Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
Three alternative cardiopulmonary resuscitation (CPR) and defibrillation training strategies for laypersons were examined in the study. The strategies were CPR/defibrillation training alone, training combined with home defibrillator purchase, and no training.

Type of intervention
Other (public health/education).

Economic study type
Cost-utility analysis.

Study population
The 'target population' was represented in the study by a hypothetical cohort of working-age trainees aged 20 to 65 years. The authors assumed that trainees had probabilities of living with children, other adults younger than 65 years, and elderly persons, that approximated the rates reported in the US Census Bureau's American Housing Survey (2001). Hypothetical trainees were placed at average risk of encountering cardiac arrest in public settings.

Setting
The setting was the community. The economic study was carried out in the USA.

Dates to which data relate
In defining the model inputs, the authors drew on effectiveness evidence published between 1992 and 2004. In estimating resource use (training costs and costs related to the treatment of cardiac arrest), the authors cited references published between 1998 and 2004 and two convenience surveys, presumably in 2004. The price year was 2004.

Source of effectiveness data
The effectiveness data were derived from a review or synthesis of completed studies, and from estimates of effectiveness based on opinion.

Modelling
A Markov model with 60 monthly transitions simulated the experiences of the hypothetical trainee cohort. The authors modelled 5 years of cardiac arrest encounters. The authors also performed a Monte Carlo analysis of 500 trials of 1,000 patients each, in which every parameter was allowed to vary independently or simultaneously. Full details of the structure of the model were presented in the paper.
Outcomes assessed in the review
The model inputs were either drawn directly from a literature review or represented authors' opinions within the ranges from published literature. Those model inputs taken directly from publications included:

- community factors (fraction of the population already having training alone or training plus purchase; annual incidence of out-of-hospital cardiac arrest),
- cardiac arrest risk,
- location of out-of-hospital cardiac arrests, and
- trainee or household factors (trainee mortality; household composition).

An important input to the model, the survival rate to hospital discharge in out-of-hospital cardiac arrest patients without bystander CPR, was clearly included in the model. It appears to have come from the literature but, oddly, its baseline value was neither directly reported nor referenced.

Study designs and other criteria for inclusion in the review
Not reported.

Sources searched to identify primary studies
Not reported.

Criteria used to ensure the validity of primary studies
Not reported.

Methods used to judge relevance and validity, and for extracting data
Not reported.

Number of primary studies included
The authors reported approximately 37 studies as sources of effectiveness evidence.

Methods of combining primary studies
The primary studies were not formally combined. The authors investigated the possibility of a meta-analysis to establish the effectiveness of bystander CPR but did not carry it out. They reported the results of 3 studies on the effectiveness of bystander defibrillation but did not formally combine them to formulate an estimate.

Investigation of differences between primary studies
The studies used for direct inputs were mainly national survey statistics. Hence, investigations of differences were not imperative. The meta-analysis of published studies in bystander CPR was declared impossible because of substantial and, by implication, insurmountable, heterogeneity.

Results of the review
The results of all the outcomes assessed in the review are reported here in the format of baseline value (range; distribution).

The fraction of the population trained in CPR alone was 0.2 (0.05 - 0.3; logistic), while the fraction of the population...
trained in CPR/defibrillation was 0.025 (0.01 - 0.10; logistic).

The annual incidence of out-of-hospital cardiac arrest, per million population, was 1,080 (1,020 - 1,140; Poisson).

The cardiac arrest risk per million individuals was 4 (2 - 8; Poisson) in children, 247 (124 - 494; Poisson) in adults aged 45 years, and 8,590 (5,000 - 21,000; Poisson) in adults aged 65 years.

The location of cardiac arrests was distributed among private residences (84.3%), small public settings (11.1%), moderate public settings (3.3%), large public settings (1.1%) and very large public settings (0.2%).

Annual trainee mortality rate was set at 0.00305 (0.001 - 0.01; lognormal).

The probabilities for trainee household composition were invariant:

- living alone, 0.17;
- living with 1 adult only, 0.69;
- living with 2 adults, 0.12;
- living with 3 adults, 0.02; and
- presence of children, 0.36.

The probability that elderly adults aged 65 years lived in the household was 0.08 (0.05 - 0.1; logistic).

The effectiveness of bystander CPR was modelled as a relative rate of increase in survival (versus no treatment) of 2 (1.2 - 3.6; lognormal).

The effectiveness of bystander CPR/defibrillation was modelled as a relative rate of increase of 4 (1.5 - 6; lognormal).

**Methods used to derive estimates of effectiveness**
The authors made assumptions to derive some estimates.

**Estimates of effectiveness and key assumptions**
The authors made assumptions to derive the baseline values of some model inputs. Such model inputs included the number of bystanders in different locations and the effectiveness of CPR/defibrillation (relative rate of increase in survival with bystander CPR; relative rate of increase in survival with bystander CPR/defibrillation).

**Measure of benefits used in the economic analysis**
The outcome measure used was the quality-adjusted life expectancy of cardiac arrest survivors. The authors reported that they measured this using the results from a study that measured health care utilities with the Health Utilities Index Mark-3 questionnaire, long-term outcomes from clinical trials enrolling patients with ventricular arrhythmia, and their own published models of life expectancy for cardiac arrest survivors (1997 to 2002). It was not reported how these studies were combined to produce a single measure of benefit.

**Direct costs**
Discounting was carried out at an annual rate of 3%. The quantities and costs of providing training programmes in 2004 were estimated separately, using a convenience survey of training programmes. The downstream health care costs accrued by additional cardiac arrest survivors over their remaining years of life and the hospitalisation cost of a resuscitated patient dying in hospital were estimated from models published between 1997 and 2002, but the quantities of resources consumed were not reported. The purchase cost of a defibrillator was estimated from a convenience survey.
of distributors. The hospitalisation cost of a resuscitated patient who did not die in hospital does not appear to have been included. The quantities and costs of trainee time spent on training programmes in 2004 were estimated using the programme survey and the average wage, according to the US Department of Labor.

