Studies in CPR training

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Declaration

I, Dr Peter Duncan Donnelly, declare that

- this thesis has been composed by myself
- that it is a result of my own work (the contribution of other members of the research team being shown in Appendix D)
- that I am a graduate of Edinburgh Medical School (MB ChB, 1985)
- that I have not submitted this thesis in candidature for any other degree, diploma or professional qualification.

26/3/99

Dr Peter D Donnelly Date

THE UNIVERSITY OF EDINBURGH

ABSTRACT OF THESIS

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This dissertation describes the development of a robust test of manikin cardiopulmonary resuscitation (CPR) performance "The Cardiff Test". The test consists of two parts. Firstly the Cardiff test of response and evaluation (CARE) assesses all of those actions important to basic life support up to that point at which chest compression and mouth to mouth ventilation begin. This includes the careful approach, the opening of the airway and casualty assessment. Secondly the video and recording Anne printout (VIDRAP) evaluates the key psychomotor skills of chest compression and mouth to mouth ventilation. In each part of the test the development of marking schedules and marking guidance is key in reducing inter and intra observer error. The advantageous and novel element of combining video recording with manikin printout is fully described. The dissertation then describes how "The Cardiff Test" was used to test the skills of 280 trainees from 9 UK cities six months after they had been trained as part of the BBC 999 road show training initiative. The innovative "cold call" methodology sought to replicate some of the immediacy and stress of a true cardiac arrest in the home. When faced unforewarned with a scenario of full cardiopulmonary arrest 6 months after training only 12% of trainees could perform effective CPR and of these 5% performed at least one element of CPR in a potentially injurious way. The majority of trainees (89%) failed to open the airway at the correct time and failed to say spontaneously that they would call an ambulance (90%). The possible reasons for, and implications of, these results are discussed as are the lessons learned from using television as a means of trainee recruitment when compared to other non-targeted means, namely; a community word of mouth approach or an approached based on editorial coverage in a local newspaper. The relevant literature is reviewed in detail and reprints of peer reviewed publications resulting from the development of the two part test and the BBC 999 evaluation are included in the appendices.

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List of Tables and Figures (by Section)

I - ACKNOWLEDGEMENTS

I ACKNOWLEDGEMENTS

Heartstart Cardiff and the Vale is funded by Bro Taf Health Authority and affiliated to the British Heart Foundation Heartstart Programme who also provided specific funding for this initiative. The co-operation of the British Broadcasting Corporation 999 editorial team is acknowledged.

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II - SYNOPSIS

II SYNOPSIS

This dissertation describes the development of a robust test of manikin cardiopulmonary resuscitation (CPR) performance "The Cardiff Test" and its application to the BBC's 999 television roadshow CPR training initiative.

The initiative trained over 8,000 individuals in 10 UK cities. Recruitment was undertaken on prime time television as part of the BBC 999 programmes, broadcast between April 8th and June 10th 1994. The innovative "cold call" video and printout based assessment that was developed, replicated some of the immediacy and stress of a true cardiac arrest in the home and minimised inter and intra observer variation in evaluation.

The socio demography of the recruited cohort is compared with that of the 999 audience and that of the UK population as a whole as well as with that of cohorts generated by other non targeted recruitment approaches. These approaches have been utilised by Heartstart Cardiff and the Vale, a community emergency life support programme of which the author is co-founder and honorary medical director.

The dissertation is arranged in the following way.

After laying out the specific questions to be addressed, the relevant literature is reviewed. First the epidemiology of ischaemic heart disease is very briefly covered before the history and development of cardiopulmonary resuscitation is examined in more depth. Attention is in turn focused upon; the early history of CPR, the coming of closed chest CPR, the safety of CPR, the mechanism of CPR effect, predictors of long term survival, rates of long term survival, quality of survival, recent innovations and new techniques, standard setting through guideline generation, and finally the ethics of resuscitation.

The next section of the literature reviews looks at each link of the chain of survival concept of cardiac arrest management in turn. Thus; achieving early access to services, the contribution of bystander CPR, the importance of early defibrillation and the contribution of Advanced Cardiac Life Support are each addressed. Attention is then turned to systems based analysis of the emergency medical services. The last two sections of the literature review cover the evaluation of CPR learning and retention and recruitment strategies for CPR training cohorts respectively

The development of a robust test - "The Cardiff Test" is then described in detail. There are two components to the test. Firstly, the Cardiff Assessment of Response and Evaluation (CARE) assesses all of those actions central to basic life support up to that point at which chest compression and mouth to mouth ventilation would begin. This includes the careful approach, the opening of the airway and casualty assessment. The

second part of the test, the Video and Recording Anne printout (VIDRAP) then evaluates the key psychomotor skills of chest compression and mouth to mouth ventilation. In each case the development of marking schedules and marking guidance is key in reducing inter and intra observer error. The advantageous novel element of combining video recording with manikin printout is fully described.

The next section details the methodology of the study of the BBC 999 training cohort. Briefly, a 6% sample (280 individuals) were visited unforewarned at home six months after initial training and asked to react to a standard scenario. This was of simulated, full adult cardiopulmonary arrest and required them to perform CPR on a recording manikin without time for revision or reflection, whilst under the added stress of being video taped. Results showed that only 12% of trainees could perform effective CPR and that of these 12 per cent, 5% performed at least one element of CPR in a potentially injurious way. The majority of trainees failed to open the airway at the correct time (89%) and failed to say spontaneously that they would call an ambulance (90%).

Overall younger people were more likely to give effective CPR as were those who had attended a retraining course. Social class and sex did not predict effectiveness but confidence did predict better performance whilst females were less likely than males to be potentially injurious.

The possible reasons for and implications of these results are fully discussed as are the lessons learned from using television as a means of recruitment when compared with other non-targeted means, e.g. a community word of mouth approach or a local newspaper based approach. Conclusions are then drawn from both the process of test development and the study results, and areas of possible further work are highlighted.

