REVIEW ARTICLE

Understanding and improving low bystander CPR rates: a systematic review of the literature

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ABSTRACT

Objectives: Cardiopulmonary resuscitation (CPR) is a crucial yet weak link in the chain of survival for out-of-hospital cardiac arrest. We sought to understand the determinants of bystander CPR and the factors associated with successful training.

Methods: For this systematic review, we searched 11 electronic databases, 1 trial registry and 9 scientific websites. We performed hand searches and contacted 6 content experts. We reviewed without restriction all communications pertaining to who should learn CPR, what should be taught, when to repeat training, where to give CPR instructions and why people lack the motivation to learn and perform CPR. We used standardized forms to review papers for inclusion, quality and data extraction. We grouped publications by category and classified recommendations using a standardized classification system that was based on level of evidence.

Results: We reviewed 2409 articles and selected 411 for complete evaluation. We included 252 of the 411 papers in this systematic review. Differences in their study design precluded a meta-analysis. We classified 22 recommendations; those with the highest scores were 1) 9-1-1 dispatch-assisted CPR instructions, 2) teaching CPR to family members of cardiac patients, 3) Braslow's self-training video, 4) maximizing time spent using manikins and 5) teaching the concepts of ambiguity and diffusion of responsibility. Recommendations not supported by evidence include mass training events, pulse taking prior to CPR by laymen and CPR using chest compressions alone.

Conclusion: We evaluated and classified the potential impact of interventions that have been proposed to improve bystander CPR rates. Our results may help communities design interventions to improve their bystander CPR rates.

RÉSUMÉ

Key words: cardiac arrest, systematic review, cardiopulmonary resuscitation

Objectifs : La réanimation cardio-respiratoire (RCR) est un maillon essentiel, quoique faible, de la chaîne de survie lors de la survenue d'un arrêt cardiaque hors de l'hôpital. Nous avons cherché à comprendre les déterminants du taux de passants pouvant administrer la RCR et les facteurs liés à une formation efficace.

Méthodes : Dans le cadre de cette revue systématique, nous avons analysé 11 bases de données électroniques, un registre d'essais cliniques et neuf sites Web scientifiques. Nous avons réalisé des recherches manuelles et communiqué avec six experts du contenu. Nous avons examiné sans restriction toutes les communications portant sur les questions suivantes : qui devrait apprendre la RCR, ce qu'on devrait enseigner, QUAND la formation devrait être renouvelée, où les cours de

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RCR devraient être offerts et pourquoi les gens ne sont pas motivés à apprendre la RCR et à l'administrer. Nous avons utilisé des formulaires normalisés pour évaluer les articles selon des critères d'inclusion, de qualité et d'extraction de données. Nous avons regroupé les publications par catégorie et classé les recommandations selon un système de classification normalisé fondé sur le niveau de preuve.

Résultats : Nous avons examiné 2409 articles et évalué le texte intégral de 411 d'entre eux. Notre revue systématique a porté sur 252 de ces 411 articles. En raison de différences dans la conception des études, nous n'avons pu réaliser une méta-analyse. Parmi les 22 recommandations que nous avons classées, voici celles qui ont obtenu la marque la plus élevée : 1) instructions de RCR données par un répartiteur 9-1-1; 2) enseignement de la RCR aux membres de la famille de cardiaques; 3) utilisation de la bande vidéo d'autoformation de Braslow; 4) augmentation du temps de pratique sur des mannequins; 5) enseignement des concepts d'ambiguïté et de diffusion de la responsabilité. Les recommandations non étayées par des preuves portaient sur les activités de formation en masse, la prise du pouls par un non-spécialiste avant de commencer la RCR et l'administration de la RCR avec compressions thoraciques seulement.

Conclusion : Nous avons évalué et classé les diverses interventions proposées pour améliorer le taux de passants pouvant administrer la RCR ainsi que leur impact potentiel. Les résultats de l'étude aideront peut-être les collectivités à concevoir des modèles pour améliorer ce taux.

Introduction

Cardiac arrest is the leading cause of mortality in North America. The annual incidence of out-of-hospital cardiac arrest in the United States and Canada is estimated to be 55 per 100 000, resulting each year in more than 173 000 cardiac arrests.[1,2] Overall survival rate for out-of-hospital cardiac arrest rarely exceeds 5%.[1,2] Bystander cardiopulmonary resuscitation (CPR) is associated with increased survival: a victim is almost 4 times more likely to survive a cardiac arrest event when receiving CPR from a bystander.[3] Unfortunately, bystander CPR rates have remained low over the past decade, rarely exceeding 20%.[2,4]

Various attempts have been made in the past to improve bystander CPR rates, including

- the organization of mass CPR training events[5–10]
- CPR training of family members of patients suffering from heart disease[11–22]
- promotional CPR videos[19,23–25]
- CPR training of high school students.[24,26–29]

None of these initiatives have succeeded in significantly improving bystander CPR or survival rates for out-of-hospital cardiac arrest. CPR instructions through 9-1-1 dispatch assistance have been shown to increase bystander CPR rates,[30] but their benefit on cardiac arrest survival remains unknown. While some communities have been able to reach bystander CPR rates as high as 54%,[31,32] factors affecting these rates in the population are still unknown.

The objectives of this study were to systematically review the determinants of bystander CPR rates in the community, more specifically:

1. *Who* should be targeted to receive CPR training?
2. *What* CPR teaching program should be implemented to maximize understanding and retention?
3. *When* should maintenance of skills sessions occur?
4. *Where* should CPR instructions be given?
5. *Why* do people lack motivation to learn or perform CPR?

Methods

Study design, subjects and interventions

We systematically reviewed experimental and nonexperimental studies published on bystander CPR, including randomized controlled trials (RCTs), quasi-experiments, observational studies, literature reviews, editorials and letters. We included human participants of any age, sex, ethnic background, social status or geographical area. We excluded studies pertaining exclusively to the curriculum of health care professionals such as physicians, medical students, nurses and EMS personnel. We reviewed all educational tools applied at the individual, group or community level. These included computer software, media campaign, CPR instructions given over the phone and various CPR training curricula.

Outcome measures and search strategy

We evaluated various CPR promoting methods for their ability to:

1. Increase the proportion of CPR-trained individuals in the population.
2. Increase the bystander CPR rate for cardiac arrest victims.

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3. Increase survival from cardiac arrest as a result of an intervention promoting CPR training.

Our information sources are available at www.cjem-online.ca/v10/n1/p51. Our electronic search strategy had no restriction for year, language or status of publication, and it was reviewed by an information specialist (www.cjem-online.ca/v10/n1/p51). We searched 11 electronic databases using the OVID interface and included subject headings, truncation terms and text words in order to access databases that do not support the use of subject headings. We used an adapted electronic search strategy for the PubMed interface. We reviewed the Cochrane Controlled Trial Registry, hand searched the *Canadian Journal of Public Health* and the journal *Resuscitation*, reviewed the bibliography of emergency medicine textbooks (see www.cjem-online.ca/v10/n1/p51) and review articles, visited the websites of numerous scientific associations and contacted content experts in the field. Content specialists were selected based on their contribution to cardiac arrest research or for the recognized success of their respective communities in promoting bystander CPR, or both.

Selection and abstraction process

We imported the references into a bibliographical database library using Endnote version 7.0.0 (Thomson Scientific, Carlsbad, California). Duplicates were removed manually. We used titles and abstracts to make a first selection of references that met the study inclusion criteria. A reference was also selected if a decision could not easily be made from the title or abstract alone. Hard copies of the selected articles were obtained for further examination. One investigator (CV) reviewed the selected printed articles using standardized criteria to determine final eligibility in the systematic review. Studies were considered for meta-analysis if measures of spread were available or obtainable and if clinical homogeneity was present. A single reviewer (CV) performed data abstraction on all the selected articles using a standardized form. Data extraction included information on publication status, year, country and language of publication. Description of the study design, participant, intervention and outcomes was then extracted. The source of the data (i.e., text, table or graph) was also mentioned.

