efficacy. Firstly there are *performance constraints* such as physical distractions and limitation of resources. The problems with the mannequin discussed above fall into this category. The second element is *ambiguity of task demands*. In an experimental setting, the required tasks are usually standardized and crystal clear, whereas the real world is a fuzzy place where things are rarely so straightforward. As an example, in our study the doctor only had to perform thorax compressions in isolation. During a real resuscitation he or she would most likely have to do this whilst thinking about or performing other tasks. However, participants probably scored their self-efficacy for thorax compressions in reference to a real resuscitation – and indeed were specifically asked to do so. Contrasting with task ambiguity is the third element, *deficient task information*. The real world may be fuzzy, but it provides rich sources of information and feedback which in our study was deliberately controlled. Colleagues are an important source of feedback during a real resuscitation. In our study individual doctors were required to manage the entire resuscitation, each assisted by only one simulated nurse who was instructed not to offer advice or information. This is an unreal situation for a hospital doctor and rarely occurs in practice. Normally suggestions and advice from other doctors and nurses would be rife. Although this experimental design mimics the instructional design of many life-support courses, it may not provide the optimal simulation of a real resuscitation.

The *consequences of efficacy misjudgement* is the fourth element identified by Stajkovic and Luthens. During the simulated resuscitation the plastic "patient" was unlikely to suffer as a result of misjudgements, whereas when dealing with a real patient the consequences of over- or underestimating one's ability can be dire. A nice illustration of this pitfall arose twice during the study. After failing to insert an intravenous canula, two doctors explicitly stated before going on to attempt an intraosseous device that they had never used the device before. One even stated that she didn't know how it worked. It is hard to image that they would have been so cavalier in clinical practice.

Only the last of the elements influencing the reliability of self-efficacy data in simulated environments gives the simulation the advantage. *Temporal disparities between self-efficacy and action* are likely to be greater when using a naturalistic approach than in an experimental setting. Self-efficacy is known to be influenced by many factors and to vary unpredictably over time, although it may also be quite stable as shown in chapter three. Performance is influenced by the self-efficacy pertaining at the time of action.[33] In the studies described in chapters five and six self-efficacy was measured directly before the performance and it is hard to conceive of a more contemporaneous measurement. In contrast temporal disparity between the measurement of self-efficacy and performance was identified earlier in this chapter as a limitation to the study of self-efficacy and skills-use in chapter four.

Additional biases from simulation studies include the effect of knowing that one is being observed and the response-fidelity of the simulator, which in our case was not very high.[34;35]

All of the above limitations would have applied equally to all participants, whether or not they had followed the APLS-course. For this reason it can be cautiously concluded that there is evidence that doctors who have followed the course show greater global resuscitation competence and self-efficacy, but are no better at individual resuscitation skills.

The final limitation to the interpretation of these findings is that the relationship between higher self-efficacy and increased transfer during a simulated resuscitation in those who have followed the APLS-course need not necessarily be a casual relationship. It is quite possible to conceive of a third factor or factors which influence both self-efficacy and transfer. Furthermore, doctors who follow the APLS may not be the same as those who choose not to, and the two groups may not have been compatible. The postulated causal relationship self-efficacy and transfer needs to be confirmed by studies in which self-efficacy is manipulated by various means and transfer is measured. If the relationship were then to hold for most sets of conditions, a casual relationship could be more confidently assumed.

<u>The effect of spaced testing on retention of knowledge and problem-solving ability in emergency medicine.</u>

In **chapter seven** one method of improving retention after a life-support course, using unannounced spaced telephone testing is explored. Retention of knowledge and skills is of crucial importance in emergency medicine and, under certain circumstances, can literally be life-saving. However, chapter two describes a general problem of poor retention after life-support courses.[36-41]

Overall retention of learned material was 70-80% after two months, which accords with other retention studies of university students.[42;43] Spaced testing, involving patient management problems, was found to improve retention of factual knowledge after a life-support course for medical students. However, there was no evidence of an effect on the ability to solve clinical problems involving application of the principles of resuscitation taught on the course. This is a highly interesting finding as there is dissonance between what was tested (clinical problem solving) and what was better retained in the tested group (factual knowledge). Practicing clinical problems appears to have a positive effect on the retention of clinical facts, but not on clinical problem-solving.

This last observation makes a test-retest effect unlikely, but it remains uncertain whether the observed effect is really due to the testing effect.[44] The findings might have been an artefact as it is known that the major principles of resuscitation are better retained than factual knowledge or skills, and the study period was not long enough to allow for attrition of clinical problem solving-skills in this area in either group.[38;39;45] Whether this is the case could be explored by repeating the experiment with a longer follow-up time.

The method used in this study, involving repeated personal telephone contact with all students, was highly labour-intensive and was not intended to be a practical method of improving retention. The experiment was designed as a pilot-study to explore the testing effect after a life-support course. Having established that there might be such and effect, further study is necessary. This should ideally involve not only a practical and reliable method of applying the testing, such as the use of e-mail or the internet, but also a more clinically relevant indicator of retention, such as performance on a simulated resuscitation.

How do the findings of the studies relate to the model?

This thesis is based on a theoretical model of the effectiveness of life-support courses which is represented in slightly modified form in figure 8.3. The model is designed around Kirkpatrick's pyramid.[46] Life-support courses can have direct effects at the lowest two levels including the learning of knowledge, skills and attitudes. Their effects at higher levels are indirect, but might be modified by factors which can be positively influenced during the course.

In order to perform a task the doctor needs not only knowledge and skills but also a predisposing attitude towards the task. There has been little research specifically aimed at the effect of life-support courses on attitudes, and, although attitude learning has been claimed by some, it is dubious whether the examples cited can be considered useful learning.[31;47-51] Several of the studies in this thesis looked at the effect of life-support courses on self-efficacy