Appendix A then provides copies of relevant 999 material including the course syllabus and the study questionnaire. Appendix B provides a photograph of "the Cardiff test" being administered and Appendix C an exemplar manikin printout. The exact role of each member of the research team is laid out in Appendix D. Appendix E provides copies of the three peer reviewed published papers which have arisen from this work. Appendix F provides a glossary of terms and abbreviations.

Finally the thesis is fully referenced in Harvard format.

III - INTRODUCTION

III INTRODUCTION

Heartstart Cardiff and the Vale came into being in 1993. It was created in response to Welsh Office encouragement to all Health Authorities to put into place cardio-pulmonary resuscitation (CPR) training programmes for members of the general public. The local Health Authority, which was then South Glamorgan Health Authority, discharged this responsibility by contracting for such a service with the Centre for Applied Public Health Medicine (a part of the University of Wales College of Medicine). This raised the interesting possibility of running the training programme in a way which facilitated evaluation. The author thus took on the responsibility of becoming medical director and lead researcher, and appointed a project manager and research officer utilising Health Authority funding.

The British Heart Foundation then contributed two grants. One for a schools based project (which is not described here) and the other for the BBC 999 project, a description of which forms the basis of this dissertation. At the time of writing Heartstart Cardiff and the Vale has trained over 30,000 individuals in the technique approved by the European Resuscitation Council (ERC 1992) by utilising an adaption of the Gothenburg cascade training method (personal communication, Stig Holmburg). The related research projects have generated a number of publications and ongoing funding has been obtained.

The British Broadcasting Corporation is licensed by Royal Charter as the national broadcasting service. It guards jealously its editorial and operating independence and continues to carry the strong ethos of public service envisaged by its founder Lord Reith. His conviction was "that broadcasting had great potential not only as a medium for entertainment but as a source of information and enlightenment, universally available". (BBC information pack) The 999 programme is an example of the result of such an ethos. This show manages to convey important and well researched safety and first aid information in an unashamedly populist way through the recreation of incidents of dramatic rescue. The programme regularly attracts an audience of 10 million (JICTAR ratings, 1996) and occupies a prime time viewing spot, usually on Friday evenings.

As part of the 999 programme the BBC runs an emergency life support training roadshow which includes instruction in CPR. This tours the country laying on weekend training courses in CPR for the general public. They are advertised on the programme broadcast two weeks in advance and members of the public are encouraged to telephone and register their interest in training. Up to 1,000 spaces are made available. These are universally oversubscribed: in 1994 50,000 people rang for 10,000 places. A percentage of those booking fail to attend but a degree of compensatory overbooking results in an average attendance of 950.

The training is provided by members of voluntary organisations. In 1994 these were the St John (and in Scotland St Andrew) Ambulance Association, the Red Cross and the

Royal Life Saving Society. All agreed to provide their services without charge and to teach CPR in accordance with a syllabus which conformed to ERC guidelines.

Members of the public were not charged for their attendance and on completion of the course received a BBC 999 information pack. The BBC readily agreed when we approached them with a view to collaborative research and the British Heart Foundation provided the necessary grant for the study.

The questions to be addressed by the research

I was interested in addressing the following questions:

1. Would the proposed means of recruitment be successful in generating large numbers of potential trainees?

2. Are those recruited for training typical in socio-demographic terms of either the general population or of the programme television audience?

3. How do they compare in socio-demographic terms as a group with those recruited by other non targeted means?

4. Are they at least as likely as those recruited by other non targeted means to live with someone with a history of heart disease and thereby be more likely to

be able to use their skills, given that most cardiac arrests occur at home?

And in particular whether;

5. it was possible to develop a robust test of manikin CPR performance which simulated a real life event?

and

6. By utilising such a test could we ascertain whether six months after training individuals would be capable of correctly performing cardiopulmonary resuscitation without warning and whilst under stress?

By answering these questions it was hoped to be able to:

- make available through the literature a robust test of CPR manikin performance,

- draw conclusions about the effectiveness of the current BBC Roadshow programme and thereby,

- help the BBC in the further development of their training initiative.

IV - LITERATURE REVIEW

IV LITERATURE REVIEW

Epidemiology of Ischaemic Heart Disease

Ischaemic heart disease is rivaled only by Cancer as the most common cause of death in the UK for men over 45 and women over 65 (British Heart Foundation 1996). Each year approximately 150,000 individuals in the UK per million die from this cause. Myocardial infarction is the single most common serious manifestation of ischaemic heart disease. Around 40% of patients die with 76% of total mortality occurring outside hospital (Norris 1998). These early deaths are mostly due to acute arrhythmias usually ventricular fibrillation (Eisenburg et al 1979 and Sedgwick et al 1994), often occurring without any warning and are thus not amenable to advances in inpatient cardiac care. Deaths amongst younger age groups are particularly likely to occur in the community with 90% of fatalities at age < 55 and 70% of those at age 65-74 happening outside hospital (Norris 1998). The UK rate of death from ischaemic heart disease has been falling in line with that in other developed countries and is predicted to continue to fall (Osmond 1991) but large discrepancies still exist across social class (Rose et al 1991) and geographical divisions within the UK and between countries world-wide (British Heart Foundation, 1998).

An explanation for these discrepancies has been eagerly sought in the hope of informing preventative strategies. Certainly active and possibly passive cigarette smoking (Barbash 1995), obesity, lack of exercise, diabetes, high blood pressure and high

cholesterol levels are associated with increased risk. However reversing them has proven difficult and sometimes initially controversial (Law 1994). The major risk factors of being male and getting older are not avoidable. Disagreement over the reliability (Kee et al 1994) and independence of family history as a factor appears to be resolved (Roncaglioni et al 1992 & Perkins 1986). But again it is not a risk amenable to treatment. Similarly if the considerable body of work now produced by the Southampton group and others (Barker et al 1989) (Lauer 1991) is accepted then the degree of mortality pre-programming is considerable and perhaps dependant upon pre-natal nutrition (Collee 1995).