Methodologic quality of reports, data synthesis and assessment of retrieval bias

We evaluated the quality of RCTs using allocation concealment and the validated Jadad scoring system.[33] This system allocates points (out of a maximum of 5) for quality and description of randomization, blinding and dropouts. Case–control and cohort studies were evaluated using the validated Newcastle–Ottawa scales.[34–36] These scales allocate stars (out of a maximum of 9) for quality of selection, comparability, exposure and outcome of study participants. We grouped studies by topic and issued a "statement of evidence" for each topic. This statement of evidence is based on the scientific quality of the studies reviewed (Box 1) and the documented effect of the intervention on bystander CPR or cardiac arrest survival rates. We have calculated the recall and precision of our electronic search strategy. Recall is defined as the number of papers included in the systematic review found by the electronic search strategy divided by those found by the full search strategy; precision is defined as the number of papers included in the systematic review found by the electronic search strategy divided by all papers found by the electronic search strategy. Expected values for recall and precision are up to 90% and 20%, respectively.[37]

Results

We completed the search strategy in September 2005, and we identified 2408 potentially relevant papers. Using predetermined selection criteria, we rejected 1997 publications based on manuscript title and abstract. We used the same criteria to review full-text copies of the remaining 411 papers. Characteristics of the 159 publications rejected at this stage are presented in Figure 1. We were unable to locate 15 of the 159 rejected publications despite exhaustive research and librarian support.

Our systematic review includes 252 publications. Meta-analysis was not possible because of the lack of homogeneity.

Our electronic search strategy was successful in retrieving 77.8% of all papers included in the systematic review. This high recall rate was achieved at the cost of having to review a large number of publications not relevant to our topic (with a precision of 8.6%). With 22.2% of all publications included in the systematic review coming from a

Box 1. Classification of the statements of evidence made from the systematic review

Quality of the evidence

I-1	Meta-analysis
I-2	At least 1 good quality randomized controlled trial
II-1	Quasi-experiment of good quality
II-2	Cohort or case–control study
II-3	Case series, noncontrolled trial, or descriptive studies
III	Expert opinion

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source other than the electronic search, we are confident that a significant effort was made to find most of the information pertaining to our topic of interest.

Characteristics of the 252 papers that were included in our systematic review are presented in Table 1. Over 62% of the literature on CPR originates from the United States and is predominantly published in English. Most publications are hypothesis generating rather than hypothesis testing. Nearly 50% of the information comes from surveys or descriptive analysis. We came across 2 systematic reviews:

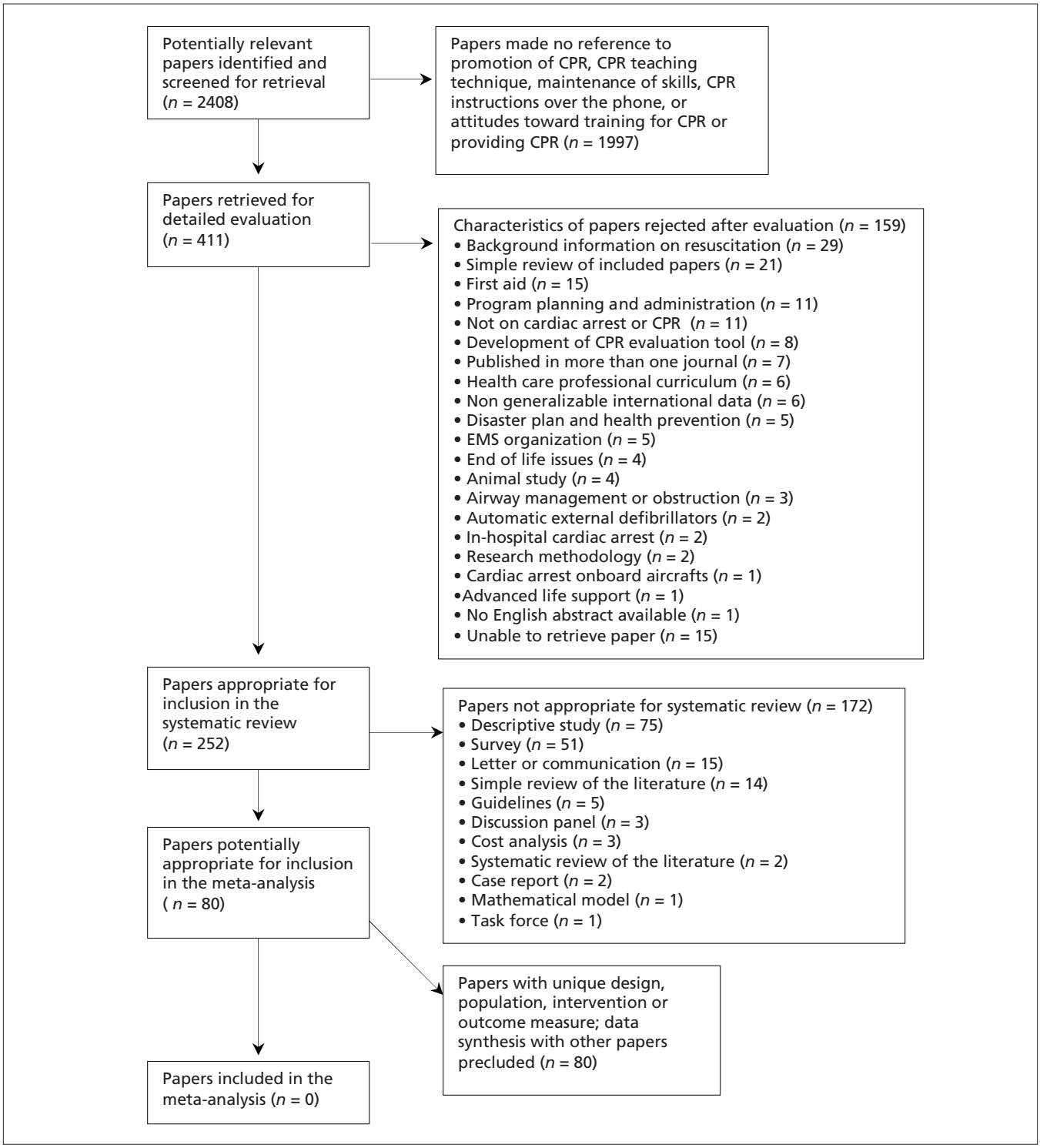

Fig. 1. Systematic review trial flow. CPR = cardiopulmonary resuscitation; EMS = emergency medical services.

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one on the effectiveness of life support courses[38]; the other on infections that were potentially acquired during CPR.[39] Hypothesis-testing studies are described in more detail at www.cjem-online.ca/v10/n1/p51, including RCTs (42), quasi-experimental (25), before–after (11), case–control (1) and cohort studies (1).

Findings from the systematic review

The large number of studies included in our systematic review precludes their individual detailed description. Instead, we grouped the studies by topic and summarized their findings. At the end of each topic we included a statement along with a measure of the quality of the evidence supporting it (Box 1). A summary of all the statements of evidence appears in Table 2.

