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
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
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:

1. the organization of mass CPR training events\(^5-10\)
2. CPR training of family members of patients suffering from heart disease\(^11-22\)
3. promotional CPR videos\(^19,23-25\)
4. 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 dispatcher 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.
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
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 information 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:
one on the effectiveness of life support courses, the other on infections that were potentially acquired during CPR. 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.

### 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. Although some efforts have been made to target groups at risk, mass training events usually attract young participants unlikely to witness cardiac arrest; they are not cost-effective 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 1. Systematic review characteristics

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

*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.

#### Table 2. Summary of findings from our systematic review

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

*CPR = cardiopulmonary resuscitation.
Up to 15% of the population suffers from long-term disabilities that may require tailored teaching strategies. Some people may not be able to sustain the effort associated with providing CPR, which is an aerobic exercise that could elicit ischemic symptoms in people with heart disease. 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. Many authors suggest we should target family members of those individuals. The estimated rate of CPR training in this target group ranges between 9% and 47%. Although the addition of counselling to deal with the stress associated with being a potential CPR provider may be required, CPR training has been shown to reduce anxiety and increase emotional adjustment and the sense of empowerment in family members of cardiac arrest survivors. Family members of individuals with cardiac disease should be trained in CPR.

Some authors suggest that physicians should “prescribe” CPR training to family members of individuals with cardiac disease. This is currently being done by 6% to 50% of surveyed physicians; another 70% to 90% said they were interested in doing so in the future. The real benefit of physician-prescribed CPR training for family members of patients with cardiac disease remains unknown.

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. Parents of young infants are another group that can learn CPR before leaving the nursery. Anecdotally, CPR training is mandatory in some countries at the time of obtaining or renewing one’s driver’s licence. 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.

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. Assar and colleagues proposed a staged teaching program. 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. Staged training is not recommended because of its low rate of completion.

Course length also varies. While 8-hour training sessions are associated with better retention of skills at 1 year, CPR can be taught successfully in 4-, 3- or even 2-hour sessions. There is good evidence demonstrating CPR skill acquisition during short CPR classes.

A study using validated readability formulas determined that transcripts of CPR classes corresponded to a 10th grade level. Because of this, Daiker estimated that 23 million American adults may not be able to comprehend the content of CPR classes. Anecdotes and digression from the CPR curriculum are associated with poorer comprehension. There are various cognitive and behavioural approaches to teaching CPR. The content of CPR classes should be reduced and simplified. This is supported by 3 literature reviews and 1 quasi-experimental study.

Good quality CPR involves chest rising with each ventilation and a palpable pulse with each chest compression. But even health care professionals cannot rapidly and accurately determine if a victim is breathing or if a pulse is present. Laymen have even more difficulty in verifying whether there is a pulse. Laymen should not check for the absence of a pulse before initiating CPR.

Another debate involves teaching chest compression alone or with ventilation. Most of the evidence supporting the chest compression alone approach comes from animal data. Contrary to animal anatomy, the human upper airway does not stay open spontaneously thus preventing the free flow of air during chest compressions. Among 885 observed cardiac arrest cases receiving bystander CPR, 16% of people survived with conventional CPR, compared with 10% who received chest compressions alone. Another study reported survival rates of 6.8% with chest compression alone, compared with 9.7% with traditional CPR ($p < 0.001$). 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 ($p = 0.005$). While chest compressions alone may be appropriate for instructions over the phone, airway and breathing management should continue to be taught as part of the CPR curriculum.
Students’ CPR skills improve significantly with more time spent practising on a manikin. Although sophisticated interactive manikins have been designed, cheaper basic models may do just fine. Other small portable prompt devices are arriving on the market. Efforts should be made to maximize the time spent practising the skills during CPR training.

Modular self-training courses can address the different pace at which various people can learn. Participants in self-training modular courses perform similarly to those taking conventional CPR classes. There are a small number of well-designed trials supporting the use and benefit of modular self-training courses.

Another popular self-training method uses videos. They can give results similar to conventional CPR training. Fewer studies found conventional CPR teaching superior to video self-teaching. Very good results have been obtained using a video developed by Braslow and colleagues. The video was validated on a group of medical students, and its effectiveness confirmed in a Baptist Church volunteer group. There is good evidence supporting the use of the Braslow self-training video.