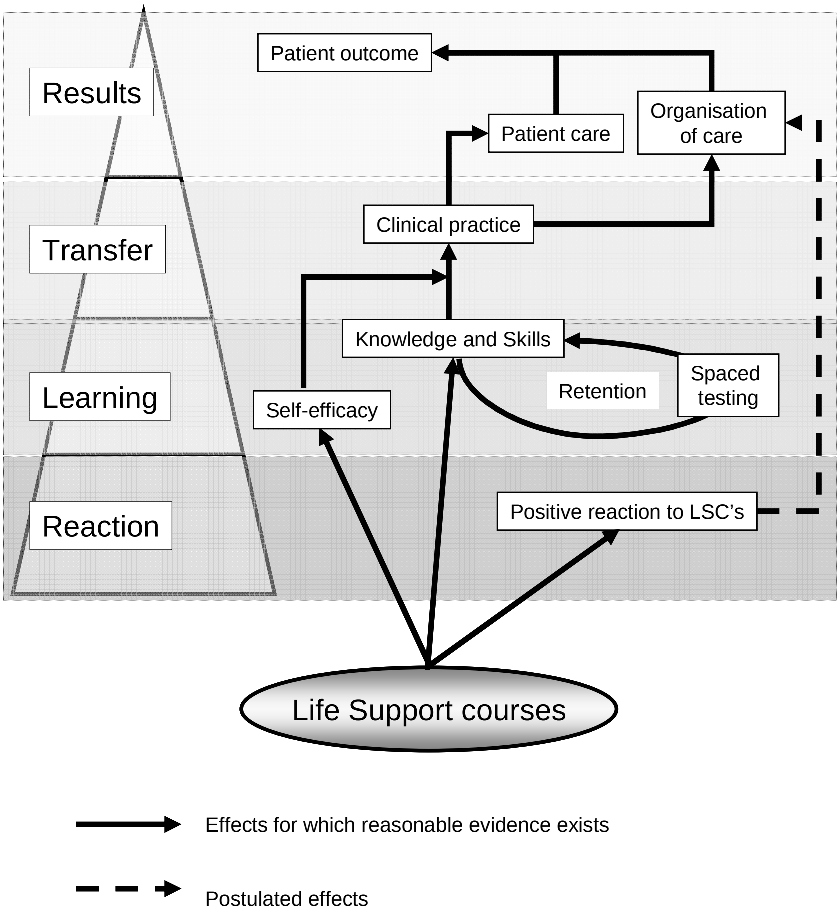

Figure 8.3: Theoretical model underlying the theme of this thesis.

which, as discussed in the introduction, shows some attributes of an attitude. One important finding of our research is that life-support courses can have a significant effect on attitudes, at least as far as self-efficacy is concerned. In terms of the model, the arrow between life-support courses and self-efficacy (as an attitude) has become solid.

Far more important is the finding that the increase in self-efficacy due to life-support course-training is related to transfer of knowledge. There was previous evidence of variable transfer of newly learned competencies into practice.[12-14;52-54] Our findings suggest that self-efficacy is an important factor in this process, at least as far as doctors are concerned. Therefore, the influence of self-efficacy on transfer is represented in the modified model by a solid arrow.

The effect of life-support courses on other attitudes, and their relationship to transfer has yet to be researched systematically. It is also interesting to speculate whether self-efficacy might also play a role in the major problem of the reluctance of laypeople to intervene in an emergency.[16]

The positive effect of adult life-support courses on knowledge and skills and their short retention times has been well described.[4;6;39;49-51;55-59] Our findings illustrate the same general effect for the APLS – knowledge and skills increase after the course, but retention times are short, although global ability to manage resuscitation adequately is generally better retained. Research into the effects of life-support courses should therefore include investigating methods to improve retention. We found that spaced testing is a potential way to do this for factual knowledge, which needs to be studied further. Spaced testing has therefore been incorporated into the modified model.

Implications of educational research findings for training in emergency medicine: From chain of survival to chain of learning

This penultimate section of the discussion considers the implications of the findings of the original and previously published research discussed in this thesis for training in emergency medicine in general and life-support courses in particular.

Much of the research described in this thesis has shown that, while learning on life-support courses can be significant, retention of little used knowledge and skills is often poor. It is knowledge and skills in exactly these areas which are the rationale for life-support courses - one does not need to attend a residential course to learn something one does daily, although this might conceivably improve quality of performance. The course should therefore provide something which is not available in daily practice, and which needs to be retained to be of benefit.

Retention can be improved by retraining, for example on a refresher life-support course, but this is expensive and tends to take staff away from the workplace at regular intervals.[36;60] Regular training can be more reasonably organised in the workplace, which also provides the opportunity for spaced learning. The advantages of spaced, rather than massed, learning have been mentioned earlier.[61] Spaced learning and continued deliberate practice improve both performance and self-efficacy and can only be realistically achieved in the workplace.[62-64] Regular re-elaboration of knowledge in this fashion, and regular simulation training can improve retention and learning.[44]

Life-support courses are clearly massed learning which is likely to be less

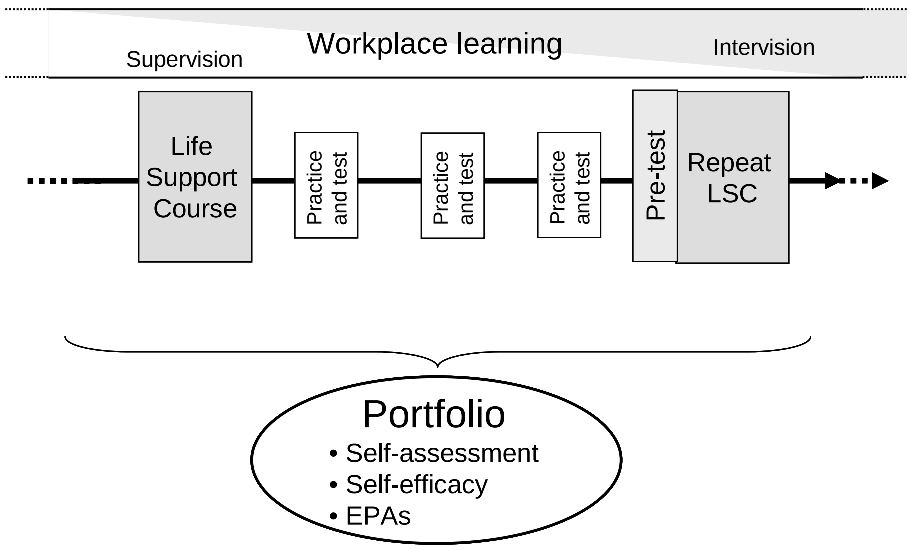

Figure 8.4: *A model for learning in emergency medicine – "the chain of learning".*

efficient, particularly in terms of learning complex skills. However they have established for themselves an important and sanctioned place in training in emergency medicine. They offer an undisturbed opportunity to learn by study and by exchanging ideas with colleagues, generally in a conducive atmosphere. Furthermore, most life-support courses have amassed considerable educational expertise, particularly in respect of simulation training, which tends to be concentrated in their training centres.

Regular and effective simulation training can also be provided in the workplace, but is not as widely used as it might be.[34;65] This has the great advantage of offering training with the actual team with which the doctor works during real emergency situations, and the transportability of many resuscitation simulators and mannequins allows training to take place in the actual environment as well.