Table 1. Systematic review characteristics

Systematic review	No. (and %)* of papers, *n* = 252
Median yr of publication (and range)	1996 (1961–2005)
Publication status	
Full paper	236 (93.7)
Abstract	16 (6.3)
Country of publication	
United States	158 (62.7)
United Kingdom	25 (9.9)
Canada	12 (4.8)
Other†	57 (22.6)
Language of publication	
English	248 (98.4)
German	3 (1.2)
Japanese	1 (0.4)
Research methodology	
Descriptive	75 (29.8)
Survey	51 (20.2)
RCT	42 (16.7)
Quasi-experiment	25 (9.9)
Letter or communication	15 (6.0)
Simple review of the literature	14 (5.6)
Before–after	11 (4.4)
Guidelines	4 (1.6)
Discussion panel	3 (1.2)
Cost-analysis	3 (1.2)
Systematic review	2 (0.8)
Case report	2 (0.8)
Case–control	1 (0.4)
Cohort study	1 (0.4)
Task force	1 (0.4)
Mathematical model	1 (0.4)
Policy statement	1 (0.4)
Topic,‡ *n* = 332	
Promotion and provision of CPR courses	97 (29.2)
Understanding and teaching CPR	82 (24.7)
Attitude, motivation and reluctance	72 (21.7)
Maintenance of skills	52 (15.7)
Instructions over the phone	29 (8.7)

RCT = randomized controlled trial; CPR = cardiopulmonary resuscitation.
*Unless otherwise specified.
†There were 16 other countries, each with less than 10 papers published.
‡A paper may cover more than 1 topic.

Who should be targeted to receive CPR training?

One approach to improving bystander CPR rates has been to train as many CPR providers as possible in mass training events. Such events can reach groups of a few hundred to thousands of participants.[5–10] Although some efforts have been made to target groups at risk,[40–42] mass training events usually attract young participants unlikely to witness cardiac arrest,[23,43,44] they are not cost-effective[45] and the effect of such interventions on survival of cardiac arrest has not been demonstrated in the literature. (Class II-3 evidence; see Box 1)

Table 2. Summary of findings from our systematic review

Suggestion	Class of evidence
Train family members of individuals with heart disease	I-2
Use the Braslows self-trainin g video	I-2
Maximize time spent practising skills on a manikin	I-2
Provide dispatch-assisted CPR instructions	I-2
Teach concepts of ambiguity and diffusion of responsibility	I-2
Reduce duration of CPR classes	I-2
Teach CPR using self-training modular courses	I-2
Take a CPR class every year	I-2
Children can be taught CPR	I-2
Parents of newborn can be taught CPR	I-2
Individuals with heart disease should not perform CPR	I-2
Staged strategy leads to low completion rate for CPR training	I-2
Laymen should not check for pulse before initiating CPR	I-2
Airway and mouth-to-mouth should still be taught during CPR classes	I-2
The content of CPR classes should be simplified	II-1
Reassure trainees about low risk of disease transmission	II-3
Television can be used to promote and teach CPR	II-3
Organize mass training events	II-3
Physicians should prescribe CPR classes	II-3
Teach CPR using peer coaching	II-3
Inform trainees about what to expect during resuscitation	II-3
Mandatory CPR training at time of renewing driver's licence	III

CPR = cardiopulmonary resuscitation.

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Up to 15% of the population suffers from long-term disabilities that may require tailored teaching strategies.[46,47] Some people may not be able to sustain the effort associated with providing CPR,[48,49] which is an aerobic exercise that could elicit ischemic symptoms in people with heart disease[50–53] (Class I-2). Until further information is available, patients with known cardiac disease should seek the approval of their treating physician before attempting to perform CPR.

Spouses of individuals with cardiac disease are the most likely to witness cardiac arrest.[54–56] Many authors suggest we should target family members of those individuals.[11–22] The estimated rate of CPR training in this target group ranges between 9% and 47%.[56–61] Although the addition of counselling to deal with the stress associated with being a potential CPR provider may be required,[62,63] CPR training has been shown to reduce anxiety and increase emotional adjustment and the sense of empowerment in family members of cardiac arrest survivors.[64–66] Family members of individuals with cardiac disease should be trained in CPR. (Class I-2)

Some authors suggest that physicians should "prescribe" CPR training to family members of individuals with cardiac disease.[67–69] This is currently being done by 6% to 50% of surveyed physicians[60,70–74]; another 70% to 90% said they were interested in doing so in the future.[74,75] The real benefit of physician-prescribed CPR training for family members of patients with cardiac disease remains unknown. (Class II-3)

Other groups have been targeted for CPR training. Students and children as young as 10 years of age, although unlikely to encounter cardiac arrest, can be taught CPR.[24,26–29,76–86] Parents of young infants are another group that can learn CPR before leaving the nursery.[87–97] Anecdotally, CPR training is mandatory in some countries at the time of obtaining or renewing one's driver's licence.[24,26] (Class III) Unfortunately, despite a few well-designed trials demonstrating the possibility of teaching CPR to children and parents of young infants, there is little evidence supporting the benefit of these interventions to bystander CPR and survival rates. (Class I-2)

What CPR training program should be implemented to maximize understanding and retention?

CPR teaching guidelines are slightly different among national resuscitation councils. All programs share similar content delivery methods, and no clear support can be given to one over the other.[98,99] Assar and colleagues proposed a staged teaching program.[100–102] In the bronze stage, students are taught to recognize a cardiac arrest, call for help, open the airway and perform chest compressions; in the silver stage, they are taught how to provide ventilation and pediatric first aid; and in the gold stage they learn pediatric CPR and neonatal first aid. Although students finishing all 3 stages have better skills than conventionally trained students, only 38% completed the program.[102] Staged training is not recommended because of its low rate of completion. (Class I-2)

Course length also varies. While 8-hour training sessions are associated with better retention of skills at 1 year,[49,103,104] CPR can be taught successfully in 4-, 3- or even 2-hour sessions.[18,81,105] There is good evidence demonstrating CPR skill acquisition during short CPR classes. (Class I-2)

A study using validated readability formulas (Smog and Flesch-Kincaid) determined that transcripts of CPR classes corresponded to a 10th grade level.[106] Because of this, Daiker estimated that 23 million American adults may not be able to comprehend the content of CPR classes.[106] Anecdotes and digression from the CPR curriculum are associated with poorer comprehension.[107] There are various cognitive and behavioural approaches to teaching CPR.[13,108–112] The content of CPR classes should be reduced and simplified. (Class II-1) This is supported by 3 literature reviews[24,25,113] and 1 quasi-experimental study.[105]

Good quality CPR involves chest rising with each ventilation and a palpable pulse with each chest compression.[114] But even health care professionals cannot rapidly and accurately determine if a victim is breathing or if a pulse is present.[115–118] Laymen have even more difficulty in verifying whether there is a pulse.[119] Laymen should not check for the absence of a pulse before initiating CPR.[46,120] (Class I-2)

Another debate involves teaching chest compression alone or with ventilation.[121,122] Most of the evidence supporting the chest compression alone approach comes from animal data.[123–126] Contrary to animal anatomy, the human upper airway does not stay open spontaneously thus preventing the free flow of air during chest compressions.[127,128] Among 885 observed cardiac arrest cases receiving bystander CPR, 16% of people survived with conventional CPR, compared with 10% who received chest compressions alone.[129] Another study reported survival rates of 6.8% with chest compression alone, compared with 9.7% with traditional CPR ($p < 0.001$).[130] In a study on dispatch instructions, 62% of 9-1-1 callers were able to perform CPR according to directives, and 81% of those were able to at least perform chest compressions correctly ($p = 0.005$).[131] While chest compressions alone may be appropriate for instructions over the phone,[132] airway and breathing management should continue to be taught as part of the CPR curriculum. (Class I-2)