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

When should maintenance of skills sessions occur?
Irrespective of the teaching method, retention of CPR knowledge and skills is poor, and can significantly decrease as early as 6 weeks after a CPR class. Retraining may be protective against decline in CPR skills. Retention of CPR knowledge and skills may be poor because students never learned them well in the first place. In a 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. This being said, there is no data suggesting outcomes are superior if a bystander were to perform CPR skills perfectly. 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% vs. 3%). 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?

Telephone instructions over the phone could improve the low bystander CPR rates observed in residential dwellings. The ability of dispatchers to recognize cardiac arrest over the phone ranges between 68% and 90%. Agonal breathing, present as frequently as 30% in cardiac arrest victims, can limit their ability to recognize cardiac arrest. In Seattle, dispatchers overcalled cardiac arrest 14% of the time, leading to 4.3% inappropriate CPR administrations, though no adverse events were incurred. CPR instructions may only be possible in 30% to 37% of cases. While callers are emotionally capable of following instructions, they are not always in close range with the victim, or they struggle with the mouth-to-mouth instructions. 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. Dispatch-assisted CPR instructions have been shown to increase bystander CPR rate, and possibly survival for cardiac arrest victims. There is strong evidence that 9-1-1 dispatchers should provide CPR instructions to callers.

Why do people lack motivation to learn or perform CPR?

Although interest in CPR training decreases with advancing age, all but 1 study show a high success rate in an older age group (> 55 yr). 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

While no CPR provider has ever been successfully sued, failure to provide support could have legal con-
sequences. 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. Today, HIV and hepatitis B cause the greatest concerns. 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. 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 have ever been linked to providing CPR. 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. Willingness to perform CPR is influenced by the relationship with the victim, as well as by the presence of vomit, dentures, blood, body odour and alcohol smell. 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. 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. But CPR training is still not an assurance of action. People are often unable to make a decision, rather than choosing not to help (the concept of ambiguity). Overall helping behaviour decreases with an increasing number of bystanders (the concept of diffusion of responsibility). Simple and complex behavioural methods exist to address those issues. 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. 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. The Mejicano and Maki review addresses only the issue of disease transmission during CPR. We found 2 other large reviews of the literature on CPR. Neither review describes the methodology by which publications were identified and selected. Chehardy used a recommendation classification system similar to our statement of evidence.
AHA Resuscitation Guidelines, 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. 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. 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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140. Dracup K, Breu C. Teaching and retention of cardiopulmonary resuscitation skills for families of high-risk patients with cardiac disease. Focus Crit Care 1987;14:67-72.


171. Lester CA, Donnelly PD, Assar D. Lay CPR trainees: retraining, confidence and willingness to attempt resuscitation 4 years after training. Resuscitation 2000;45:77-82.


Understanding and improving low bystander CPR rates


Correspondence to: Dr. Christian Vaillancourt, The Ottawa Hospital, Civic Campus, Clinical Epidemiology Unit, Rm. F658, 1053 Carling Ave, Ottawa ON K1Y 4E9; cvaillancourt@ohri.ca
**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
  - Psylinfo
  - 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

### 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

### Trial registry
- Cochrane Controlled Trial Registry

### Review of bibliography

#### Textbooks

#### Review articles
Online appendix 2. Electronic search strategies for the systematic review

OVID search
PreMEDLINE/MECLINE, 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$ characterist$ or communit$ or neighborhood 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 neighborhood* 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*
### Online appendix 3. Hypothesis testing studies: characteristics by methodology