Training at base-hospitals can also be better tailored to the individual needs of the learner. One way to do this is by using spaced testing, which can not only identify areas of weakness, but also improves retention. Needs can also be assessed by looking at critical incidents, near-misses and complications in practice.[66;67]

The combination of life-support training and workplace training can be looked upon as a "chain of learning" analogous to the chain of survival of resuscitation and is illustrated in figure 8.4.[68] Life-support courses are only one link in the chain and learning in the workplace should be considered the most important element. Younger trainees require considerable supervision in their daily work. As competence improves, the amount of supervision required declines, but the need for feedback does not. There is however no standardised validated method of deciding when supervision can be reduced. The relatively new concept of Entrustable Professional Activities (EPAs) be helpful in making this decision.[69] Specialists, of course, need to continue to learn and intervision or peer review can provide feedback which may be helpful to some.

A method is needed to keep track of the chain of learning and to identify weaknesses in practice. One way to do this is a portfolio, which can be used by trainees and specialists alike. This should include regular measurements of self-efficacy, not as a method of self-assessment, but as an index of likely transfer. The portfolio could also include self- and peer-assessments of all the necessary emergency tasks expected of competent practitioner in the relevant field, together with trainer-assessments for trainees. These tasks can be defined and described in terms of competencies or EPAs.[69-71] The important point is that it is the *competence* of the doctor which needs to be assessed, which can only be indirectly measured in terms of what he or she actually does in clinical practice and the quality of that performance. This is not just the sum of the *competencies* which the doctor can demonstrate when tested and which he or she *could* do in practice given the will and the daring (self-efficacy) to do so. Life-support courses are not able to assess at this level, which corresponds to the highest tier of Miller's pyramid[72], but are limited, at best, to the assessment of individual competencies.

<u>What should life-support courses in the light of this research do?</u>

The chain of learning will be most effective if the base hospital and the life-support course both teach the same thing. This requires coordination between the two in which the educational expertise of many life-support course organisers should be acknowledged, tapped and usefully applied. Such a collaboration allows for longer-term follow-up of the effectiveness of courses, than is generally employed at present. This will allow the issue of retention to be better addressed, and life-support courses should consider introducing the element of retention into their learning objectives.

Not only retention, but also transfer could be addressed by better follow-up. This thesis presents some anecdotal evidence that doctors are willing to attempt procedures during simulations which they don't seem to use in practice. Are life-support courses only teaching doctors to manage simulated resuscitations? To answer this question requires more systematic audit of the effects of courses on clinical practice, which cooperation between course organisers and base hospitals could facilitate.

Life-support courses not only have a duty to keep up to date (which, incidentally, has been questioned[73]) but should also take a leading role in evaluating the evidence of effectiveness of new and established therapies and organisational practices, and of relevant developments in education.

Self-efficacy has been found to be a significant factor in training on life-support courses which promotes perseverance in both practice and learning, is probably a determinant of transfer and may correlate with overall resuscitation competency.[19] As such it deserves the specific attention of those involved in life-support courses. Self-efficacy for specific tasks can be easily measured and course organisers should consider doing this as it may well be as important to clinical practice as measuring factual knowledge, practical skills and competencies.

Training needs vary among individuals and refresher courses might be made more appropriate to individual participants if systematic pre-testing in base-hospitals were introduced as a needs analysis tool.[23] This would allow the course to focus on the real deficiencies, increase learner autonomy and conceivably further improve the learning outcome. It is known that basic-life-support skills are widely deficient in many doctors and those identified as most deficient deserve the most attention. Life-support courses should also concentrate on those skills which can be learned in the limited time available, particularly those skills which also potentially contribute most to patient outcome, such as use of the intraosseous device and automatic external defibrillator.

Many life-support courses tend to concentrate on training the individual, just as conservatoria have tended to concentrate on training soloists. However, music and emergency medicine are more often team activities. Training in a team introduces new and important aspects of clinical competence such as leadership, dealing with conflict and group dynamics. These are important issues in clinical practice but not always addressed during life-support courses. The introduction of more team exercises into the courses could change this.

Instructors for life-support courses are generally selected from those participants who have done well on the course and have shown particular characteristics which are supposed to suggest suitability. The criteria used vary from course to course, but the selection is usually largely subjective.[74-76] Possession of a higher level of knowledge or skill than the minimum required for certification is not usually a selection criterion. Instructors often have equivalent practical expertise and experience to those they teach, and being an instructor on a life-support course may not guarantee improved retention of knowledge or skills.[49;77] This raises questions about the expert-status of instructors, although many may have extensive expertise in specific areas of it.

Although it can certainly be valid to use what is essential peer-teaching on life-support courses, the perceived status of the instructor can have implications for self-efficacy. In terms of self-efficacy, social persuasion in the form of feedback is most effective if it comes from a respected and creditable source.[11] An instructor who is seen as a great expert has the potential to increase self-efficacy more than one who has equivalent knowledge and experience to the learner. Life-support courses should consider whether peer-teaching or teaching by experts or a mix of these two is the best method of achieving their aims.

In contrast to social persuasion, vicarious experience appears to have the most effect on self-efficacy if the performer is of approximately equal status to the learner.[11] Thus trainees are likely to gain most from watching other trainees perform, while the self-efficacy of specialists' may be reduced by watching a trainee achieve a level of performance which they themselves have not attained. Course organisers should consider this aspect when assigning participants from different backgrounds to courses or to groups within courses.

In terms of self-efficacy it is too early to make a recommendation for the "no-death rule". Although allowing the simulated patient to die does appear to have a negative effect on self-efficacy, the possibly negative effects of allowing the patient to survive inadequate treatment unrealistically still need to be explored.

Unanswered questions and directions for future research.

The model presented in figure 8.3 is incomplete. Although this thesis has generated some additional evidence for a number of the relationships shown, the effect of the reaction to a life-support course on the organisation of patient care remains unproven. Chapter two presents a number of incidental findings that suggest such an effect, but this relationship does not seem to have been directly explored.[14;78] One difficulty in this respect is how to isolate the effect of the participant's reaction to the course from that of learning. For instance, if after following a course a doctor ensures that all the necessary resuscitation equipment is immediately available in his or her department, is this an effect of their reaction to the course, a response to advice to do so given on the course, or a case of attitude learning?

Other useful additions to the model would be the demonstration of the effect of life-support courses on attitudes other than self-efficacy and their relationship with effects at higher levels of the pyramid, and the investigation of other methods of improving retention following life-support courses. At the same time continuing efforts should be made to assess the clinical impact of life-support courses. It is almost axiomatic to state that in the design phase of a new life-support course, or any other educational intervention, attention should be given to its evaluation.[79] Unfortunately, rarely on the introduction of a new course into the Netherlands has a baseline measurement been made which might subsequently help to assess its clinical impact.