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Students' CPR skills improve significantly with more time spent practising on a manikin.[82,133–135] Although sophisticated interactive manikins have been designed,[136–138] cheaper basic models may do just fine.[139] Other small portable prompt devices are arriving on the market.[140] Efforts should be made to maximize the time spent practising the skills during CPR training.[25,113,141–143] (Class I-2)

Modular self-training courses can address the different pace at which various people can learn.[95,144] Participants in self-training modular courses perform similarly to those taking conventional CPR classes.[38,77,145–147] There are a small number of well-designed trials supporting the use and benefit of modular self-training courses. (Class I-2)

Another popular self-training method uses videos.[19,23–25] They can give results similar to conventional CPR training.[79,81,94,148–153] Fewer studies found conventional CPR teaching superior to video self-teaching.[93,154,155] Very good results have been obtained using a video developed by Braslow and colleagues.[156] The video was validated on a group of medical students,[157] and its effectiveness confirmed in a Baptist Church volunteer group.[158] There is good evidence supporting the use of the Braslow self-training video. (Class I-2)

Another self-training method involves peer teaching (where a family member or friend becomes the instructor after having received basic CPR training).[159–162] A peer teaching program successfully trained 1303 laymen over a few weeks in Norway.[160] However, there is insufficient data to support the use of peer teaching at the moment. (Class II-3)

When should maintenance of skills sessions occur?

Irrespective of the teaching method, retention of CPR knowledge and skills is poor,[24,27,38,163–169] and can significantly decrease as early as 6 weeks[88,105] after a CPR class. Retraining may be protective against decline in CPR skills.[170] Retention of CPR knowledge and skills may be poor because students never learned them well in the first place. In 1 study, investigators independently examined students at the completion of their CPR class; although all students received their CPR certification, none of them passed according to strict American Heart Association (AHA) criteria.[171] This being said, there is no data suggesting outcomes are superior if a bystander were to perform CPR skills perfectly.[55,172] Prior CPR training, even if completed a long time ago, appeared to result in better survival compared with the victims who received no CPR (11% v. 3%).[173] While there is good evidence that retraining should take place on a regular basis in order to meet the AHA certification standards (Class I-2), there is little evidence that regular retraining is necessary for bystander CPR to be effective.

Where should CPR instructions be given?

Television has an influence on awareness and understanding of CPR.[108,174–177] It is considered a privileged window into the population segment that is aged 50 years and older.[178] In Seattle, Washington, repeated CPR instructions on television have led to a significant rise in bystander CPR rates.[179] Although promising, there are currently limited data supporting the use of television to promote or teach CPR. (Class II-3)

CPR instructions over the phone could improve the low bystander CPR rates observed in residential dwellings.[18,67,180,181] The ability of dispatchers to recognize cardiac arrest over the phone ranges between 68% and 90%.[173,182] Agonal breathing, present as frequently as 30% in cardiac arrest victims, can limit their ability to recognize cardiac arrest.[183,184] In Seattle, dispatchers overcalled cardiac arrest 14% of the time, leading to 4.3% inappropriate CPR administrations, though no adverse events were incurred.[185] CPR instructions may only be possible in 30% to 37% of cases.[186–190] While callers are emotionally capable of following instructions,[173,191,192] they are not always in close range with the victim,[31,191,192] or they struggle with the mouth-to-mouth instructions.[193–195] In a randomized controlled trial of instructions to provide full CPR versus chest compressions alone, complete delivery of the instructions was achieved in 62% and 81%, respectively.[131] Dispatch-assisted CPR instructions have been shown to increase bystander CPR rate,[30] and possibly survival for cardiac arrest victims.[173,196] There is strong evidence that 9-1-1 dispatchers should provide CPR instructions to callers. (Class I-2)

Why do people lack motivation to learn or perform CPR?

Although interest in CPR training decreases with advancing age,[197–201] all but 1 study[107] show a high success rate in an older age group (> 55 yr).[148,202,203] Common reasons for not learning CPR include

- lack of time or interest
- inconvenience of having to leave the house
- cost
- inability to find a course
- bad health or physical limitations
- fear of contracting HIV
- fear of being sued.[6,81,112,152,199,204–206]

While no CPR provider has ever been successfully sued,[207,208] failure to provide support could have legal con-

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sequences.[209] We have descriptive evidence that modifiable factors exist and influence the knowledge translation of CPR skills in the community (Class II-3), but little is known about how to modify behaviour.

People are afraid they may contract an infectious disease when learning CPR on a manikin or when providing CPR to a victim. Historically, tuberculosis and polio were major concerns on the minds of potential rescuers.[108] Today, HIV and hepatitis B cause the greatest concerns.[108,210–213] But no case of HIV, hepatitis B, hepatitis C, or Creutzfeld–Jakob disease has ever been reported as a result of providing CPR to a victim or a manikin.[13,39,214,215] Only 15 cases of *Neisseria meningitidis,* 3 cases of enteric pathogens, 2 cases of labial herpes, 1 case of tuberculosis and 1 potential case of SARS[216] have ever been linked to providing CPR.[39] It is extremely safe to practise CPR. Fears about disease transmission should be addressed in CPR classes. (Class II-3)

Mouth-to-mouth ventilation is an intimate act that may dissuade rescuers from performing CPR.[129,217] Willingness to perform CPR is influenced by the relationship with the victim,[7,15,40,58,218–222] as well as by the presence of vomit, dentures, blood, body odour and alcohol smell.[161,223–225] Information on what to expect when required to perform CPR should be provided. (Class II-3)

Most CPR providers describe their experience as being positive.[43,226,227] CPR certification is associated with greater confidence in one's ability to provide care, which in turn is associated with an increase in helping behaviour.[17,57,142,228–231] But CPR training is still not an assurance of action.[187,232–235] People are often unable to make a decision, rather than choosing not to help (the concept of ambiguity).[235] Overall helping behaviour decreases with an increasing number of bystanders (the concept of diffusion of responsibility).[234,236–239] Simple and complex behavioural methods exist to address those issues.[240–242] CPR teaching should include information on the concepts of ambiguity and diffusion of responsibility. (Class I-2)

Discussion

The findings of our systematic review of the literature on bystander CPR can be summarized in the following way:

Who

There seems to be clear evidence that family members of potential victims of cardiac arrest should be targeted for CPR training. Those include spouses of individuals with known coronary disease and all senior citizens, perhaps with the exception of individuals who may not be able to sustain the physical effort required to perform CPR, such as patients who themselves suffer from coronary disease.

What

The content of most CPR classes need to be simplified and shortened. Time spent training on a manikin should be maximized, ventilations should continue to be taught and checking for a pulse should be omitted for laymen. CPR classes should include information about the very low–risk of disease transmission and about the concepts of ambiguity and diffusion of responsibility. The use of visual aids such as the Braslow video and self-training methods should be encouraged.

When

Although the ability to pass a CPR competency test starts to fade within months of the initial training, there is acceptable evidence that prior training in CPR may help save lives regardless of how long it has been since the training last occurred.

Where

Perhaps the most attractive intervention to increase bystander CPR rates is providing CPR instructions over the phone to callers reporting a victim of cardiac arrest. There is clear evidence that such an intervention is associated with higher bystander CPR rates.

Why

The lack of motivation to leave the house and register for a CPR class seems to be a major determinant of low bystander CPR rates, perhaps more so than the fear of disease transmission or litigation. We need to consider measures that will actively recruit individuals for CPR training.