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcome measure</th>
<th>Jadad scale</th>
<th>Allocation concealment</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assar et al. (2000)</td>
<td>n = 505 Population of South Wales Volunteers trained in CPR or not Age range 23-56 years</td>
<td>1: Staged CPR teaching (2 hrs) 2: Conventional CPR teaching (2 hrs)</td>
<td>Multiple CPR skill comparisons (with no statistical adjustment) No. ventilations, No. chest compressions, hand position, and time to CPR</td>
<td>2</td>
<td>Not used</td>
<td>Staged teaching leads to better skills.</td>
</tr>
<tr>
<td>Atkinson et al. (1999)</td>
<td>n = 48 (n = 48)</td>
<td>1: CPR without instructions 2: CPR instructions on the phone 3: CPR instructions by video-link 4: Instructions given by instructor</td>
<td>1: Video self-training in CPR (25 min) 2: Conventional CPR teaching (4 hrs)</td>
<td>1</td>
<td>Not used</td>
<td>Video-link instructions were best. Telephone instructions were good. Previous training had no influence on skill.</td>
</tr>
<tr>
<td>Batcheller et al. (2000)</td>
<td>n = 202 Recruited from community Mean age 59.4 years</td>
<td>1: Perform regular CPR 2: Perform CPR with ACD device</td>
<td>Effective ventilation, effective compressions, and effective CPR delivery</td>
<td>2</td>
<td>Not used</td>
<td>Self-trained did generally better than conventionally trained.</td>
</tr>
<tr>
<td>Baubin et al. (1996)</td>
<td>n = 12 Professional rescuers Mean age 38.8 +/- 7.9 years</td>
<td>1: Retested at 3 months + refresher 2: Retested at 6 months + refresher 3: Retested at 1 year</td>
<td>Duration of CPR, quality of CPR, oxygen consumption, heart rate, and lactate level</td>
<td>1</td>
<td>Not used</td>
<td>Conventional CPR demands less energy than ACD and can be performed longer (29 min vs. 16 min).</td>
</tr>
<tr>
<td>Bordin et al. (1993)</td>
<td>n = 96 Nurses Mean age 28.7 +/- 7.1 years</td>
<td>1: Telephone prompt alongside manikin 2: No telephone prompt</td>
<td>Calling 9-1-1 for help</td>
<td>2</td>
<td>Not used</td>
<td>Group trained with prompt telephone remembered to call 9-1-1 more often.</td>
</tr>
<tr>
<td>Bilger et al. (1997)</td>
<td>n = 200 Medical (18%) and laypeople (82%) Mean age 38.4 years</td>
<td>1: CPR without instructions 2: CPR + education on heart disease 3: CPR + social support</td>
<td>CPR skills</td>
<td>2</td>
<td>Not used</td>
<td>Instructions every 6 months are necessary.</td>
</tr>
<tr>
<td>Capon et al. (2000)</td>
<td>n = 202 Auto industry employees 55% between 21-35 years</td>
<td>1: TV spots on CPR (60 sec) 2: Nothing</td>
<td>CPR skills</td>
<td>3</td>
<td>Not used</td>
<td>Both groups had similarly bad CPR skills.</td>
</tr>
<tr>
<td>Chamberlain et al. (2001)</td>
<td>n = 495 Population of South Wales Mean age 42 years</td>
<td>1: Staged CPR teaching (2 hrs) 2: Conventional CPR teaching (2 hrs)</td>
<td>Likelihood of returning for further training or retraining</td>
<td>2</td>
<td>Not used</td>
<td>Staged teaching led to higher likelihood of return visits to complete or repeat training.</td>
</tr>
<tr>
<td>Coleman et al. (1991)</td>
<td>n = 48 College students Age range 18-70 years</td>
<td>1: Self-taught class (4 hrs) 2: Conventional CPR teaching (4 hrs)</td>
<td>Written exam and skill exam according to Mandel check-list Time to continuous efforts No. compressions in 9 min.</td>
<td>2</td>
<td>Not used</td>
<td>Both groups were equivalent.</td>
</tr>
<tr>
<td>Dorph et al. (2003)</td>
<td>n = 26 Center for elderly Median age 78 years</td>
<td>1: Traditional Dispatch CPR 2: Compression only Dispatch CPR</td>
<td>Time to continuous efforts No. compressions in 9 min.</td>
<td>1</td>
<td>Not used</td>
<td>Poor CPR both groups; more chest compressions in group 2.</td>
</tr>
<tr>
<td>Donnelly et al. (2000)</td>
<td>n = 250 Laymen Age unknown</td>
<td>1: European Resuscitation guidelines 2: ILCOR guidelines 3: American Heart guidelines</td>
<td>CPR skills evaluated according to CARE and VIDRAP protocol</td>
<td>2</td>
<td>Not used</td>
<td>European and ILCOR guidelines appeared easier to learn; retention was poor irrespective of method.</td>
</tr>
<tr>
<td>Dracup et al. (1986)</td>
<td>n = 134 Heart disease patients Mean age 59 years</td>
<td>1: CPR teaching (90 min) 2: Heart disease education (90 min) 3: Nothing</td>
<td>Multiple adjective affect checklist, psychological adjustment to illness scale and CPR quiz.</td>
<td>1</td>
<td>Not used</td>