Thus we are forced to accept that only some risk factors are avoidable and then often only with difficulty (Osler et al 1995, Oxcheck study group 1994, Pyorala et al 1994, Luepker et al 1994 & Family Heart Study Group 1994). The success of the tobacco and dietary industries depends largely on their addictiveness and ineffectiveness respectively. So whilst we must encourage people to stop smoking and moderate weight through exercising more and eating less (particularly saturated fats), we must also accept the need to provide care for the victims of this continuing epidemic, which even based on extrapolations of today's downward trend will still give rise to more than 116,000 deaths per year by the year 2004. Secondary prevention has a role for initial survivors and stopping smoking (Manson et al 1992) and dietary modification (Lorgeril et al 1994) are helpful. Married victims are more likely to survive (Chandra et al 1983) and the benefits of physical (British Cardiac Society 1992) and psychological rehabilitation are proven (Jones and West, 1996).

Inpatient care of myocardial infarction, has seen a number of important developments in recent years. Twenty years ago the value of coronary care units could legitimately be questioned (Colling et al 1976). This has changed with the introduction of thrombolytic agents which have been accepted as effective and generally safe. When used in combination with aspirin under optimal conditions they reduce mortality by around 40 per 1,000. Other pharmacological agents particularly beta-blockers, aspirin and more recently statins continue to have a role following recovery from infarction and the afore-mentioned physical and psychological rehabilitation, dietary and lifestyle changes hasten recovery and prevent relapse. However none of these advances help those myocardial infarction victims who die within the first hours, often at home. For some reason the role of prehospital thrombolysis remains controversial despite positive study results (Rawles 1998, Rawles 1997) and delays in seeking help following symptom onset appear almost universal (Ho 1991).

For a few people, especially those with an established history of repeated life threatening arrythmias, an implantable defibrillator may be an option. But to the vast majority with no relevant prior history this is neither practical nor warranted. In some cases prodromal symptoms are few, and in some others, coronary arteries may show no obstructive lesions (Brecker et al 1993). More usually there is nothing to distinguish the likely victim of sudden cardiac arrest from those more generally at risk of CHD (Kannel et al 1975 & Shaper et al 1986).

For those patients (approximately 155,000 per year in the UK) who do suffer cardiac arrest, survival is dependent on their arrhythmia being rapidly converted into a productive one thus restoring cerebral and coronary blood flow. This is achieved by external cardiac defibrillation. Recent advances in defibrillator technology, in particular in rhythm recognition, means that these machines can now be used by a wider range of less specialised staff or even lay individuals. A number of factors predict the likely success of defibrillation. Principally the faster the better, with each minute's delay in the non-resuscitated individual decreasing chances of successful cardioversion by approximately 10%.

The provision of rapid high quality bystander cardiopulmonary resuscitation is also important and more likely to occur when the arrest occurs outside of the home (Litwin et al 1987). In particular; it increases the length of time the patient stays in a potentially salvageable rhythm, i.e., ventricular fibrillation (VF), improves chances of survival to admission and decreases mortality following admission. As 76 % of arrests occur at home, the role of the relative 'bystander' is of crucial importance (Litwin et al 1987).

Respiratory arrest (Jones et al 1995) and arrests in young people (Safranek et al 1992 & Weiss et al 1991) are distinct in their aetiology with a greater likelihood of the involvement of toxic substances and less events of cardiac origin. They are amenable to intervention by Emergency Life Support (ELS) services set up primarily for cardiac incidents but will not be further considered here. Other aspects of the so called chain of survival, namely early access and advanced cardiac life support, will be discussed in due

course, but firstly it is necessary briefly to examine the history and development of cardiopulmonary resuscitation.

The history and development of cardiopulmonary resuscitation Early History

Rosenthal (1987) quotes William Harvey in his work "On the motion of the Heart and blood" published in 1675.

"Experimenting with a pigeon upon an occasion after the heart had wholly ceased to pulsate and the auricles too had become motionless, I kept my finger wetted with saliva and warm for a short time upon the heart and observed that under the influence of this formentation it recovered new strength and life, so that both ventricles and auricles pulsated, contracting and relaxing alternately, recalled as it were from death to life".

This would appear to constitute one of the earlier animal studies of resuscitation. Attempts at resuscitation or reanimation of humans had been described even earlier - indeed in biblical times (Paraskos 1992) but perhaps Harvey's work is a reasonable starting point from which to chronicle our developing fascination with the act of reviving the apparently dead.

Berden records that in 18th century Holland, mouth to mouth or mouth to nose resuscitation was frequently practised by members of a "Society to rescue people from

drowning" (Berden 1993) and in the 19th century the work of Schiff (Pearson 1965) is seen as the first successful use of open-chest cardiac massage in an animal model. His work led to an attempt by Niehaus to perform human open chest CPR and the first known survivor of such an open chest approach was reported by Ingelsrud in 1901 (Rosenthal 1987). By 1953 Stephenson (Stephenson et al 1953) was able to report on 1,200 cases of arrest managed by open chest CPR with highly creditable survival rates of 28%.

The coming of closed chest CPR

However such techniques were of necessity, limited in terms of where and by whom they could be applied. After successful animal experiments Kouwenhoven (1960) and his colleagues, in a landmark paper described the technique of closed chest CPR in humans. The outstanding results achieved (100% initial survival, 70% defect free survival at 10 months) have never been repeated and subsequent papers, as discussed elsewhere in this review have shown much lower survival rates. However in the years between the Kouwenhoven and subsequent papers the transition from open to closed chest resuscitation had occurred without there ever being a randomised controlled trial.