Our search strategy identified 2 other systematic reviews of the literature pertaining to CPR.[38,39] Jabbour and colleagues reviewed the effectiveness of basic and advanced life support courses on the basis of mortality and morbidity, retention of knowledge and change in practice behaviour. With regard to basic life support, they conclude that knowledge retention is poor, that modular courses are effective and that more studies on provider behaviours are warranted.[38] The Mejicano and Maki review addresses only the issue of disease transmission during CPR.[39] We found 2 other large reviews of the literature on CPR.[19,24] Neither review describes the methodology by which publications were identified and selected. Chehardy used a recommendation classification system similar to our statement of evidence.[19] The 2005

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AHA Resuscitation Guidelines,[243] published 2 months after we completed our search strategy, concentrated on the science of CPR rather than on determinants of its practice among bystanders.

Limitations

Our review had several potential limitations. First, because there was a significant amount of information to be reviewed and synthesized, a non-negligible amount of time elapsed between the completion of our search strategy and the publication of our results. A number of pertinent papers that could have affected our findings and recommendations may have been published during that period of time. For example, a recent study by Nagao may have influenced our recommendations against removing the ventilation component of CPR.[244] Second, manuscript selection and data extraction were completed by a single reviewer; the potential selection bias resulting from this practice was limited by the use of standardized criteria for study selection and data extraction. Third, while we could not evaluate selection and extraction bias with formal statistical testing such as Funnel plots or file drawer numbers, our search strategy recall was in agreement with current methodologic standards for systematic reviews.[37] In other words, we found an adequate number of studies in sources other than electronic searching. Fourth, we could have restricted our search strategy to experimental or well-designed observational studies, but felt that important information could be missed if we neglected to review other types of publications such as editorials, letters and expert communications. Finally, while the diversity of patient populations, interventions and outcome measures precluded a formal meta-analysis, we were able to group studies by topics and suggest statements of evidence, along with the quality of the evidence supporting that statement. To receive a high score, an intervention needed to be based on solid research methodology and show an effect on bystander CPR rates or survival for out-of-hospital cardiac arrest.

Conclusion

This systematic review of the literature examines the determinants of bystander CPR. Lack of interest and motivation play a major role in the lack of CPR training in the community. Targeted efforts are required to recruit learners most likely to witness cardiac arrest. CPR class format and content need to be shortened and simplified; learners need to spend more time practising on manikins; reassurance with regard to infectious diseases should be maintained; and more attention should be paid to behavioural aids that promote helping attitudes. Improved strategies to provide dispatcher-assisted CPR instructions should also be developed.

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Online appendix 1. Information sources included in the systematic review

Electronic search

- PubMed
- OVID
  - EBM review
  - Biological Abstract
  - CINAHL
  - Current Content/All eds
  - Dissertation Abstracts
  - ERIC
  - HealthSTAR
  - PreMedline and Medline
  - PAIS international
  - PsyInfo
  - SocioFile

Hand search

- *Resuscitation*
- *Canadian Journal of Public Health*

Experts in the field

- Dr. Andy Anton, Calgary, Alberta
- Dr. Wes Clark, Ottawa, Ontario
- Dr. Ian Stiell, Ottawa, Ontario
- Dr. Valerie De Maio, Chapel Hill, North Carolina
- Dr. Mickey Eisenberg, Seattle, Washington
- Dr. Lars Wik, Oslo, Norway

Trial registry

- Cochrane Controlled Trial Registry

Scientific association websites

- Heart and Stroke Foundation of Canada
- American Heart Association
- Resuscitation Council (UK)
- Canadian Association of Emergency Physicians
- Association des Médecins d'Urgence du Québec
- American College of Emergency Physicians
- Society for Academic Emergency Medicine
- Canadian Coordinating Office for Health Technology Assessment
- National Institute for Clinical Excellence

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Online appendix 2. Electronic search strategies for the systematic review

OVID search

PreMEDLINE/MEDLINE, EBM Cochrane-ACP JC-DARE, EBM Cochrane Controlled Trials Register, Biological Abstract, CINAHL, Current Content, Dissertation Abstract, ERIC, HealthSTAR, PAIS International, PsyInfo, SocioFile

Teaching

1. exp teaching/ or exp education/ or exp computer user training/ or exp educational technology/ or exp models, educational/ or exp audiovisual aids/ or exp textbooks/
2. (teach$ or educat$ or academi$ train$ or educat$ personnel or educat$ techni$ or teach$ metho$ or train$ activit$ or train$ techni$ or [train$ adj3 train$] or [comput$ adj3 train$] or educat$ technolog$ or educat$ mode$ or instruct$ mode$ or audiovisua$ or textboo$).tw.

Cardiopulmonary resuscitation

3. exp cardiopulmonary resuscitation/ or exp resuscitation/ or exp first aid/ or exp heart massage/ or exp respiration, artificial/
4. (cardio?pulmonary resuscitation or resuscitatio$ or mouth?to?mouth or basic life support or cpr or code blue or first aid? or first respond$ or heart massage or cardiac massage or artificial respiration).tw.

To the population

5. bystander/ or exp sociology/ or exp population characteristics/ or exp residence characteristics/ or exp group processes/ or exp group structure/ or exp behavior/ or exp psychology, social/ or exp social medicine/ or exp social planning/
6. (population or bystander? or social phenomen$ or sociolog$ or population characterist$ or residenc$ characterict$ or communit$ or neighborhoo$ or domicile or group proces$ or group structu$ or behavi$ or social medicine or social pla$).tw.
7. exp population/

Merging medical subject headings with text word search

8. or/1-2
9. or/3-4
10. or/5-7

Combining concepts

11. and/8-10

PUBMED

#4 Search #1 AND #2 AND #3

#3 Search population OR bystander OR social phenomen* OR sociolog* OR population characterist* OR residenc* characterist* OR communit* OR neighborhoo* OR domicile OR group proces* OR group structu* OR behavi* OR social medicine OR social pla*

#2 Search cardiopulmonary resuscitation OR resuscitatio* OR mouth to mouth OR basic life support OR cpr OR code blue OR first aid OR first respond* OR heart massage OR cardiac massage OR artificial respiration

#1 Search teach* OR educat* OR academi* train* OR educat* personnel OR educat* techni* OR teach* metho* OR train* activit* OR train* techni* OR train* train* OR comput* train* OR educat* technolog* OR educat* mode* OR instruct* mode* OR audiovisua* OR textboo*

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Online appendix 3. Hypothesis testing studies: characteristics by methodology