<td>Anxiety was worst in CPR group. Adjustment to illness was worst in CPR and education group compared with placebo.</td>
</tr>
<tr>
<td>Dracup et al. (1994)</td>
<td>n = 337 Family members of heart disease patients Mean age 59 +/- 10.5 years</td>
<td>1: CPR teaching only 2: CPR + education on heart disease 3: CPR + social support</td>
<td>24-item self administered questionnaire</td>
<td>1</td>
<td>Inadequate</td>
<td>Very positive feeling about CPR training without an increased sense of burden or responsibility compared with placebo.</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
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<tr>
<td>Moser et al. (1997) n = 674</td>
<td>Heart disease patients Mean age 62.9 +/- 10.1 years Family members Mean age 59.8 +/- 10.9 years</td>
<td>1 - CPR teaching 2 - CPR + education on heart disease 3 - CPR + social support</td>
<td>Multiple affective adjective checklist, psychological adjustment to illness scale and Spanier dyadic adjustment scale</td>
<td>1 - Inadequate</td>
<td>Patients cope better than family members received social support.</td>
<td></td>
</tr>
<tr>
<td>Dracup et al. (1998) n = 480</td>
<td>Parents of sick infants Mean age 29.9 +/- 8.4 years</td>
<td>1 - Conventional CPR class 2 - Conventional CPR class + social support 3 - CPR self-training video</td>
<td>Mandel CPR skill checklist, PAIS, multiple affect checklist and perceived social support scale</td>
<td>2 - Not Used</td>
<td>No difference between group 1 and 2; self-training may not be appropriate for that population.</td>
<td></td>
</tr>
<tr>
<td>Dracup et al. (2000) n = 335</td>
<td>Parents of sick infants Mean age 30 +/- 6 years</td>
<td>1 - Conventional CPR class 2 - Conventional CPR class + social support 3 - CPR self-training video</td>
<td>Psychological adjustment to illness, Spielberger state of anxiety inventory, McMaster family assessment device, PAIS</td>
<td>1 - Inadequate</td>
<td>CPR training increases adjustment to illness although anxiety is increased at first. Group 2 did best.</td>
<td></td>
</tr>
<tr>
<td>Monsieurs et al. (1996) n = 206</td>
<td>EMT-1; EMT-2; PM-1; PM-2</td>
<td>Pre-op CABG volunteer on/off pump; pulse check</td>
<td>Pulse present or no; Time delay before decision</td>
<td>2 - Not used</td>
<td>Diagnostic accuracy increases with training; overall sens. 90% and spec. 55%; delay 24-32 sec.</td>
<td></td>
</tr>
<tr>
<td>Eisenberg et al. (1995) n = 17,318</td>
<td>Washington households Head of household &gt;50 years</td>
<td>1 - CPR self-training video 2 - Nothing</td>
<td>Bystander CPR rate N = 65 cardiac arrests</td>
<td>2 - Not used</td>
<td>Sending a video to households does not increase bystander CPR.</td>
<td></td>
</tr>
<tr>
<td>Hallstrom et al. (2000) n = 520</td>
<td>9-1-1 callers Age unknown</td>
<td>1 - Instruction to do chest compression 2 - Instruction to do full CPR</td>
<td>Delivery of intervention and survival to hospital discharge</td>
<td>3 - Adequate</td>
<td>Group 1 more likely to complete instructions. Survival was similar.</td>
<td></td>
</tr>
<tr>
<td>Hawk et al. (1992) n = 84</td>
<td>University students Age unknown</td>
<td>1 - CPR + bystander education (2 hrs) 2 - CPR training alone</td>
<td>Helping behavior and appropriateness of intervention</td>
<td>4 - Adequate</td>
<td>Group 1 helped significantly more often; trend toward more appropriate intervention in group 1.</td>
<td></td>
</tr>
<tr>
<td>Kaczorowski et al. (1998) n = 44</td>
<td>Medical student Age unknown</td>
<td>1 - Video + unsupervised manikin practice at 3-5 months 2 - Booster training + supervised manikin practice at 3-5 months 3 - No booster training session</td>
<td>Neonatal knowledge and skill retention at 6-8 months</td>
<td>2 - Not used</td>
<td>No difference between groups. All groups performed significantly badly.</td>
<td></td>
</tr>
<tr>
<td>Kittson et al. (1986) n = 96</td>
<td>University students Age unknown</td>
<td>1 - Conventional CPR teaching 2 - CPR teaching with task behaviour 3 - CPR teaching with progressive part practice</td>
<td>19-item skill competency scale</td>
<td>1 - Not used</td>
<td>Innovative teaching methods were much more effective than conventional teaching.</td>
<td></td>
</tr>
<tr>
<td>Komlasky et al. (1990) n = 28</td>
<td>Parents of apneic infants Mean age 29.8 years OBGEP students Mean age 24.8 +/- 12.5 years</td>
<td>1 - CPR + home visit/manikin practice 2 - CPR + telephone/clinic follow-up</td>