The Safety of CPR

Safety is a difficult concept to hold in perspective in a situation where resuscitation is required. If nothing is done the patient is guaranteed the ultimately dangerous outcome

of death. However minimising injury - particularly injury that may jeopardise recovery is clearly important. Powner and colleagues (1984) reviewed autopsy reports carried out on 76 victims of unsuccessful resuscitation and found one abnormality secondary to CPR in 40% and two or more complications in 11%. Fractured ribs and sternum and bone marrow emboli were thought probably not to be life threatening.

However others have suggested that CPR related injuries may be highly significant. For example the six flail chested patients in Bjork's (1982) study, all died. There are also reports of splenic (Stallard 1997) and gastric (Reiger 1997) (Oh 1998) rupture. Fatal Gastro-oesophageal lacerations (McGrath 1983) and Mallony-Weiss syndrome (Norfleet et al.1990) also occur as occasionally does Pneumoperitoneum (Hartoko, 1991). Ultrasonography has been suggested as a noninvasive way of assessing complications (Corbett 1997). Further anecdotes of injury and death after possibly unnecessary or inappropriate CPR administration exist (Duncan 1985). Thus safety comprising attention to personal (rescuer) safety, careful assessment and good techniques are important teaching and testing points if allegations of harm are to be avoided.

The mechanism of CPR effect

Following the widespread adoption of external CPR, speculation on the mechanism of its efficacy in cardiac arrest continued. Originally it was assumed that chest compression was creating an artificial systolic phase through mechanical ventricular

compression between the sternum and vertebrae. Under this model the removal of sternal compression was seen merely as a passive phase allowing ventricular refilling.

However this theory did not explain a number of observations. For example why did patients with flail chest not respond as readily to CPR and indeed as has been mentioned in one series, so frequently died (Bjork et al 1982). This suggested that the mechanical integrity of the thoracic cage was important and a series of ingenious and careful investigations eloquently described by Berden (1993) gave rise to the alternative "thoracic pump theory".

The experimental physiological support to this alternative model was supplied by Nieman (1981) using a dog model. It was speculated that during the artificial systolic phase a general rise in intra thoracic pressure compresses the pulmonary vascular bed resulting in blood flowing to the left side of the heart and across, also backward to the right side of the heart and caval veins. Brain backflow being prevented by jugular venous valves, cerebral blood flow is thus achieved in systole. The process is reversed in 'diastole'. The appreciation that this thoracic pump model has some physiological support has led to the development of a number of innovative new experimental techniques (see below). Recently there has been renewed interest in the cardiac pump explanation of CPR effect and both Pell et al (1994b) and Kuhn et al (1991) suggest that this mechanism may indeed be of paramount importance. Perhaps the fairest summary would be to state that both mechanisms may make a contribution.

Factors which predict patient survival

A number of factors predict survival following cardiac arrest outside hospital. A formal multivariate analysis published in 1991 (Wilcox-Gok 1991) suggested that a short arrest to CPR interval and a short CPR to defibrillation interval enhanced chances of survival. Personal factors apparently related to survival are generally in fact working through the variable of "favourable post arrest rhythm" i.e., course Ventricular Fibrillation or Ventricular Tachycardia. Favourable post arrest rhythm is itself acknowledged to be a marker of favourable cardiac condition and when other factors are considered it is not, in itself, predictive of good outcome.

Thus speed remains of the essence both in terms of rapid CPR delivery, but also in terms of minimising the time to first defibrillatory shock. Call to CPR time has been shown to be important in some groups (Martens et al 1993) and good CPR is better than poor CPR at producing survivors (Wik et al 1994). In hospital, mortality following out of hospital cardiac arrest appears to be determined by pre-hospital factors, e.g., collapse to CPR time, collapse to return of circulation time (Hallstrom et al 1985). This was also found by an Edinburgh based group (Grubb et al 1995), where immediacy of intervention, skill of rescuer, conscious level on admission and ventilatory requirement on admission were amongst the factors predicting outcome. Younger age, being married and being better educated increase your chances of receiving CPR in Australia (Heller et al 1995) and thus beneficially affect survival.

An attempt has been made to produce predictive instruments of survival following in hospital CPR, and the prognosis after resuscitation (PAR) score appears more useful than the pre-arrest morbidity (PAM) score (O'Keeffe et al 1994). Analyses have been done on subsets of arrests, e.g., only those in ventricular fibrillation (Herlitz et al 1994b & Herlitz et al 1995a) or those in Electromechanical dissociation (EMD) (Herlitz et al 1995b) or those in asystole (Herlitz et al 1994c). Survival is greater in those in Ventricular Fibrillation but in one case study more than half of those initially resuscitated died in hospital (Herlitz et al 1995a). Absence of a significant premorbid condition, younger age, speed to defibrillation and existence of bystander CPR all predicted favourable outcome (Herlitz et al 1995a & Herlitz et al 1994a).

Survival in those found in EMD was poor; 13% to hospital, 2% to home (Herlitz et al 1995b) as it was with asystole; 7% to hospital, 2% to home (Herlitz et al 1994c). With many of these patients asystole may have followed a period of Ventricular Fibrillation (VF) and we know that low frequency fibrillation indicates poor survival chances and that those monitored on a coronary care unit at the time of their arrest show greater Ventricular Fibrillation frequency (and better survival) if their Ventricular Fibrillation is not secondary to cardiac failure or cardiogenic shock (Stewart et al 1992). The implication once again is that pre-arrest condition and time from arrest to defibrillatory shock determine the quality of Ventricular Fibrillation found on paramedic arrival and thus the likelihood of defibrillatory success. In such a model the proven role of

bystander CPR may be in prolonging the occurrence of high frequency "salvageable" Ventricular Fibrillation.