Study	Participants	Intervention	Outcome measure	Jadad scale	Allocation concealment	Conclusion
Randomized controlled trial						
Assar[100] (2000) *n* = 505	Population of South Wales Mean age 42 years	1- Staged CPR teaching (2 hrs) 2- Conventional CPR teaching (2 hrs)	Multiple CPR skill comparisons (with no statistical adjustment)	2	Not used	Staged teaching leads to better skills.
Atkinson[188] (1999) *n* = 48	Volunteers trained in CPR or not Age range 23-56 years	1- CPR without instructions 2- CPR instructions on the phone 3- CPR instructions by video-link 4- Instructions given by instructor	No. ventilations, No. chest compressions, hand position, and time to CPR	1	Not used	Video-link instructions were best. Telephone instructions were good. Previous training had no influence on skills.
Batcheller[148] (2000) *n* = 202	Recruited from community Mean age 59.4 years	1- Video self-training in CPR (25 min) 2- Conventional CPR teaching (4 hrs)	Effective ventilation, effective compressions, and effective CPR delivery	2	Not used	Self-trained did generally better than conventionally trained.
Baubin[50] (1996) *n* = 12	Professional rescuers Mean age 30.8 +/- 7.9 years	1- Perform regular CPR 2- Perform CPR with ACD device	Duration of CPR, quality of CPR, oxygen consumption, heart rate, and lactate level	1	Not used	Conventional CPR demands less energy than ACD and can be performed longer (29 min v. 16 min).
Berden[164] (1993) *n* = 96	Nurses Mean age 28.7 +/- 7.1 years	1- Retested at 3 months + refresher 2- Retested at 6 months + refresher 3- Retested at 1 year	CPR skills	2	Not used	Instructions every 6 months are necessary.
Bilger[143] (1997) *n* = 200	Medical (18%) and laypeople (82%) Mean age 38.4 years	1- Telephone prompt alongside manikin 2- No telephone prompt	Calling 9-1-1 for help	2	Not used	Group trained with prompt telephone remembered to call 9-1-1 more often.
Capone[177] (2000) *n* = 202	Auto industry employees 55% between 21-35 years	1- TV spots on CPR (60 sec) 2- Nothing	CPR skills	3	Not used	Both groups had similarly bad CPR skills.
Chamberlain[102] (2001) *n* = 495	Population of South Wales Mean age 42 years	1- Staged CPR teaching (2 hrs) 2- Conventional CPR teaching (2 hrs)	Likelihood of returning for further training or retraining	2	Not used	Staged teaching led to higher likelihood of return visits to complete or repeat training.
Coleman[145] (1991) *n* = 49	College students Age range 18-70 years	1- Self-taught class (4 hrs) 2- Conventional CPR teaching (4 hrs)	Written exam and skill exam according to Mandel check-list	2	Not used	Both groups were equivalent.
Dorph[195] (2003) *n* = 20	Center for elderly Median age 78 years	1- Traditional Dispatch CPR 2- Compression only Dispatch CPR	Time to continuous efforts No. compressions in 9 min.	1	Not used	Poor CPR both groups; more chest compressions in group 2
Donnelly[98] (2000) *n* = 250	Laymen Age unknown	1- Europeen Resuscitation guidelines 2- ILCOR guidelines 3- American Heart guidelines	CPR skills evaluated according to CARE and VIDRAP protocol	2	Not used	European and ILCOR guidelines appeared easier to learn; retention was poor irrespective of method.
Dracup[62] (1986) *n* = 134	Heart disease patients Mean age 59 years Family members Mean age 49 years	1- CPR teaching (90 min) 2- Heart disease education (90 min) 3- Nothing	Multiple adjective affect checklist, psychological adjustment to illness scale and CPR quiz.	1	Not used	Anxiety was worst in CPR group. Adjustment to illness was worst in CPR and education group compared with placebo.
Dracup[204] (1994) *n* = 337	Family members of heart disease patients Mean age 59 +/- 10.5 years	1- CPR teaching only 2- CPR + education on heart disease 3- CPR + social support 4- Nothing	24-item self administered questionnaire	1	Inadequate	Very positive feeling about CPR training without an increased sense of burden or responsibility compared with placebo.

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Online appendix 3. Continued

Study	Participants	Intervention	Outcome measure	Jadad scale	Allocation concealment	Conclusion
Dracup[63] (1997) *n* = 674	Heart disease patients Mean age 62.9 +/- 10.1 years Family members Mean age 59.0 +/- 10.9 years	1- CPR teaching only 2- CPR + education on heart disease 3- CPR + social support 4- Nothing	Multiple adjective affect checklist, psychological adjustment to illness scale and Spanier dyadic adjustment scale	1	Inadequate	Patients coped better if their family members received social support.
Dracup[154] (1998) *n* = 480	Parents of sick infants Mean age 29.9 +/- 8.4 years	1- Conventional CPR class 2- Conventional CPR class + social support 3- CPR self-training video	Mandel CPR skill checklist, PAIS, multiple affect checklist and perceived social support scale	2	Not Used	No difference between group 1 and 2; self-training may not be appropriate for that population.
Dracup[155] (2000) *n* = 335	Parents of sick infants Mean age 30 +/- 8 years	1- Conventional CPR class 2- Conventional CPR class + social support 3- CPR self-training video	Psychological adjustment to illness, Spielberger state of anxiety inventory, McMaster family assessment device, PAIS	1	Inadequate	CPR training increases adjustment to disease although anxiety is increased at first. Group 2 did best.
Eberle[118] (1996) *n* = 206	EMT-1; EMT-2; PM-1; PM-2	Pre-op CABG volunteer on/off pump; pulse check	Pulse present or no; Time delay before decision	2	Not used	Diagnostic accuracy increases with training; overall sens. 90% and spec. 55%; delay 24-32 sec.
Eisenberg[10] (1995) *n* = 17 318	Washington households Head of household >50 years	1- CPR self-training video 2- Nothing	Bystander CPR rate N = 65 cardiac arrests	2	Not used	Sending a video to households does not increase bystander CPR.
Hallstrom[131] (2000) *n* = 520	9-1-1 callers Age unknown	1- Instruction to do chest compression 2- Instruction to do full CPR	Delivery of intervention and survival to hospital discharge	3	Adequate	Group 1 more likely to complete instructions. Survival was similar.
Hawks[233] (1992) *n* = 84	University students Age unknown	1- CPR + bystander education (2 hrs) 2- CPR training alone	Helping behavior and appropriateness of intervention	4	Adequate	Group 1 helped significantly more often; trend toward more appropriate intervention in group 1.
Kaczorowski[165] (1998) *n* = 44	Medical student Age unknown	1- Video + unsupervised manikin practice at 3-5 months 2- Booster training + supervised manikin practice at 3-5 months 3- No booster training session	Neonatal knowledge and skill retention at 6-8 months	2	Not used	No difference between groups. All groups performed significantly badly.
Kittleson[110] (1986) N = 96	University students Age unknown	1- Conventional CPR teaching 2- CPR teaching with task behaviour 3- CPR teaching with progressive part practice	19-item skill competency scale	1	Not used	Innovative teaching methods were much more effective than conventional teaching.
Komelasky[88] (1990) *n* = 28	Parents of apneic infants Mean age 29.8 years	1- CPR + home visit/manikin practice 2- CPR + telephone/clinic follow-up	Spielberger state-trait anxiety inventory and CPR skills	2	Not used	No difference in anxiety level or CPR skills between groups.
Liberman[81] (2000) *n* = 61	CEGEP students Mean age 24.8 +/- 12.5 years	1- 4 hrs, manikin:student 1:4 2- 4 hrs, manikin:student 1:1 3- 2 hrs, manikin:student 1:1 4- 11 min, self-training video+manikin	CPR skills	1	Not used	No difference between groups. Self-training video group did just as well.
Mandel[133] (1987) *n* = 67	City employee Age unknown	1- CPR theory review (3 pages) 2- CPR video review (15 min)	CPR skills	1	Not used	Overall skills were similar; better compression rate in video group.
Messmer[93] (1993) *n* = 30	Substance abuse mothers Mean age 28.6 +/- 5.3 years	1- Interactive CPR video + manikin 2- Conventional CPR training	CPR knowledge and skills	1	Not used	Conventional CPR training method led to better results.
Monsieurs[147] (2004) *n* = 41	1st year nursing students Mean age 21 +/- 8 years	1- JUST CD-ROM (60-min. training) 2- Nothing	Positive helping attitude BLS skills	2	Not used	Increased helping attitude; CPR skills remain suboptimal
Moser[152] (1999) *n* = 335	Parents of sick infants Mean age 30.5 +/- 8.5 years	1- Video on CPR 2- Conventional CPR teaching 3- Conventional CPR + social support 4- Nothing	CPR attitude scale, willingness to attempt CPR, anxiety, sense of burden and feeling of loss of control	1	Not used	Intervention groups performed better on all counts. Groups 2 and 3 performed better than group 1.
Moser[65] (2000) *n* = 196	Family members of heart disease patients Mean age 59 +/- 10.5 years	1- CPR + education on heart disease 2- CPR + social support 3- Nothing	Multiple affect adjective check list and control attitudes scale	1	Not used	Perceived control and emotional adjustment improved in both groups.