<td>Spielberger state-trait anxiety inventory and CPR skills</td>
<td>2 - Not used</td>
<td>No difference in anxiety level or CPR skills between groups.</td>
<td></td>
</tr>
<tr>
<td>Liberan et al. (2000) n = 61</td>
<td>City employee Age unknown</td>
<td>1 - CPR theory review (3 pages) 2 - CPR video review (15 min)</td>
<td>CPR skills</td>
<td>1 - Not used</td>
<td>No difference between groups. Self-training video group did just as well.</td>
<td></td>
</tr>
<tr>
<td>Mandel et al. (1987) n = 67</td>
<td>Substance abuse mothers Mean age 28.6 +/- 5.3 years</td>
<td>1 - CPR teaching 2 - Conventional CPR training</td>
<td>CPR knowledge and skills</td>
<td>1 - Not used</td>
<td>Overall skills were similar; better compression rate in video group.</td>
<td></td>
</tr>
<tr>
<td>Mossner et al. (1993) n = 30</td>
<td>1st year nursing students Mean age 21 +/- 8 years</td>
<td>1 - JUST CD-ROM (60 min. training) 2 - Nothing</td>
<td>Positive helping attitude</td>
<td>2 - Not used</td>
<td>Conventional CPR teaching method led to better results.</td>
<td></td>
</tr>
<tr>
<td>Monsieurs et al. (2004) n = 41</td>
<td>Patients of sick infants Mean age 30.5 +/- 8.5 years</td>
<td>1 - Video on CPR 2 - Conventional CPR teaching 3 - Conventional CPR + social support 4 - Nothing</td>
<td>CPR attitude scale, willingness to attempt CPR, anxiety, sense of burden and feeling of loss of control</td>
<td>1 - Not used</td>
<td>Intervention groups performed better on all counts. Groups 2 and 3 performed better than group 1.</td>
<td></td>
</tr>
<tr>
<td>Moser et al. (1999) n = 305</td>
<td>Family members of heart disease patients Mean age 59 +/- 10.5 years</td>
<td>1 - CPR + education on heart disease 2 - CPR + social support</td>
<td>Multiple affective adjective check list and control attitudes scale</td>
<td>1 - Not used</td>
<td>Perceived control and emotional adjustment improved in both groups.</td>
<td></td>
</tr>
<tr>
<td>Study</td>
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</tbody>
</table>
| Nelson et al. (1984) | Medical students, hospital personnel, and laypeople | 1- Modular CPR class +/- 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.
| Ruppert et al. (1999) | Health care workers and laymen | 1- Using a live person | 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 et al. (1983) | University students | 1- Modular CPR teaching | CPR knowledge and skills. | 1 | Not used | Neither group could perform CPR after 9 weeks.
| Todd et al. (1985) | University students | 2- Conventional CPR teaching | Helping behaviour | 2 | Not used | Ambiguous situation and presence of many bystanders decreases helping behaviour. Training only influence nature of help provided.
| Su et al. (2000) | Paramedics | 1- Knowledge + manikin 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 et al. (2003) | Hospital mailing list | 1- Traditional CPR training (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 et al. (1998) | Medical students | 1- Video self-training (34 min) | Overall CPR competency and skills | 5 | Unclear | Video self-training led to superior competency and skills.
| Todd et al. (1999) | Baptist church-laymen | 1- Video self-training (34 min) | Written test, overall CPR competency and CPR skills measured at 12 months | 5 | Adequate | Video self-training led to similar competency and skills.
| Tom et al. (1998) | Laymen | 1- Conventional CPR class + peer coaching | CPR knowledge and skills | 1 | Not used | Outcome measure not influenced by peer coaching.
| Vanderschmidt et al. (1975) | School children | 1- Didactic teaching + manikin | CPR knowledge and skills | 1 | Not used | Group 1 did better. 11th grade students did better.
| Ward et al. (1997) | University students | 1- Didactic teaching only | 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 et al. (2001) | Paramedics | 1- Wallet size check list | CPR skills | 2 | Not used | Automated voice advisory manikin rapidly improves CPR skills. |
| Yakel et al. (1989) | Nurses 3 different wards | 1- Video self-training (34 min) | Written test, overall CPR competency and CPR skills measured at 12 months | 5 | Adequate | Video self-training led to similar competency and skills.
| Quasi-experiment Bang et al. (1999) | 2- Conventional CPR class | 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. |
| Berkbotha et al. (1975) | School children | 1- Conventional CPR teaching | 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. |
## Online appendix 3. Continued