Factors predicting survival in the elderly have been specifically researched. Relatively low survival rates, even for in patients in ventricular fibrillation, have been recorded (Murphy et al 1989). Poorer survival at age over seventy following in patient arrests is not echoed by poorer survival in the over 70's who arrest outside hospital (Juchems et al 1993) where old age does not appear to be a determinant of prognosis or outcome after CPR. This German research is supported by American data (Wuerz et al 1993) which also suggests that age alone should not deter resuscitation attempts. The elderly appear to overestimate the likely success of CPR (Miller et al 1992) and yet accept its inappropriateness in certain patient groups, e.g., those with severe Alzheimer's disease. Finally severe hypoxaemia during CPR may predict some cerebral dysfunction in patients "rescued" by emergency extracorponeal life support (ECLS) (Kurose et al 1995) but attempts to perhaps address this by supplementing rescuer breaths (Rottenberg et al 1994) with added oxygen whilst experimentally successful, seem totally impractical in a community setting.

The principal predictors of survival from cardiac arrest thus remain; speed to CPR and speed to first defibrillatory shock. The key to minimising time delays is to be found in considering the chain of survival concept in the context of Emergency Medical Services Systems.

Long term survival

While the initial aim of resuscitation may be to deliver to hospital an alive patient and the hospital's aim is to discharge the same, long term survival is obviously what is really important. A number of studies have tracked those surviving resuscitation to ascertain long term survival. These are shown in Table 1 adapted from Eisenberg et al (1984a) by the addition of more recent data Kimman et al (1994), Heller et al (1995) and Cobbe et al (1996).

Table 1. Studies Reporting Long-term Survival after Resuscitation and Discharge from Out-of-hospital Cardiac Arrest.*

Location	Reference	No.	Type of Patient	Long Term Survival: Per Cent Alive at 1 yr	2 yr	3 yr	4 yr
Oslo	Lunde Skulberg (1973)	94	All patients including trauma	-	80	-	-
Miami	Liberthson et al (1974)	42	Ventricular fibrillation	Mean Survival: 13 months			
Minneapolis	Rockswald et al (1979)	47	All patients	85	50	-	-
Michigan & Ohio	Goldenstein et al (1981)	142	All patients	80‡	65‡	53‡	45
Seattle	Cobb et al (1978)	406	Ventricular fibrillation	74	64	55	50
King County	Eisenberg et al (1982)	276	Cardiac arrest due to heart disease	76	66	55	49
Scotland	Cobbe et al (1996)	680	All patients	84	77	78	68††
Rotterdam	Kimman et al (1994)	240	All patients	80	-	-	61▲
New South Wales	Heller et al (1995)	58	Cardiac arrest due to heart disease	-	81**	-	-

* Unless indicated, trauma patients are excluded.
† Only ambulatory patients were given long-term follow-up.
‡ Estimated from data in article.
++ 28 day survival used as proxy for hospital discharge
▲ 5 year survival
†† product limit estimates as mean follow up was 25 months (range 0-68)

Overall around 50% of those discharged alive are still alive at 4 years. This can be compared with figures of 66% for myocardial infarction patients and 80% for age-sex matched controls.

Long term survival is less in those with primary arrhythmia in the absence of infarction (Kimman et al 1994)

No previous myocardial infarction, no heart failure during admission and age under 60 are all factors predisposing to long term survival. A short time for collapse to CPR and from CPR to defibrillation is also predictive of survival, short and long term. Clearly, unusual arrest cases occur, and children in particular may survive unscathed following very prolonged immersion in cold water (Siebke et al 1975). However for cardiac cases in middle aged and elderly adults speed to CPR and to defibrillation remain key predictors.

Quality of Survival

Clearly quality of life following successful resuscitation is as important an evaluative parameter as absolute number of survivors and a number of studies have tracked quality of survival following discharge. Examples are shown in table 2.

Table 2 Studies Reporting Morbidity of Patients after Resuscitation and Discharge from Out-of-hospital Cardiac Arrest.

Location	Reference	No.	Type of Patient	Morbidity
Oslo	Lunde Skulberg (1973)	94	All patients including trauma	21% with mental impairment
Miami	Liberthson et al (1974)	42	Ventricular fibrillation	60% prearrest status 28% some impairment but could function at home
Minneapolis	Rockswald et al (1979)	83	All patients	60% full mental function 40% chronic care facility
Aahrus	Wernberg Thompson (1979)	36	All patients	22% residual brain damage 6% institutionalised
St Paul	Snyder et al (1980)	25	All patients	64% excellent recovery 32% good recovery 4% poor recovery
Denver	Earnest et al (1980)	20†	All patients	53% independent living 32% returned to work
Seattle	Cobb et al (1975)	21	Ventricular fibrillation	57% normal or slight impairment of exercise capacity
Seattle and King County	Bergner et al (1982)	426	Ventricular fibrillation	9% chronic care facility; most returned to prearrest status
Scotland	Cobbe et al (1996)	680	All patients	89% normal or only mildly impaired 8-5% moderately impaired 3% severely impaired

* Unless indicated, trauma patients are excluded
† 20 of 38 patients still alive three and a half years following out-of-hospital cardiac arrest.

adapted from Eisenberg et al (1984a) by the addition of the more recent Scottish data

So whilst a significant minority suffer some disability, 60% recover to resume previous activities and 80 to 90% can maintain independent existence (Eisenberg et al 1984a).

Recent innovations and new techniques

Resuscitation techniques do not stand still and current practice is constantly under challenge. Examples in the last five years include the reasoned advocacy (backed by simple but clever research) for the use of the nasal route for maternal resuscitation of infants (Tonkin et al 1995). The advocacy of chest compression as an adjustment to the Heimlich manoeuvre in choking (Skulberg 1992). The introduction of a new recovery position (Handley 1993) and its subsequent likely revision (Handley 1997, Leaves 1997) and reassurance about the extreme remoteness of contracting infectious diseases from mouth to mouth ventilation (Cummins 1989b, AHA 1989).