As far as the study of self-efficacy in relation to emergency medicine is concerned, this thesis raises several important questions which need to be investigated. Self-efficacy deserves to be studied in greater depth outside the context of life-support courses and, in particular, in clinical practice. As discussed above, the influence of positive or negative events during a real resuscitation might have repercussions for the doctor's subsequent performance. It is unproven whether the negative effect of death on self-efficacy found in a simulated environment also applies to clinical practice, and if so, whether this always a temporary and easily remedial phenomenon or a more persistent problem with significant consequences. At a less dramatic level, in learning resuscitation and other procedures in clinical practice, the effect of mastery experiences on the doctor's self-efficacy needs to be studied.

Studies of this kind require a reliable and valid measurement instrument and the visual analogue scale may be useful here, but needs to be better validated in individuals over longer periods of time. A validation study of this kind might be difficult to accomplish as it will be necessary to take into account the many frequently encountered factors which can potentially alter self-efficacy.

Hospital medicine generally, and emergency medicine in particular, are team activities. The research presented in this thesis has focused on the individual working in isolation. Thus important factors which influence self-efficacy, especially social persuasion and vicarious experience, were not addressed, and need to be in subsequent studies. Such research should initially be aimed at establishing the clinical relevance of self-efficacy. Subsequently, if this is found to be significant, further research should be aimed at the factors which can influence it. This should include consideration of self-efficacy in all its dimensions.

Within the context of life-support courses there remain a number of unanswered questions: What is the time course of the changes in self-efficacy after a life-support course? How does feedback and vicarious experience affect self-efficacy? Are there better ways to provide feedback than the almost universal Pendleton-rules?[80;81] Is the status of the person giving the feedback important? Is it reasonable to allow a simulated patient to "survive" treatment which would invariably be fatal in practice? Is it always desirable to reduce stress among the participants, or is a certain degree of stress during a simulation, which mimics the real-world setting, beneficial?

The paradoxical finding that an increase in self-efficacy for resuscitation procedures increased their use in a simulated environment, but there was no evidence of this in clinical practice, raises the question of whether self-efficacy really does predict clinical behaviour or only behaviour during a simulation? If self-efficacy truly is a factor in transfer after life-support courses, is this also the case in other areas of medical education – especially in the learning of clinical and technical skills – and is there evidence of a threshold effect?

Aside from medical education, self-efficacy may play a role in determining whether a lay-bystander initiates resuscitation appropriately in advance of the arrival of professional help. More research into this area might reveal an important factor which can be beneficially manipulated with the potential to save numerous lives.

The final area of future research which arises from this thesis and which is of great interest to the author is the exploration of the learning environment and its relationship to learning and self-efficacy. The reciprocal triadic relationship at the heart of social cognitive theory is illustrated once more in figure 8.5. This thesis has addressed aspects of two of these elements – behaviour and personal factors, especially self-efficacy. Environmental factors which pertain during learning on life-support courses have been given little attention or deliberately controlled. In fact, the literature search for chapter two revealed no research at all in the area of the learning environment of life-support courses, despite there being increasing general interest in the learning environment at both undergraduate and postgraduate level.[82-90]

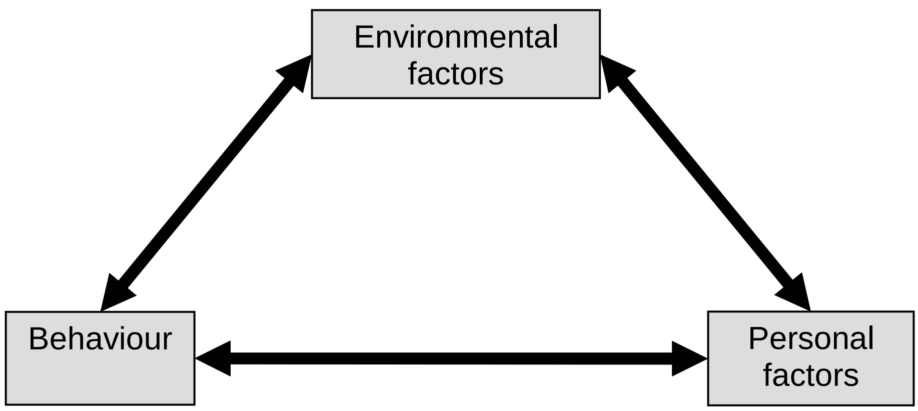

Figure 8.5: *The triadic reciprocal relationship between the individual, behaviour and the environment*

The investigation of the learning environment should begin with a description of the object under study, possibly involving a definition and a method of registering changes or, better still, of measuring some aspect(s) of it. Unfortunately, a clear definition of the learning environment is elusive, but instruments have been developed to measure it in various educational contexts.[85;86;91-95] It should therefore be possible to devise an instrument to measure the learning environment of a life-support course, and the author is involved in a project do this. Important research questions to be addressed with this instrument are: To what extent is the learning environment a factor in the effect of life-support courses at all levels of Kirkpatrick's hierarchy? If such a positive effect exists, what are the factors which most crucially distinguish a good from a bad environment in terms of the effects of the course, and how can these be usefully manipulated? How does the learning environment relate to the real-world environment pertaining during an emergency situation in clinical practice?

Research into the learning environment of life-support courses will hopefully shed some light on these areas and also increase our knowledge of the role of self-efficacy in emergency medicine.

General conclusions

The most clinically relevant conclusion to this thesis is neither optimistic nor new - doctors are not good at resuscitation. In particular, doctors are known to be poor first-responders who generally have inadequate basic-life-support skills and this has been described frequently.[1-3;6;7;96] The research presented here provides further evidence for this sad state of affairs. However, as training has been shown to improve the outcome of resuscitation, this thesis might be able to make a modest contribution to improving outcome.[97]

Another major conclusion of this thesis is that self-efficacy is an important aspect of training in emergency medicine which can be usefully modified by life-support courses in ways which might improve clinical competence. Although many of the teaching and learning methods employed on life-support courses are likely to positively influence self-efficacy, this effect has up to the present largely been an unconscious one. None of the life-support courses mentioned in chapter two refers to self-efficacy in its learner- or instructor material, nor is self-efficacy mentioned in any of the published descriptions of these courses, nor in the latest international guidelines on resuscitation and on resuscitation-training from the European Resuscitation Council.[74-76;98-103] The scarce research into self-efficacy and emergency medicine which does exist has been done by behavioural scientists.[64]

It is concluded that self-efficacy deserves more attention in (re-)

> *formulating the learning objectives of life-support courses. Those involved in the provision of such courses, particularly clinician-instructors and educationalists, ought to familiarise themselves with the construct of self-efficacy.*

Attrition of knowledge following training is a great problem in emergency medicine. The study presented in chapter seven suggests one way to improve retention using spaced testing. Spaced testing appears to be particularly good at improving retention of factual knowledge, but might have a less noticeable effect on problem-solving ability. Although the method used in the study was labour-intensive, spaced testing could be employed on a self-study basis using the supplementary internet resources to life-support courses which already exist.[104]