<table>
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<tr>
<th>Study</th>
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</thead>
<tbody>
<tr>
<td>Boye (2002) n = 96</td>
<td>Non-medical personnel</td>
<td>1- Chest compressions with CPR-Ezy</td>
<td>Hand position; % effective compressions and rate</td>
<td>--</td>
<td>--</td>
<td>Hand position improved in 31% of group 2; rate and effective compressions improved in group 2; Video 2 more effective than video 1 (prototype) and conventional teaching. Also if &gt;40 years old.</td>
</tr>
<tr>
<td>Braslow (1997) n = 642</td>
<td>Laymen</td>
<td>1- Self-instruction video 1 (30 min)</td>
<td>Chest compression, ventilation, and overall CPR skills</td>
<td>--</td>
<td>--</td>
<td>All intervention groups shared similar CPR knowledge; CPR skills were best in group 3.</td>
</tr>
<tr>
<td>Braslow (1997) n = 350</td>
<td>Laymen</td>
<td>1- Self-training at home + observer</td>
<td>CPR knowledge and skills</td>
<td>--</td>
<td>--</td>
<td>Protocol phone instructions were better than impromptu instructions. Groups without prior CPR knowledge did as well as instruct.</td>
</tr>
<tr>
<td>Carter (1984) n = 143</td>
<td>Laymen</td>
<td>1- Protocol phone instruct/flow CPR</td>
<td>Helping behaviour (yes or no)</td>
<td>--</td>
<td>--</td>
<td>All intervention groups demonstrated improved propensity to help compared with control group. Group 3 did best.</td>
</tr>
<tr>
<td>Edwards (1985) n = 135</td>
<td>Oil company employee</td>
<td>1- Interactive video-disc CPR class</td>
<td>CPR knowledge, skills and retention</td>
<td>--</td>
<td>--</td>
<td>Knowledge and skills deteriorated at 3 months. Groups were similar. Group 1 started CPR components later, but were more effective. Both groups improved. No difference between groups.</td>
</tr>
<tr>
<td>Flosch (1995) n = 188</td>
<td>Laymen</td>
<td>1- Phone instruct. / no CPR training</td>
<td>Overall CPR effectiveness, time to ventilation and compression</td>
<td>--</td>
<td>--</td>
<td>Group 1 started CPR components later, but were more effective. Small group did better than large. Both groups improved. No difference between groups.</td>
</tr>
<tr>
<td>Gee (1996) n = 72</td>
<td>Nuns</td>
<td>1- Teaching classes of 6</td>
<td>CPR knowledge and skills</td>
<td>--</td>
<td>--</td>
<td>Small group did better than large. Both groups improved. No difference between groups.</td>
</tr>
<tr>
<td>Handley (1998) n = 48</td>
<td>Laymen</td>
<td>1- Thought 4-step sequence (2 hrs)</td>
<td>CPR skills</td>
<td>--</td>
<td>--</td>
<td>No difference between groups.</td>
</tr>
<tr>
<td>Hawke (1998) n = 98</td>
<td>University students</td>
<td>1- American Red Cross CPR</td>
<td>Helping behaviour (yes or no)</td>
<td>--</td>
<td>--</td>
<td>All intervention groups demonstrated improved propensity to help compared with control group. Group 3 did best.</td>
</tr>
<tr>
<td>Korttila (1979) n = 102</td>
<td>Army conscripts</td>
<td>1- 2 hour class/recording manikin</td>
<td>CPR skills (recorded), 3 different set of criteria</td>
<td>--</td>
<td>--</td>
<td>Nobody passed the test in 2-3 hour class with non-recording manikin; Manikin-trained group did much better. Overall no difference.</td>
</tr>
<tr>
<td>Lester (1997) n = 243</td>
<td>Middle or Junior High school students</td>
<td>1- CPR class taught by teacher + peer</td>
<td>CPR knowledge and skills</td>
<td>--</td>
<td>--</td>
<td>Girls did better than boys in group 2. Overall no difference.</td>
</tr>
<tr>
<td>Lind (1961) n = 466</td>
<td>Age range 12-14 years</td>
<td>1- 2 hour class/recording manikin</td>
<td>Quality of ventilations</td>
<td>--</td>
<td>--</td>
<td>Manikin-trained group did much better. Overall no difference.</td>
</tr>
<tr>
<td>Long (1990) n = 30</td>
<td>Parents of sick infants</td>
<td>1- Audio-visual CPR teaching</td>
<td>CPR knowledge and skills</td>
<td>--</td>
<td>--</td>
<td>No difference between groups.</td>
</tr>
<tr>
<td>Lucia (1999) n = 28</td>
<td>Health care professional</td>
<td>1- Sedentary CPR instructors</td>
<td>Heart rate, VO₂ max, and lactate levels for 18-min CPR session</td>
<td>--</td>
<td>--</td>
<td>Physical fitness may have a positive influence on resuscitation.</td>
</tr>
<tr>
<td>Noordergraaf (1997) n = 161</td>
<td>Medical students</td>
<td>1- Actar 911 manikin 1:1 ratio</td>
<td>CPR skills</td>
<td>--</td>
<td>--</td>
<td>No difference between groups.</td>
</tr>
</tbody>
</table>