The fact that such reassurance is felt to be needed may, in part, help explain why in recent years an increasing interest has arisen in the possibility of removing ventilation from bystander CPR protocols. This seemingly radical move is worthy of consideration for a number of reasons. Firstly animal model data exists (Berg et al 1993(a) & Berg et al 1993(b)) to suggest that chest compressions alone may be almost as valuable as chest compressions plus ventilations.

Secondly in human subjects observational data suggests that chest only CPR improves survival over no intervention although falling short of good full CPR which has been shown to be better than poor CPR (Wik 1994, Gallagher 1995).

Thirdly there is abundant evidence that people find full current CPR difficult to learn (Morgan et al, 1996). It is arguable that any detriment to CPR efficacy through pursuing a chest compression only policy would be more than compensated for by the ease of learning and retention, and by the likelihood of intervention. This radical hypothesis remains to be tested, although early in vitro work is promising in terms of learning and retention (Assar D et al 1999). Meantime less radical changes have their advocates e.g. single as opposed to double breaths (Melker 1985) or the use of audible rate guidance (Kern et al 1992).

Alternative mechanisms of CPR administration have also been suggested and sometimes evaluated. For example the intriguing active compression/decompression devices which, both in appearance and use, resembled the sink plunger from which they were derived, do seem to have an explicable mechanism of action (Pell et al 1994a) but thus far have produced mixed results (Nolan et al 1998, Plaisance et al 1997). Vest CPR * trials continue although not yet in UK ambulances where intuitively their contribution would seem likely to be maximised.

The technological advances in defibrillator technology also potentially have policy implications. In particular their ability to recognise and only shock rhythms which are both immediately life threatening and amenable to defibrillation is important. But so is their greater reliability, longer battery duration, portability, and improved ease of use.

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* CPR performed through the use of a rhythmically inflated and then deflated pneumatic check vest.

Lay people can learn to use the devices in two hours (Eisenberg 1989) and their potential use in the home environment has been described (Pierce 1985). Student nurses have shown themselves able to rapidly respond with a defibrillator if adequately trained (McKee et al 1994) and St John Ambulance volunteers are as good at learning the necessary skills as nurses (Walters et al 1994). These facts raise the intriguing possibility of community defibrillation and the American Heart Association has been actively pursuing this.

Mechanical ventilation has advantages and advocates in the hospital department (Idris et al 1994). Some would also argue for the routine use of sedation (Martens et al 1995) for pathophysiological as well as humanitarian reasons.

However these suggestions are only variations on a theme and there are two more radical initiatives to consider. Firstly what has become known as "dispatcher assisted cardiopulmonary resuscitation". In this, callers are encouraged to act and are coached through CPR delivery in real time. Meanwhile paramedics speed to the scene. In vitro studies suggest (Kellerman et al 1989) that telephone CPR offers a safe and cost effective means to increase the rate of bystander CPR and also improves the quality of CPR performed.

Equally exciting is the concept of the Medical Emergency Team (Lee et al 1995, Hourihan et al 1995) with its remit of identifying in hospital patients in danger and preventing avoidable cardiac arrests.

As developments in the field of resuscitation continue then so standard setting through the generation of clinical guidelines grows in importance.

Standard setting through guideline generation

Following landmark papers on mouth to mouth ventilation (Safar et al 1958, Elam et al 1958) in 1958 and on external cardiac massage in 1960 (Kouwenhoven 1960); the American Heart Association (AHA) wasted little time in developing standards which were then discussed later that year at a National Academy of Sciences - National Research council conference (National Research Council 1966). In the years between that conference and the second one in 1973, progress ensued through the production of instructional materials and the spread of training.

The 1973 conference made a number of important recommendations including the introduction of widespread lay training, the certification of competence and the introduction of integrated comprehensive community wide Emergency Life Support programmes. Specific recommendations and explicit standards were published (AHA 1974).

Subsequent conferences in 1979 and 1983 promoted prevention and community involvement (McIntyre KM, 1980) and paediatric resuscitation respectively. The 1985 conference encouraged the targeting of CPR training, endorsed the use of thrombolytics

and emphasised the importance of early defibrillation (AHA 1986). The 1992 conference considered research into the possible transmission of infectious disease (Cummins 1989b & AHA 1989) and defibrillation (Kerber 1991). Much other research was also considered utilising predefined criteria and objective evaluation of published evidence (American Heart Association 1992).

CPR guidelines were updated, and crucially, the conference recommended that international organisations with an interest in this area should synchronise guideline review and collaborate in international working groups to review evidence. Implicit in this was the aspiration to one day produce internationally accepted statements which could lead to global standardisation of CPR training, performance and evaluation (American Heart Association 1992).

Meanwhile parallel developments were occurring elsewhere. A number of European countries founded resuscitation councils including the UK. They developed their own guidelines which were eventually consolidated by the European Resuscitation Council in 1992 (European Resuscitation Council 1992a, Paediatric Life Support Working Party of European Resuscitation Council 1994, European Resuscitation Council Basic Life Support Working Group 1993 & ERC 1994). Meanwhile co-operation between those with a particular interest in evaluation led to the widespread adoption of internationally agreed definitions for data reporting (European Resuscitation Council 1992b) which addressed the concerns many had about the lack of comparability of previous work (Eisenberg et al 1990).

Large scale participation by international delegates at the AHA 1992 Conference and the far sightedness of the organising committee in giving over a session to international issues gave rise to the movement for greater international co-operation and ILCOR (The International Liaison Committee on Resuscitation) was formed (Chamberlain & Cummins 1997). ILCOR currently consists of representatives of the American Heart Association (AHA), the Heart and Stroke Foundation of Canada (HSFC), the European Resuscitation Council (ERC), the Australian Resuscitation Council (ARC), the Resuscitation Council of Southern Africa (RCSA) and the Council of Latin America for Resuscitation (CLAR).