> *It is concluded that the issue of retention should receive more attention during life-support courses, and methods to improve it should be introduced into the course and the period following it. Learning aims and objectives should be (re-)formulated to include an element of retention.*

Life-support courses are good at improving both doctors' conceptual knowledge and their ability to lead a simulated resuscitation with a fair degree of retention. They are however less good at teaching them factual knowledge and complex skills. This dissonance between global ability and performance on specific, vital tasks (which are often delegated to other members of the health-care team) emerged from the three studies described in chapters five, six and seven, and has also been reported earlier.[39;40;105] Life support courses are too short to be reasonably expected to be appropriate settings to learn complex skills such as endotracheal intubation. Such skills are better learned through deliberate practice over longer periods.[18;62]

> *It is concluded that life-support courses should be seen as only one link in a "chain of learning" in emergency medicine. Follow-up in the workplace is necessary in order to maximize retention, facilitate transfer and encourage future learning. Trainers at base hospitals and organisers of life-support courses should work together to facilitate this.*

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Appendices

Appendix A: Questionnaires used in the validation study of the visual analogue scale (chapter 3)

Onderdeel A

Geef uw zelfvertrouwen op dit moment aan door een verticaal streepje op onderstaande balk te zetten voor wat betreft:

1) kinderreanimatie in het algemeen
2) hartmassage bij kinderen
3) kapbeademing bij kinderen
4) inbrengen van een intraossale naald bij kinderen.
5) omgaan met de computer

VOORBEELD

totaal geen vertrouwen — extreem veel vertrouwen

1. Kinderreanimatie in het algemeen

totaal geen vertrouwen — extreem veel vertrouwen

2. Hartmassage bij kinderen

totaal geen vertrouwen — extreem veel vertrouwen

3. Kapbeademing bij kinderen

totaal geen vertrouwen — extreem veel vertrouwen

4. Inbrengen van een intraossale naald (botnaald) bij kinderen

totaal geen vertrouwen — extreem veel vertrouwen

5. Omgaan met de computer

totaal geen vertrouwen — extreem veel vertrouwen

Onderdeel B

U wordt nu gevraagd om in het lege vakje rechts van iedere vraag in een getal van 0-100 aan te geven in hoeverre u tot de betreffende handeling in staat bent. Gebruik hierbij onderstaande schaal.

Het gaat bij alle vragen om uw eigen inschatting van uw vaardigheden in het geval dat u *op dit moment* met een ernstig ziek of zwaargewond kind geconfronteerd wordt.

0 10 20 30 40 50 60 70 80 90 100

kan ik zeker niet **kan ik zeker wel**

VOORBEELD	
1. Ik kan een gewicht van 40 kg optillen.	55

Kinderreanimatie in het algemeen	
1. Ik kan normale van afwijkende vitale parameters bij een ernstig ziek kind onderscheiden	
2. Ik kan de vroege verschijnselen van respiratoire insufficiëntie bij een kind herkennen	
3. Ik kan een intraveneus infuus inbrengen bij een *zuigeling*	
4. Ik kan een intraveneus infuus inbrengen bij een *peuter*	
5. Ik kan een intraveneus infuus inbrengen bij een *kind van 9 jaar*	
6. Ik kan een kind met hypovolemische shock behandelen	
7. Ik kan de Glasgow Coma Score van een kind bepalen	
8. Ik kan de APGAR-score van een pasgeborene bepalen	
9. Ik kan een pasgeborene reanimeren	
10. Ik kan ventrikelfibrilleren bij een kind behandelen	
11. Ik kan een kind intuberen	

Hartmassage bij kinderen	
1. Ik kan onmiddellijk herkennen wanneer hartmassage nodig is bij een *pasgeborene*	
2. Ik kan onmiddellijk herkennen wanneer hartmassage nodig is bij *een kind van 9 jaar*	
3. Ik kan hartmassage met de juiste frequentie geven bij een *pasgeborene*	
4. Ik kan hartmassage met de juiste frequentie geven bij een *kind van 9 jaar*	
5. Ik kan mijn handen op precies de juiste plaats voor hartmassage plaatsen bij een *pasgeborene*	
6. Ik kan mijn handen op precies de juiste plaats voor hartmassage plaatsen bij een *kind van 9 jaar*	
7. Ik kan de thorax tot de optimale diepte voor hartmassage indrukken bij een *pasgeborene*	
8. Ik kan de thorax tot de optimale diepte voor hartmassage indrukken bij een *kind van 9 jaar*	
9. Ik kan hartmassage perfect coördineren met ventilatie als iemand anders het kind beademt	
10. Ik kan hartmassage perfect coördineren met ventilatie als ik alleen ben	
11. Ik kan optimale hartmassage bij een kind volhouden gedurende minstens *10 minuten*	
12. Ik kan optimale hartmassage bij een kind volhouden gedurende minstens *20 minuten*	
13. Ik kan mij blijven concentreren op hartmassage ondanks afleidingen rondom het bed	
14. Ik kan adequate hartmassage geven bij een kind dat neervalt op straat	
15. Ik kan beoordelen of de hartmassage effectief is	

Kapbeademing (masker- en ballonbeademing) bij kinderen	
1. Ik kan de optimale maat kapje (gezichtsmasker) kiezen	
2. Ik kan het hoofd van het kind precies in de juiste positie voor kapbeademing houden	
3. Ik kan de zuurstof op de juiste manier aansluiten	
4. Ik kan de luchtweg tijdens kapbeademing met één hand vrijhouden bij een *pasgeborene*	
5. Ik kan de luchtweg tijdens kapbeademing met één hand vrijhouden bij een *kind van 9 jaar*	
6. Ik kan het kapje (gezichtsmasker) zonder dat het lekt op het gezicht houden bij een *pasgeborene*	
7. Ik kan het kapje (gezichtsmasker) zonder dat het lekt op het gezicht houden bij een *kind van 9 jaar*	
8. Ik kan een pasgeborene met de optimale frequentie en teugvolume op de kap beademen	
9. Ik kan een kind van 9 jaar met de optimale frequentie en teugvolume op de kap beademen	
10. Ik kan zonder moeite beoordelen of de kapbeademing adequaat is bij een *pasgeborene*	
11. Ik kan zonder moeite beoordelen of de kapbeademing adequaat is bij een *kind van 9 jaar*	
12. Ik kan kapbeademing optimaal coördineren met gelijktijdige hartmassage, als iemand anders masseert	
13. Ik kan kapbeademing coördineren met de eigen ademhaling van een kind dat deels spontaan ademt	