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Online appendix 3. Continued

Study	Participants	Intervention	Outcome measure	Jadad scale	Allocation concealment	Conclusion
Nelson[146] (1984) *n* = 104	Medical students, hospital personnel, and laypeople Age unknown	1- Modular CPR class +/- refresher 2- Conventional CPR +/- refresher	Written exam, CPR skills, and harmful behaviour	1	Not used	At 1 year, all groups equal. At 2 years, groups with refresher did better. At 4 years, all groups did badly.
Ruppert[116] (1999) *n* = 261	Health care workers and laymen Age unknown	1- Using a live person 2- Using a manikin	Determination of breathing status (yes or no)	1	Not used	Only 5% could make the correct diagnosis within the 5 sec recommended by AHA.
Shantzis[163] (1983) *n* = 90	University students Age unknown	1- Modular CPR teaching 2- Conventional CPR teaching	CPR knowledge and skills.	1	Not used	Neither group could perform CPR after 9 weeks.
Shotland[234] (1985) *n* = 163	University students Age unknown	2X2X2 table varying: Ambiguity, number of bystander, training status	Helping behaviour	2	Not used	Ambiguous situation and presence of many bystanders decreases helping behaviour. Training only influence nature of help provided.
Su[166] (2000) *n* = 43	Paramedics Age unknown	1- Knowledge + manikin refresher 2- Manikin refresher 3- Knowledge refresher 4- No refresher	Pediatric CPR knowledge and skills measured at 12 months	2	Not used	All groups returned to pre-training level at 12 months with or without a refresher at 6 months.
Swor[121] (2003) *n* = 80	Hospital mailing list Mean age 71.5 years	1- Traditional CPR training (2h) 2- Chest compression only (2h)	Knowledge/perception; fear of infection; retention at 3 months	2	Not used	Similar perceived ability; fear of infection less in group 2; 49.1% competent at 3 months (same)
Todd[157] (1998) *n* = 89	Medical students Mean age 23.1 +/- 2.9 years	1- Video self-training (34 min) 2- Conventional CPR class (4 hrs)	Overall CPR competency and skills	5	Unclear	Video self-training led to superior competency and skills.
Todd[158] (1999) *n* = 107	Baptist church laymen Mean age 34.4 +/- 8.6 years	1- Video self-training (34 min) 2- Conventional CPR class (4 hrs)	Written test, overall CPR competency and CPR skills	5	Adequate	Video self-training led to similar competency and skills.
Toms[162] (1998) *n* = unknown	Laymen Age unknown	1- Conventional CPR class + peer coaching 2- Conventional CPR class	CPR knowledge and skills	1	Not used	Outcome measure not influenced by peer coaching.
Vanderschmidt[76] (1975) *n* = 400	School children Age 8th and 11th grade	1- Didactic teaching + manikin 2- Didactic teaching only	CPR knowledge and skills	1	Not used	Group 1 did better. 11th grade students did better.
Ward[167] (1997) *n* = 169	University students Age unknown	1- Wallet size check list 2- Longer, more detailed check list 3- No check list	CPR skills 2 months later	1	Not used	Longer check list did the best. No difference between wallet size check list and no check list.
Wik[138] (2001) *n* = 24	Paramedics Age unknown	Cross-over trial 1- 3 min CPR, automated feedback 2- 3 min CPR, no feedback	CPR skills	2	Not used	Automated voice advisory manikin rapidly improves CPR skills.
Yakel[99] (1989) *n* = 106	Nurses 3 different ward) Age unknown	1- HeartSaver CPR teaching 2- BCLS teaching	CPR skills	1	Not used	Area of work did not make a difference. Group 2 did better.
Quasi-experiment						
Bang[173] (1999) *n* = 427	9-1-1 callers reporting cardiac arrest Mean age 69 +/- 15 years	1- Phone instruct./no previous training 2- Phone instruct./previous training 3- Phone instruct./CPR aborted 4- No instruct. re previous training 5- Instructions declined by caller 6- No instructions offered	Adequacy of cardiac arrest by dispatcher, survival to hospital discharge.	-	—	High accuracy of dispatchers for diagnosis of cardiac arrest. Bystanders with previous CPR training did better, more so with phone instructions. Phone instructions increase survival.
Berkebile[79] (1975) *n* = 446	School children Age range 12-13, 15-17 years	1- Conventional CPR teaching 2- Self-training + manikin 3- CPR video only 4- CPR video + manikin 5- Nothing	CPR knowledge and skills. Attempt at doing CPR.	—	—	Self-training compares to conventional CPR teaching. Manikin practice is important. CPR video only was better than no instructions at all.

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Online appendix 3. Continued

Study	Participants	Intervention	Outcome measure	Jadad scale	Allocation concealment	Conclusion
Boyle[140] (2002) *n* = 32	Non-medical personnel Age unknown	1- Chest compressions 2- Chest compressions with CPR-Ezy	Hand position; % effective compressions and rate	—	—	Hand position improved in 31% of group 2; rate and effective compressions improved in group 2
Braslow[156] (1997) *n* = 642	Laymen Mean age 32.8 years	1- Self-instruction video 1 (30 min) 2- Self-instruction video 2 (35 min) 3- Conventional CPR class (3-4 hrs)	Chest compression, ventilation, and overall CPR skills	—	—	Video 2 more effective than video 1 (prototype) and conventional teaching. Also if >40 years old.
Breivik[149] (1980) *n* = 230	Laymen Mean age 31 years	1- Self-training at home + observer 2- Self-training at home + no observer 3- Self-training at driving school 4- Nothing	CPR knowledge and skills	—	—	All intervention groups shared similar CPR knowledge; CPR skills were best in group 3.
Carter[189] (1984) *n* = 143	Laymen Mean age 53.5 +/- 7.4 years	1- Protocol phone instruct./know CPR 2- Protocol phone instruct. 3- Impromptu phone instruct./know CPR 4- Impromptu phone instruct.	CPR cycle, ventilations, compressions, confusion, unrequested returns to phone and time to first compression	—	—	Protocol phone instructions were better than impromptu instructions. Groups without prior CPR knowledge did as well with instruct.
Edwards[150] (1985) *n* = 65	Oil company employee Age unknown	1- Interactive video-disc CPR class 2- Conventional CPR class	CPR knowledge, skills and retention	—	—	Knowledge and skills deteriorated at 3 months. Groups were similar.
Flesche[190] (1995) *n* = 188	Laymen Age unknown	1- Phone instruct./ no CPR training 2- No phone instruct./ CPR trained	Overall CPR effectiveness, time to ventilation and compression	—	—	Group 1 started CPR components later, but were more effective.
Greig[168] (1996) *n* = 72	Nurses Age unknown	1- Teaching classes of 6 2- Teaching classes of 15-20	CPR knowledge and skills	—	—	Small group did better than large. Both groups improved.
Handley[105] (1998) *n* = 48	Laymen Mean age 27.3 years	1- Thought 4-step sequence (2 hrs) 2- Thought 8-step sequence (2 hrs)	CPR skills	—	—	No difference between groups.
Hawks[241] (1998) *n* = 98	University students Mean age 22.8 years	1- American Red Cross CPR 2- National Safety Council CPR 3- Emergency helping behaviour class + CPR 4- Nothing	Helping behaviour (yes or no)	—	—	All intervention groups demonstrated improved propensity to help compared with control group. Group 3 did best.
Korttila[137] (1979) *n* = 102	Army conscripts Mean age 20 +/- 2 years	1- 2 hour class/recording manikin 2- 3 hour class/non-recording manikin	CPR skills (recorded), 3 different set of criteria	—	—	Nobody passed the test in 2-3 hour class with non-recording manikin.
Latane[236] (1968) *n* = 58	University students Age unknown	1- Alone in smoke-filling room 2- With 2 actors in smoke-filling room 3- 3 subjects in smoke-filling room	Time necessary to notice and report the smoke	—	—	Alone subject noticed and reported smoke much faster.
Lester[161] (1997) *n* = 243	Middle or Junior High school students Age range 11-12 years	1- CPR class taught by teacher 2- CPR class by teacher + peer	CPR knowledge and skills	—	—	Girls did better than boys in group 2. Overall no difference.
Lind[82] (1961) *n* = 466	School children Age range 12-14 years	1- CPR class + manikin (2 hrs) 2- CPR video only	Quality of ventilations	—	—	Manikin-trained group did much better.
Long[151] (1992) *n* = 30	Parents of sick infants Mean age 29 years	1- Didactic CPR teaching 2- Audio-video CPR teaching	CPR knowledge and skills	—	—	No difference between groups.
Lucia[52] (1999) *n* = 28	Health care professional Mean age 34 +/- 6 years	1- Sedentary CPR instructors 2- Fit laymen without CPR training	Heart rate, VO_2 max, and lactate levels for 18-min CPR session	—	—	Physical fitness may have a positive influence on resuscitation.
Noordergraaf[139] (1997) *n* = 161	Medical students Age unknown	1- Actar 911 manikin 1:1 ratio 2- Little Anne manikin 1:1 ratio 3- Recording resusc. Anne 4-5:1 ratio	CPR skills	—	—	No difference between groups. Individual manikin preferred.