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### Online appendix 3. Continued

<table>
<thead>
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<tbody>
<tr>
<td>Birkhäuser (1985)</td>
<td>Parents of healthy infant</td>
<td>60% between 25-35 years</td>
<td>CPR knowledge, self-efficacy and anticipated anxiety</td>
<td></td>
<td></td>
<td>CPR knowledge better, self-efficacy better and less anxiety.</td>
</tr>
<tr>
<td>Van Kerschavere et al. (1989)</td>
<td>School students</td>
<td>Age 12, 14, 17 and 20 years</td>
<td>CPR, knowledge, CPR skills and fear to apply CPR</td>
<td></td>
<td></td>
<td>Skills improved with repeated training unlike knowledge and fear.</td>
</tr>
<tr>
<td>Winchell et al. (1986)</td>
<td>Laymen and health care</td>
<td>20 different groups</td>
<td>CPR skills on recording manikin</td>
<td></td>
<td></td>
<td>Group 1 did better.</td>
</tr>
<tr>
<td>Beamant et al. (1978)</td>
<td>University students, age unknown</td>
<td>1: Info on diffusion of responsibility</td>
<td>Helping behaviour (yes or no)</td>
<td></td>
<td></td>
<td>Knowing about diffusion of responsibility improved helping.</td>
</tr>
<tr>
<td>Pan et al. (1989)</td>
<td>Targeted laymen, age &gt;40 years</td>
<td>1: Phone instructions provided to callers reporting cardiac arrest</td>
<td>CPR knowledge and skills on recording manikin</td>
<td></td>
<td></td>
<td>Delay in helping if larger group size, except in group 1.</td>
</tr>
<tr>
<td>Gomboski et al. (1982)</td>
<td>Laymen, age unknown</td>
<td>1: Teaching in 3 sessions (8 hrs)</td>
<td>CPR knowledge and skills at one year</td>
<td></td>
<td></td>
<td>No difference between groups.</td>
</tr>
<tr>
<td>Alvarez (1975)</td>
<td>High school students, age unknown</td>
<td>1: Medic II program (includes mandatory CPR class in high school)</td>
<td>CPR knowledge and skills at 12 months</td>
<td></td>
<td></td>
<td>Did well on written exam.</td>
</tr>
<tr>
<td>Becker (1999)</td>
<td>Population based, age unknown</td>
<td>1: Public service announcements teaching CPR on TV</td>
<td>Rate of bystander CPR for 289 cardiac arrests</td>
<td></td>
<td></td>
<td>Fair results on skill testing.</td>
</tr>
<tr>
<td>Birchler (1983)</td>
<td>School children, age range 10-12 years</td>
<td>1: First aid and infant CPR via video, lecture, demonstration, and practice</td>
<td>CPR skills</td>
<td></td>
<td></td>
<td>Young children can learn to do infant CPR well.</td>
</tr>
<tr>
<td>Bosma (1989)</td>
<td>High school students, age unknown</td>
<td>1: System for training and assessing resuscitation skills (STARS)</td>
<td>Number of errors and time to reach preset criterion for CPR skill</td>
<td></td>
<td></td>
<td>Delayed prompting technique did best.</td>
</tr>
<tr>
<td>Conroy (1990)</td>
<td>Post-partum mothers, age unknown</td>
<td>1: 17 min video, 20 min lecture, and manikin practice. Revision in 2nd time.</td>
<td>CPR knowledge</td>
<td></td>
<td></td>
<td>Knowledge increased but not maintained at 6 months.</td>
</tr>
<tr>
<td>Cully (1991)</td>
<td>9-1-1 callers, age unknown</td>