Inbrengen van een botnaald (intraossale naald) bij kinderen	
1. Ik kan de optimale plaats voor het inbrengen van een botnaald identificeren	
2. Ik kan een botnaald inbrengen bij een *kind van 1 jaar*	
3. Ik kan een botnaald inbrengen bij een *kind van 5 jaar*	
4. Ik kan een botnaald inbrengen bij een *kind van 12 jaar*	
5. Ik kan beoordelen of de botnaald goed zit	
6. Ik kan de botnaald tot de optimale diepte inbrengen	
7. Ik kan een botnaald bij een dik kind inbrengen	
8. Ik kan een botnaald inbrengen als dit met uiterste spoed moet	
9. Ik kan een botnaald inbrengen ondanks vele afleidingen rondom het bed	
10. Ik kan een botnaald bij een kind bij bewustzijn inbrengen als ik er een indicatie voor zie	
11. Ik kan een botnaald inbrengen als ik de enige in het team ben, die er een indicatie voor ziet	

Omgaan met een computer	
1. Ik kan voor problemen met de computer meestal zelf een oplossing vinden	
2. Ik kan meestal begrijpen waarom een software programma wel of niet werkt op de computer	
3. Ik kan de termen begrijpen en hanteren die gebruikt worden bij de computer hardware	
4. Ik kan de termen begrijpen en hanteren die gebruikt worden bij de computer software	
5. Ik kan een grafiek maken in Excel	
6. Ik kan een chi-kwadraat test uitvoeren met Excel	
7. Ik kan een foto bewerken op de computer	
8. Ik kan een video monteren op de computer	
9. Ik kan de functie 'wijzigingen bijhouden' in Word gebruiken	
10. Ik kan de computer gebruiken om informatie te ordenen	
11. Ik kan de computer gebruiken om numerieke data te analyseren	

Onderdeel C

Achtergrondinformatie

1. **In welk ziekenhuis werkt u?**

   UMC Utrecht / UMC St Radboud Nijmegen*

2. **Wat is uw beroep?**

   Intensive Care verpleegkundige / arts*

3. **Indien u arts bent, wat is uw (moeder)specialisme?**

   Kindergeneeskunde / Anesthesiologie / overige nl.:……………………………………… *

4. **Indien u arts bent, bent u in opleiding of gespecialiseerd?**

   In opleiding / Gespecialiseerd*

* doorhalen wat niet van toepassing is

Dit is het einde van de vragenlijst
Dank u voor uw medewerking

Appendix B: Penalty scoring system for OSCEs of chest compressions and bag and mask ventilation referred to in chapters 5 and 6

Chest compressions

Modified Berden score

We scored competence using a penalty scale based on that of Berden and modified to take account of the ERC 2005 recommendations for paediatric external chest compressions. The modified Berden score is the sum of the paediatric penalty points for each of the following components:

Components	Berden original	Berden score	Paediatric modification	Paediatric score
ECC Hand-position	Correct	0	Correct	0
3 independent observers	Incorrect	5	Incorrect	5
Compression frequency (/min). Berden was based on a recommended frequency of 80-100. ERC 2005 = 100.	>140	15	>150	15
	>120 ≤140	10	>130 ≤150	10
	>100 ≤120	5	>110 ≤130	5
	≥ 80 ≤100	0	≥ 90 ≤110	0
	≥ 60 < 80	10	≥ 70 < 90	10
	≥ 40 < 60	15	≥ 50 < 70	15
	< 40	20	< 50	20
Impression depth (mm)	> 60	10	> 60	10
Based on one third of the thorax depth of the mannequin (4,83 cm) this being mid-range of the Berden scale.	> 51 ≤ 60	5	> 51 ≤ 60	5
	≥ 38 ≤ 51	0	≥ 38 ≤ 51	0
	≥ 30 < 38	5	≥ 30 < 38	5
	≥ 22 < 30	10	≥ 22 < 30	10
	< 22	20	<22	20
Compression / relaxation ratio expressed as duty cycle. Otherwise unmodified	**C/R ratio**		**Duty cycle**	
	>1,4	10	>58%	10
	≥0.6 ≤ 1.4	0	≥38% ≤ 58%	0
	<0.6	10	<38%	10
Release (% > 5mm compression during the relaxation phase).	Not part of the original Berden score		< 10%	0
			> 10%	5

Bag and mask ventilation

The height (103,5cm) and body proportions of the mannequin corresponded to a child of 3,75 years, with an estimated weight of 16,5 kg according to the third Dutch growth survey. Based on the advice of standard anaesthesia textbooks[27;28] we considered a tidal volume of 7ml/kg = 115 ml and a respiratory frequency of 22/min to be ideal for this mannequin. We scored the airway-pressure as the percentage of inflations which were less than 35 cm H_2O, this being the minimum oesophageal opening pressure in adults and stillborn babies.[29;30]

We were unable to find a validated scoring system for bag and mask ventilation and we therefore derived the ventilation penalty score as the sum of the penalty points for the following components:

Component	Value	Penalty points
Ventilation rate (/min)	≥40	20
	≥30 <40	10
	≥16 <30	0
	≥10 <16	10
	<10	20
Expired volume (ml)	≥250	15
	≥200 <250	10
	≥140 <200	5
	≥ 90 <140	0
	≥ 65 < 90	10
	< 65	20
Airway pressure (%)	≥ 95 – 100	0
	≥ 90 < 95	5
	≥ 85 < 80	10
	≤ 80	20

Test questions used in the study of the testing-effect on retention in chapter 7

DEEL 1
Beschikbare tijd: 5 minuten

1. Wat zijn de onmiddellijk levensbedreigende thoraxletsels die bij alle zwaargewonden kinderen dienen te worden uitgesloten?
2. Wat zijn de drie belangrijkskte **algemene** symptomen van een levensbedreigend thoraxletsel bij kinderen?

DEEL 2

Beschikbare tijd: 10 minuten

3. Een kind van 8 jaar wordt opgenomen op de SEH na een auto-ongeval. Zij is grauw, zweterig en verward. De bovenste luchtweg is open. Zij ademt 80 keer per minuut met een klein teugvolume. De linker thoraxhelft komt niet goed omhoog met de ademhaling. Aan de linkerkant van de thorax is de percussietonus dof en is het ademgeruis verminderd. De trachea is centraal. De hartfrequentie is 140/min, de bloeddruk 70/40 en de capillary refill 4 seconden.

   a) Welk thoraxletsel heeft dit kind waarschijnlijk?

   b) Wat zijn de drie belangrijkste aspecten van de behandeling?