This committee held a series of meetings between 1992 and 1997 which culminated in 1997 with the launch of the ILCOR advisory statements on; basic life support (Handley et al 1997) and advanced life support (Kloeck et al 1997), early defibrillation (Bossaert et al 1997), Paediatric life support (Nadkarni et al 1997) and resuscitation in special situations (ILCOR, 1997). The launch of these statements was carried out at the successful CPR 1997 conference held in Brighton, UK and coincided with the publication of standard protocols for reviewing, reporting and conducting research on in hospital resuscitation (Cummins et al, 1997).

The ERC have subsequently adopted new protocols including one on basic life support (BLS) based upon the ILCOR statements (ERC Working Group on BLS, 1998) and one on advanced life support (Robertson, 1997). This followed the demonstration that the

new BLS guidelines were no more difficult to learn than their predecessors (Donnelly et al 1998).

Thus in less than 30 years since the birth of modern day resuscitation the International Resuscitation research community has reached the point where they have agreed guidelines on data collection and definitions and agreed statements on almost all aspects of resuscitation practise. It is arguable that few areas of medical endeavour could demonstrate such degrees of international agreement and consensus.

The ethics of resuscitation

With medical procedures, proof of efficacy is no argument for universal application. There will always be situations, in which, and individuals in whom, resuscitation attempts could be considered unethical. Much has been written in recent years about this problem. Review articles tend to deal in general principles (Baskett 1993) and may cite case studies (Baskett 1990) or are the product of expert working groups (Holmberg et al 1992).

However it is some of the more specific research articles which are most illuminating. These focus on specific questions. For example; do nurses know the resuscitation status of their patients? (Jones 1993) answer no, does unwanted resuscitation occur in the pre-hospital setting? (Dull et al 1994) answer yes, can a "do not resuscitate" programme be made to work in the community? (Sosna et al 1994) answer yes.

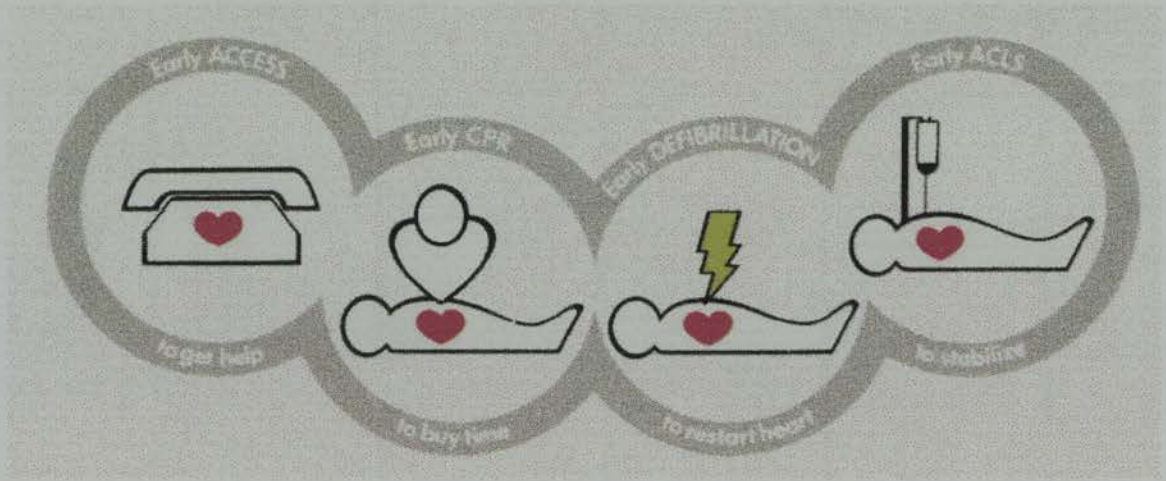
One of the most difficult areas is the debate over whether it is possible or indeed desirable for paramedics to exercise discretion about when to withhold resuscitation in community settings (Marsden, 1995). In practice there is some evidence that such discretion is already exercised (Donnelly, 1995) (Weston, 1995), in at least one part of the UK. The need for some flexibility is argued by some of the most experienced researchers in the field (Eisenberg et al 1985) and in some instances attempts are made in seemingly futile situations in an attempt to persuade family and by-standers that "everything was tried". The particular difficulties in situations where children are involved have been identified (Davies et al 1992(a) & Davies et al 1992 (b)). It has also been pointed out that ethical decisions over resuscitation cannot be divorced from the resource issue involved in providing the medical logistics necessary for a good response (Davies et al 1992(a)).

In summary, resuscitation decisions provide uniquely complicated ethical dilemmas for at the very point of death the (sometimes) slim possibility of achieving additional life of varying quantity and quality must be balanced with the need to respect patient autonomy and maintain patient dignity, all of this debate having to occur within a framework of resource practicality and in a highly emotionally charged environment.

The chain of survival concept

The chain of survival concept is explained in an American heart Association Medical/Scientific statement published in 1991 (Cummins et al 1991a) and illustrated diagramatically below in Figure 1. It was originally described in German (Douglas Chamberlain, personal communication)

Fig 1 - Chain of Survival



Briefly the paradigm calls for the early alerting of the emergency medical services followed by the rapid provision of bystander CPR until the delivery of a successful

defibrillatory shock is achieved. Finally, skilled advanced cardiac life support should occur en route to hospital. I shall address each link of the chain in turn.

Early access

Arguably this is less of a problem in the UK than in the USA. The UK has had a standard national emergency number (999) for many years. This is not the case in the USA, although 911 is now being more widely used. However, early access also requires patients and families to correctly recognise the early signs and symptoms of a myocardial infarction or of a cardiac arrest and act appropriately. An alarming number of people delay calling for help and then may do so to a family friend, relative or even minister of religion rather than to the emergency services or their own doctor (Weston et al 1994a)

Attempts to improve people's awareness and reaction to the signs and symptoms of myocardial infarction have met with limited success. One television campaign (Eppler, 1994) appeared to produce a transient increase in the Emergency Room attendances following symptom reporting. However, many of those attending had symptoms of non-cardiac origin and thus while coronary care admissions rose, so did the number of people discharged home. The effect disappeared at the end of the, presumably expensive, media campaign.