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Online appendix 3. Continued

Study	Participants	Intervention	Outcome measure	Jadad scale	Allocation concealment	Conclusion
Schlessel[97] (1995) *n* = 83	Parents of healthy infant 60% between 25-35 years	1- Infant CPR training (4 hrs) 2- Nothing	CPR knowledge, self-efficacy and anticipated anxiety	—	—	CPR knowledge better, self-efficacy better and less anxiety.
Van Kerschaver[83] (1989) *n* = 265	School students Age 12, 14, 17 and 20 years	1- Test plus second training 2- Test only	CPR knowledge, CPR skills and fear to apply CPR	—	—	Skills improved with repeated training unlike knowledge and fear.
Winchell[135] (1966) *n* = 2027	Laymen and health care 20 different groups	1- Practiced on manikin (10 groups) 2- No manikin practice (10 groups)	CPR skills on recording manikin	—	—	Group 1 did better.
Beaman[242] (1978) *n* = 27	University students Age unknown	1- Info on diffusion of responsibility 2- Nothing	Helping behaviour (yes or no)	—	—	Knowing about diffusion of responsibility improved helping.
Pantin[231] (1982) *n* = 92	University women Age unknown	1- Video on helping in emergencies 2- No video	Helping behaviour in group size of 2 v. 6	—	—	Delay in helping if larger group size, except in group 1.
Friesen[144] (1984) *n* = 63	Nurses Age unknown	1- Self-paced teaching method 2- Didactic teaching	CPR knowledge and skills retention at 2 and 8 weeks	—	—	No difference between groups.
Gombeski[104] (1982) *n* = unknown	Laymen Age unknown	1- Teaching in 3 sessions (8 hrs) 2- Teaching in 1 session (4 hrs)	CPR knowledge and skills at one year	—	—	Both groups substandard. Group 1 did better.
Before–after						
Alvarez[78] (1975) *n* = 42	High school students Age unknown	1- Medic II program (includes mandatory CPR class in high school)	CPR knowledge and skills at 12 months	—	—	Did well on written exam. Fair results on skill testing.
Becker[179] (1999) *n* = unknown	Population based Age unknown	1- Public service announcements teaching CPR on TV	Rate of bystander CPR for 289 cardiac arrests	—	—	Bystander CPR increased from 43% to 55% p <0.05
Bircher[77] (1983) *n* = 87	School children Age range 10-12 years	1- First aid and infant CPR via video, lecture, demonstration, and practice	CPR skills	—	—	Young children can learn to do infant CPR well.
Bosma[109] (1989) *n* = unknown	High school students Age unknown	1- System for training and assessing resuscitation skills (STARS) 2- Delayed prompting technique 3- Conventional CPR teaching	Number of errors and time to reach preset criterion for CPR skill	—	—	Delayed prompting technique did best.
Conroy[89] (1990) *n* = 51	Post-partum mothers Age unknown	1- 17 min video, 20 min lecture, and manikin practice. Revision in 2nd time.	CPR knowledge	—	—	Knowledge increased but not maintained at 6 months.
Culley[31] (1991) *n* = 267	9-1-1 callers Age unknown	1- Phone instructions provided to callers reporting cardiac arrest	Bystander CPR rate and survival to hospital discharge	—	—	Bystander CPR rate increased from 32% to 54% p <0.001. Trend toward improvement in survival.
Curry[169] (1987) *n* = 85	Health care professional Age unknown	1- Conventional CPR training	CPR knowledge and skills at 6 and 12 months	—	—	Knowledge and skills back to pre-test level at 6 and 12 months.
Delooz[175] (1984) *n* = unknown	Flemish population Age unknown	1- TV flashed with goal to promote CPR classes, followed by survey	Awareness, understanding, and commitment to take CPR class	—	—	Awareness and understanding increased. Commitment to take CPR class mainly in <25 years old.
Sunde[134] (1998) *n* = 421	Laymen Age unknown	1- Mass mailing calendars with CPR 2- Calendar +/- manikin to take home	CPR skills	—	—	Mass mailing of CPR instructions not useful. Practice is necessary.
Pane[41] (1989) *n* = 1388	Targeted laymen Age >60 years	1- Targeted recruitment of seniors for mass CPR training, then survey	Demographic data compared with previous mass training event	—	—	The >60 age group doubled. More family members of cardiac patients.
Eisenberg[181] (1985) *n* N = 446	9-1-1 callers Mean age 53.5 +/- 16.6 years	1- Phone instructions provided to callers reporting cardiac arrest	Bystander CPR rate and survival to hospital discharge	—	—	Bystander CPR rate increased by 11.1% (95%CI 1.8-20.4). Four lives may have been saved.

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Online appendix 3. Continued

Study	Participants	Intervention	Outcome measure	Jadad scale	Allocation concealment
Case-control	Cases	Control	Outcome measure	Newcastle-Ottawa Scale	Conclusion
Goldberg[197] (1984) *n* = 501	1- Family members of heart disease patients	1- Family members of non-cardiac patients 2- Random neighbourhood control	Previous CPR training status (yes or no)	6/9	Family members of cardiac patients were less likely to be trained in CPR; if they were, they had taken the class much further in the past compared with control.
Cohort study	Cohort	Control	Outcome measure	Newcastle-Ottawa Scale	Conclusion
Jackson[20] (1997) *n* = 927	1- Victims of cardiac arrest at home	1- Victims of cardiac arrest in a public venue	Likelihood of receiving bystander CPR	6/9	More likely to receive bystander CPR in public venue: crude OR 3.8 (99%CI 2.5-5.9), adjusted OR 1.8 (95%CI 1.1-2.9)

CPR = cardiopulmonary resuscitation; ACD = active compression-decompression; ILCOR = international liaison committee on resuscitation; CARE = Cardiff assessment of response and evaluation; VIDRAP = video and recording Anne printout; PAIS = psycholosocial adjustment to illness scale; CABG = coronary arterial bypass graft; CEGEP = collège d'enseignement général et professionnel; BLS = basic life support; BCLS = basic cardiac life support; CPR-Ezy = manufacturer trademark.

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