4. Een kind van 4 jaar wordt opgenomen met een trauma capitis na een val van 10 meter. Zij is door de ambulanceverpleegkundige reeds geïntubeerd en beademd. Na enkele minuten daalt de zuurstofsaturatie tot 82% ondanks toediening van 100% zuurstof. De rechter thoraxhelft lijkt minder te bewegen dan de linker maar is goed geëxpandeerd. Aan de rechterkant is het ademgruis verminderd en de percussietonus hypersonoor. De trachea is iets verplaatst naar links.

   a) Welk thoraxletsel heeft dit kind waarschijnlijk?

   b) Wat zijn de drie belangrijkste aspecten van de behandeling

5. Een 14-jarige jongen wordt opgevangen na een vechtpartij waarbij hij een messteek in de linker thoraxhelft zou hebben opgelopen. Hij ziet bleek, heeft ernstige pijn en zwaar bemoeilijkte ademhaling. Het ademgeruis aan de linker thorax helft is minimaal, de percussietonus is hypersonoor. Er is een 3 cm steekwond in vierde intercostale ruimte in de voorste axillaire lijn, die nauwelijks bloedt maar borrelt met de ademhaling. De trachea is centraal. Hartfrequentie is 140/min, de bloeddruk 70/40 en de capillaire refill 4 seconden.

   a) Welk thoraxletsel heeft dit kind waarschijnlijk?

   b) Wat zijn de drie belangrijkste aspecten van de behandeling

6. Een kind van 6 jaar is geschept door een auto en klaagt over ernstige pijn rechts in de thorax en benauwdheid. Rechts-anterolateraal is een grote kneuzing. Het kind heeft een zuurstofsaturatie van 89% in air. Als u het aangedane gebied onderzoekt leidt dit tot ernstige pijn en u voelt de ribben "meegeven" met palpatie. Het aangedane gebied beweegt abnormaal bij de ademhaling.

   a) Welk thoraxletsel heeft dit kind waarschijnlijk?

   b) Wat zijn de drie belangrijkste aspecten van de behandeling

7. Een kind van 8 jaar wordt op de intensive care wegens astma beademd. Plotseling daalt de zuurstofsaturatie van 100% naar 88% en blijft verder dalen. De bloeddruk daalt van 90/45 tot 30/0. De hartfrequentie stijgt van 100/min naar 180/min. De rechter thoraxhelft beweegt minder dan de linker. Ademgeruis is minder aan de rechterkant en de percussietonus is aldaar hypersonoor.

   a) Welk thoraxletsel heeft dit kind waarschijnlijk?

   b) Wat zijn de drie belangrijkste aspecten van de behandeling

DEEL 3

Beschikbare tijd: 15 minuten

8. Wat zijn de symptomen van een spanningspneumothorax?
9. Wat is de specifieke behandeling van een spanningspneumothorax?
10. Beschrijf in 2 a 3 regels hoe de behandeling van de vorige vraag wordt uitgevoerd.
11. Wat zijn de symptomen van een massale hemopneumothorax?
12. Wat is de specifieke behandeling van een massale hemopneumothorax?
13. Wat zijn de symptomen van een open pneumothorax?
14. Wat is de specifieke behandeling van een open pneumothorax?
15. Hoe moet de wond van een open pneumothorax in eerste instantie worden afgeplakt?
16. Wat zijn de symptomen van een fladderthorax?
17. Wat is de behandeling van een fladderthorax?
18. Wat zijn de symptomen van een harttamponade?
19. Wat is de specifieke spoedeisende behandeling van een harttamponade op de afdeling spoedeisende hulp?
20. Beschrijf 2 a 3 regels hoe de behandeling van de vorige vraag wordt uitgevoerd.

Summary in plain English

Nederlandse samenvatting voor niet-ingewijden

Dankwoord

Curriculum vitae

Summary in plain English

Doctors are generally unacceptably poor at resuscitation and this has been shown to lead to unnecessary mortality. This problem has led to the development of structured resuscitation training in the form of life-support courses, which have become very popular and are widely advocated, but which are expensive in time and money. This thesis looks at some of the mechanisms by which life-support courses can be effective, focusing primarily on the issues of self-efficacy and retention

Ultimately life-support courses should improve patient outcome. A model of the mechanism by which this can occur is presented. Both knowledge in the widest sense and attitudes need to be positively influenced in order for transfer of new learning to clinical practice to occur. Only then can patient outcome be influenced by improvements in patient care or its organisation.

Self-efficacy is a psychological construct which refers to a person's belief in their ability to deal with situations effectively and is believed to be of importance in fostering transfer. The effect of self-efficacy on transfer was explored studies of doctors using paediatric resuscitation knowledge and skills. An instrument to measure self-efficacy in this context was developed and validated. It was found that the Advanced Paediatric Life Support (APLS) course has a significant effect on self-efficacy in relation to paediatric resuscitation tasks, but that this did not lead to an overall increase in use of the relevant skills, which may have been related to lack of opportunity to use them. However, when doctors were presented with such an opportunity during a simulation, a clear relationship between self-efficacy and skill-use emerged.

During the above mentioned studies it was again confirmed that that doctors are generally poor at resuscitation. However, those who had followed the APLS generally performed better, although this does not prove a causal relationship between the APLS and clinical competence.

In a separate study, testing at intervals was found to have a positive effect on retention following a life-support course in a group of students who had followed a life-support course. Such *spaced testing* appears to be particularly good at improving retention of factual knowledge, but might have a less noticeable effect on problem-solving ability, possibly because this is better retained anyway.

Although it is uncertain whether performance of many emergency interventions is significantly influenced by the extent of a doctor's factual knowledge, the problem of attrition of knowledge following training is real. It is concluded that retention should receive more attention during and following life-support courses, starting with the reformulation of learning objectives to include an element of retention.

The major conclusion of this thesis is that self-efficacy is an important aspect of training in emergency medicine which can be usefully modified by life-support courses in ways which might improve clinical competence. Most life-support courses employ teaching methods which can improve self-efficacy, but hitherto these have been employed in an uncontrolled and largely unconscious fashion. Self-efficacy deserves more attention in (re-)formulating the learning objectives of life-support courses. These objectives should also be formulated to include an element of retention.

Nederlandse samenvatting voor niet-ingewijden

Artsen kunnen in het algemeen minder goed reanimeren dan het publiek van hen zou verwachten, en het is waarschijnlijk dat dit tot onnodige sterfte leidt. Als reactie op dit probleem zijn in de afgelopen decennia in Nederland zogenaamde life-support cursussen ontwikkeld – korte bijscholingen op gebied van reanimatie en spoedeisende geneeskunde voor artsen en overige professionals in de gezondheidszorg. De Advanced Paediatric Life-Support (APLS) cursus is hier een voorbeeld van. Deze cursussen vereisen een aanzienlijke investering van tijd en geld. In dit proefschrift is onderzocht hoe life-support cursussen voor artsen effectiever kunnen worden.