Statistical analysis of costs
The costs were treated deterministically in the base-case analysis. In the Monte Carlo simulations, the costs were drawn from a probability distribution as for all inputs.

Indirect Costs
Productivity losses for the cardiac patients were not included.

Currency
US dollars ($).

Sensitivity analysis
Sensitivity analyses were performed on all input variables to the model. Once threshold cost-effectiveness values for key inputs had been determined, the authors tested several alternative CPR/defibrillation training scenarios. Finally, a Monte Carlo simulation was performed with 500 trials of 1,000 patients each, for which each input was allowed to vary independently and simultaneously over a specified probability distribution. The ranges (in contrast to baseline point estimates) were mainly derived from the range of point estimates in the literature.

Estimated benefits used in the economic analysis
Training unselected laypersons in the use of CPR/defibrillation yielded an average of 2.7 quality-adjusted life-hours per trainee. The addition of a home defibrillator yielded an additional 5.4 quality-adjusted life-hours per trainee.

Cost results
The expected cost per trainee of training in CPR/defibrillation was $62, while the expected cost per trainee of training plus purchase was $1,587. The expected cost of no training was $0.

Synthesis of costs and benefits
The estimated benefits and costs were combined via incremental cost per quality-adjusted life-year (QALY) ratios.

The incremental cost per QALY of training alone versus no training was $202,400 per QALY gained.

The incremental cost per QALY of training plus purchase versus training alone was $2,489,700 per additional QALY gained. The sensitivity analyses indicated that the effectiveness of CPR in improving cardiac arrest outcomes was the most influential factor in the model.

Training cost less than $100,000 per QALY only if CPR without defibrillation increased cardiac arrest survival by at least 12%.

CPR/defibrillation training cost less than $100,000 per QALY if average survival was 8.4 QALYs, or if fewer than 5% of adults were already trained in CPR.

Training cost less than $75,000 per QALY if the cardiac arrest risk of the trainee's household exceeded 4.8 times the national average.

Purchase of a home defibrillator cost less than $100,000 per QALY if the device cost less than $5, or if the cardiac arrest risk of the trainee's household exceeded 32 times the national average.
Certain sub-populations suggested better cost-effectiveness in targeted training scenarios. For example, training the spouse of a 50-year-old survivor of a recent myocardial infarction cost $47,900 per additional QALY.

Authors' conclusions
Unselected training of laypersons in cardiopulmonary resuscitation (CPR) and defibrillation cost over $200,000 per quality-adjusted life-year (QALY) gained. Training became more efficient when the training cost and duration were substantially reduced, or when trainees lived with persons who were elderly or had cardiovascular disease.

CRD COMMENTARY - Selection of comparators
The comparators were explicitly justified on the basis that widespread training of the general adult population in CPR has long been the policy goal of many national (USA) and international health organisations. You should decide whether it is a relevant policy goal in your own health care setting.

Validity of estimate of measure of effectiveness
The authors did not state that a systematic review of the literature was undertaken. They appear to have used data from the available studies selectively. They also did not provide an appropriate justification for their choices of certain key effectiveness variables, where the literature informed but did not supply, the precise estimates used. The impact of differences between the primary studies was not considered when estimating effectiveness. The estimates were investigated in sensitivity analyses, using ranges that appear to have been appropriately supported by the literature.

Validity of estimate of measure of benefit
The estimate of benefit was modelled using results from several studies. As the method of derivation in each study and the method of combining the results were not described, it is impossible to comment on the validity of this approach. The instrument used to measure utilities was the Health Utility Index Mark-3, but it was unclear which values were measured or whether measurement was carried out appropriately. These issues make it difficult to accept the authors' conclusions at face value, as the elicitation of benefit (the key driver in a cost-utility analysis) was not transparently presented.

Validity of estimate of costs
All the categories of cost relevant to the societal perspective adopted were included in the analysis. The costs and the quantities were not reported entirely separately. The authors used the price of training programmes as a proxy for their prices, which may have resulted in some overestimation. The downstream health costs were estimated from other published models, again resulting in a lack of clarity around the estimates. It is difficult to judge whether costs were modelled and valued appropriately. A sensitivity analysis of the prices or total costs was conducted, using ranges that appear to have been appropriate. A sensitivity analysis of the quantities was not conducted. The authors reported updating prices to 2004 dollars, though the method of doing so was not presented.

Other issues
The authors did not make substantial comparisons of their findings with other studies, except to say that prior findings suggested that CPR training programmes do not attract enough trainees who face high likelihoods of encountering cardiac arrest. The issue of generalisability to other settings was not addressed and would not be possible based on this report alone. The authors did not report their results selectively and their conclusions reflected the scope of the analysis.

The authors reported a number of further limitations to their study. First, the possible overestimation of the prevalence of resuscitation training in the general population. Second, the possible underestimation of the true incidence of cardiac arrest. Third, many estimates were derived from single studies and the data informing several model variables were limited. Fourth, the possible underestimation of the benefit of bystander CPR. Fifth, the absence of modelling of skill deterioration over time. Sixth, the assumption that the trainees would always be present at arrests occurring in households. Finally, the assumption that the presence of more than one capable trainee at a cardiac arrest did not add
health benefit to the patient.

**Implications of the study**
The authors recommended that the time, effort and money expended on resuscitation training should be proportional to a trainee's risk of encountering cardiac arrest and, therefore, targeted recruitment efforts should be encouraged. Unselected training is costly in comparison with other health initiatives.

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