<td>1: Phone instructions provided to callers reporting cardiac arrest</td>
<td>Bystander CPR rate and survival to hospital discharge</td>
<td></td>
<td></td>
<td>Fair results on skill testing.</td>
</tr>
<tr>
<td>Curry (1987)</td>
<td>Health care professional, age unknown</td>
<td>1: Conventional CPR training</td>
<td>CPR knowledge and skills at 6 and 12 months</td>
<td></td>
<td></td>
<td>Trend toward improvement in survival.</td>
</tr>
<tr>
<td>Doherty (1984)</td>
<td>Flemish population, age unknown</td>
<td>1: TV flashed with goal to promote CPR classes, followed by survey</td>
<td>Awareness, understanding, and commitment to take CPR class</td>
<td></td>
<td></td>
<td>Knowledge and skills back to pre-test level at 6 and 12 months.</td>
</tr>
<tr>
<td>Sunde (1998)</td>
<td>Laymen, age unknown</td>
<td>1: Mass mailing calendars with CPR</td>
<td>CPR skills</td>
<td></td>
<td></td>
<td>Awareness and understanding increased. Commitment to take CPR class mainly in &gt;25 years old.</td>
</tr>
<tr>
<td>Pane (1989)</td>
<td>Targeted laymen, age &gt;40 years</td>
<td>2: Calendar +/- manikin to take home</td>
<td>Demographic data compared with previous mass training event</td>
<td></td>
<td></td>
<td>The &gt;60 age group doubled. More family members of cardiac patients.</td>
</tr>
<tr>
<td>Eisenberg (1985)</td>
<td>9-1-1 callers, mean age 53.5 +/- 16.6 years</td>
<td>1: Phone instructions provided to callers reporting cardiac arrest</td>
<td>Bystander CPR rate and survival to hospital discharge</td>
<td></td>
<td></td>
<td>CPR knowledge better.</td>
</tr>
</tbody>
</table>

### Before-after

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<td>Before - after</td>
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### Online appendix 3. Continued

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<tr>
<td>Case-control</td>
<td>Goldberg</td>
<td>Cases 1: Family members of heart disease patients</td>
<td>Control 1: Family members of non-cardiac patients 2: Random neighbourhood control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1984)</td>
<td></td>
<td>Previous CPR training status (yes or no)</td>
<td>6/9</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>n = 501</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohort study</td>
<td>Jackson</td>
<td>Cohort 1: Victims of cardiac arrest at home</td>
<td>Control 1: Victims of cardiac arrest in a public venue</td>
<td></td>
<td></td>
<td>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 1.1-2.2)</td>
</tr>
<tr>
<td></td>
<td>(1997)</td>
<td></td>
<td></td>
<td>6/9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 927</td>
<td></td>
<td></td>
<td></td>
<td></td>
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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 = psychological adjustment to illness scale; CABS = coronary artery bypass graft; CEGEP = collège d'enseignement général et professionnel; BLS = basic life support; BCLS = basic cardiac life support; CPR-Ezy = manufacturer trademark.