Uiteindelijk zouden life-support cursussen ervoor moeten zorgen dat sterfte en blijvende ziekte na een acute, ernstige ziekte afnemen. Dit effect kan slechts indirect optreden, door gedragsveranderingen bij de artsen. Gedragsverandering, bij voorbeeld het gebruik van een nieuwe techniek, kan alleen plaatsvinden indien de arts de benodigde kennis en vaardigheden opdoet, de juiste attitude heeft en de nieuwe procedure durft uit te voeren. Men spreekt van *transfer* wanneer een nieuw geleerde techniek daadwerkelijk in de praktijk wordt uitgevoerd.

Een essentieel element in bovengenoemd proces is “durven”. Psychologisch, heeft het concept van *zelf-effectiviteit* een belangrijke rol in het durven uitvoeren van een handeling. Zelf-effectiviteit slaat erop hoe goed een persoon gelooft dat hij/zij in staat is om een bepaalde situatie effectief aan te pakken. Een persoon met een hogere zelf-effectiviteit zou een bepaalde situatie of handeling waarschijnlijker aanpakken dan iemand met een lagere zelf-effectiviteit voor de betreffende handeling of situatie.

Het effect van zelf-effectiviteit op transfer werd in dit proefschrift bij kinderartsen en anesthesiologen onderzocht. Ten eerste werd een meetinstrument voor zelf-effectivitiet ontwikkeld en op betrouwbaarheid gecontroleerd. Vervolgens werd in een vragenlijstonderzoek bewezen dat de APLS-cursus tot een meetbare toename van zelf-effectiviteit leidt. Er waren echter geen aanwijzingen dat de cursus leidde tot toename van de frequentie waarmee de technieken, die bij de cursus werden geleerd, in de praktijk uitgevoerd werden. Mogelijk had dit te maken met het feit dat er bij deze groep weinig gelegenheid was om deze technieken uit te voeren.

Echter, toen artsen bij een gesimuleerde reanimatie wel in de gelegenheid werden gesteld om de technieken te verrichten, was een duidelijk verband tussen zelf-effectiviteit en gedrag te zien.

Helaas werd tijdens dit onderzoek wederom bewezen dat artsen slecht kunnen reanimeren. Het goede nieuws is dat degenen die de APLS-cursus hadden gevolgd, in het algemeen beter waren, alhoewel deze bevinding op zichzelf onvoldoende bewijzend is voor een positief effect van de cursus.

Het andere thema van dit proefschrift is retentie van kennis na een life-support cursus. Het kunnen onthouden (retentie) van de juiste procedures, is van levensbelang in reanimatie. Er is vaak in deze situatie geen tijd om iets op te zoeken en weinig bedenktijd. Helaas blijkt dat retentie na een life-support cursus vrij beperkt is. Het laatste onderzoek van dit proefschrift was een studie naar het effect van toetsen op retentie. Toetsen na een leerervaring kan het onthouden van de leerstof bevorderen, zonder dat er verder gestudeerd wordt. Dit heet het "testing effect", en blijkt te berusten op het feit dat het toetsen het individu dwingt tot herbeschouwen van de stof waardoor het beter in het geheugen wordt opgeslagen.

In de laatste studie van het proefschrift vertoonden studenten geneeskunde een betere retentie na een life-support cursus indien er na de cursus viermaal een korte mondelinge, telefonische toets over een periode van twee maanden werden afgenomen. Interessant was de bevinding dat alhoewel de toets uit praktijkgerichte vragen bestond, de studenten de theoretische kennis beter onthielden, terwijl er geen effect bleek te zijn op de retentie van de praktijkgeoriënteerde leerstof.

De twee hoofdconclusies van dit proefschrift zijn: dat zelf-effectiviteit een belangrijk en beïnvloedbaar element van leren bij life-support cursussen is, dat meer aandacht van cursusorganisatoren verdient; en, dat intervaltoetsen een mogelijke techniek is om retentie na een life-support cursus te verbeteren.

Dankwoord

Writing a PhD thesis is a team effort. There may be only one name on the cover, but the thesis is the product of the labours of dozens of people, most of whom (I hope!) are mentioned in these paragraphs.

To begin in English. I am grateful to my friends from the Advanced Life Support Group UK and the ALSG International Paediatric Working Group for their indirect support and motivation to carry out this research. In particular I would mention Sue Wieteska and Barbara Phillips who were so helpful in the early years of the Dutch APLS and who have continued their support ever since. Also to Jonathan Wyllie who (almost certainly unconsciously) set me on the path of exploring self-efficacy in connection with life-support courses.

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Curriculum vitae

Nigel Turner was born at the end of the 1950's in southeast England. Although you wouldn't know the former to look at him, you would know the latter to hear him speak Dutch. He attended Brentwood School, which gave him a wide general knowledge-base and a love of things intellectual (and a life-long aversion to sport and hierarchical nonsense). He studied at Leeds University which gave him a wide knowledge of medicine (now out-dated and long forgotten) and an interest in Anaesthesiology. After completing basic training in Anaesthesiology and Intensive Care Medicine in Sheffield, in the department of Professor Walter Nimmo, and working for a short while in Accident and Emergency Medicine, he worked as fellow in the Surgical and Thoracic Intensive Care Units and in Cardiac Anaesthesia at the University Hospital Groningen in Netherlands (heads of department: Dr Dinis Reis-Miranda and Professor Pim Hennis) where he fell in love with the country and some of its inhabitants. He returned to the UK to complete Senior Registrar training in Birmingham under the avuncular supervision of Professor Peter Hutton.

Since 1994 he has been proud to work in Utrecht (head of department: Professor Hans Knape) and after having worked in 24 different hospitals since graduation still regularly admits that the Wilhelmina Children's Hospital is the best! He is currently primarily involved in paediatric cardiac anaesthesia and intensive care.

In 1996 he was one of the founders of the Dutch Foundation for the Emergency Medical Care of Children (Stichting SHK) and was closely involved in the introduction of the Advanced Paediatric Life Support and similar courses into the Netherlands. This generated a deep interest in Medical Education leading amongst other things to this thesis, under the (con)genial supervision of Professor Olle ten Cate, and doing a Master's degree in Medical Education at the University of Dundee (head of department: Professor Margery Davis).

He is particularly interested in the educational aspects of emergency medicine and is a member of the Scientific Committee of the Dutch Resuscitation Council, the International Paediatric Working Group of the Advanced Life Support Group and several other similar national and international *ad hoc* committees. He has contributed to several textbooks on emergency medicine, including two internationally acclaimed standard works.

Outside emergency medicine he has acted as educational advisor to several educational projects, most notably the WOKK-course on the recognition and management of child abuse for paediatricians.

Since 2001 he has been actively involved in the Federation of European Associations of Paediatric Anaesthesia, initially as Dutch representative and more latterly as a member of the executive committee, and hopes to be equally supportive to the forthcoming European Society of Paediatric Anaesthesia.

He lives with Sibylle and Linda in *hartje Amsterdam*, where he is also intermittently assistant teacher of English at the *Kleine Reus* Primary School.