Thus, for these two reasons the resource implications of any call fast campaign must be carefully considered. It may be that local initiatives focused on educating practice reception staff have a role to play (Lervy and Glen, 1998) and certainly popular television programmes with very large audiences, e.g., "999" may improve the public's knowledge. Altering behaviour is more difficult both to achieve and to demonstrate. Nevertheless, the early alerting of the emergency services in either a case of cardiac arrest or a suspected case of myocardial infarction remains important and requires further research.

The contribution of bystander CPR

The argument for bystander participation

The arguments for bystander provided cardiopulmonary resuscitation arise directly from an examination of the descriptive epidemiology of sudden cardiac death. An examination of 296 out of hospital coronary heart disease deaths (Fitzpatrick et al 1992) showed that 73% occurred at home, and that bystanders attempted CPR in only 16% of witnessed arrests. The authors concluded that unless a greater proportion of patients received CPR before the arrival of the emergency services the then planned provision of defibrillators was "unlikely to have a significant impact on death outside hospital caused by coronary heart disease".

Attempts to quantify the potential impact of bystander CPR on mortality depend for their conclusion upon the assumptions made in terms of potentially achievable survival to discharge from hospital. Thus Weston and colleagues (Weston et al 1994a) provided point estimates for the number of lives saved per annum per 100,000 population as high as 40 and as low as 6. Their estimate based on high percentages of victims being found in ventricular fibrillation (VF) was 10.5 per 100,000 per year. Based on current VF rates a point estimate of 2 per 100,000 can be made for South Glamorgan. However, the argument becomes rather circular at this point as relatively low bystander intervention rates (in this case 32% of witnessed arrests) when combined with unexceptional ambulance attendance times will by definition give fairly low VF rates on paramedic arrival (46% in this case). Whereas we know that rates of 75% are found in areas with high bystander intervention rates and rapid paramedic attendance. Thus to base an estimate of the anticipated value of the contribution of a bystander CPR scheme upon the results of existing practice by definition produces highly conservative results.

It is therefore arguable that their estimate of annual lives saved of "up to 6" per hundred thousand could be equally well replaced by "up to 19" if less conservative assumptions are made. Perhaps the point estimate of 10.5 per 100,000 or roughly 1 life saved per 10,000 population per annum is the most useful working figure. The discussion of such estimates is also useful in emphasising the interdependence of various links in the chain of survival in particular between the provision of bystander CPR and the rapidity of the delivery of the first defibrillatory shock. This was demonstrated empirically by

Eisenberg and colleagues (Eisenberg et al 1979) who advocated citizen CPR training and technician defibrillation as a means of shortening the respective time intervals.

A considerable body of evidence now documents the contribution of bystander CPR in improving survival rates both to hospital admission and to hospital discharge. Examples include the work of Copley and colleagues in Alabama (Copley et al 1977) of Cummins and Eisenberg in Seattle (Cummins et al 1985), of Spaite and colleagues in Arizona (Spaite et al 1990), of Herlitz and colleagues in Gothenburg (Herlitz et al 1994a), of Ritter and colleagues in Michigan (Ritter et al 1985) and Thompson and colleagues at the University of Washington (Thompson et al 1979).

These results are summarised in table 3:

Table 3 - studies reporting the effect on survival of bystander CPR.

Investigations	Study end point	Numbers (%) surviving without bystander CPR	Numbers (%) surviving with bystander CPR	Statistical significance (p value)
Copley et al (1977)	admission	6/12 (50%)	6/7 (85%)	P<0.01
Thompson et al (1979)	discharge	43/207 (21%)	47/109 (43%)	P<0.001
Cummins et al (1985b)	discharge	158/718 (22%)	185/579 (32%)	P<0.05
Ritter et al (1985)	ROSC	N/A (14.6%)	N/A (22.9%)	p<0.001
Ritter et al (1985)	discharge	N/A (4.7%)	N/A (11.9%)	P<0.001
Spaite et al (1990)	discharge	12/212 (6%)	13/86 (15%)	P<0.05
Herlitz et al (1994)	discharge	109/1357 (8%)	76/303 (25%)	P<0.001

Dispatcher assisted CPR; a new way to encourage bystander CPR

In 1974 the Phoenix Fire Department in Arizona, USA assigned paramedics to act as ambulance dispatchers within their control rooms to enable them to give CPR instruction

by telephone in an emergency. Although no formal evaluation was performed, a number of successes were recorded anecdotally. King County, Washington, was therefore encouraged to carry out a formal in vitro evaluation of telephone CPR using community volunteers and a simulated cardiac arrest event (Carter et al 1984). The wording of the instructional message turned out to be of central importance and a carefully prepared standardised form of instruction produced statistically significantly better results than ad-hoc advice from professional dispatchers. The introduction of such a service was then undertaken in King County and the rate of bystander CPR increased from 32% (1976-1981) to 54% (1982-1988) (Culley et al 1991). Unfortunately in this instance an increase in survival could not be illustrated. The authors also concluded that delays in proper delivery of telephone CPR can be minimised through retraining. The same research centre has separately demonstrated that the dispatcher CPR protocols they had developed were successful in screening out those incidents that are not, but may resemble, cardiac arrest (Clark et al 1994). Further in vitro evidence of the efficacy of dispatcher assisted CPR comes from a Tennessee (Kellermann 1989) study which showed that a combination of prior training and dispatcher assistance gave the best results.

The giving of telephone advice in an ambulance dispatch system is now increasingly being adopted and giving rise to the need for the development of added skills in the staff involved. For example, how to gain control of the emergency caller (Clawson 1986). Such protocol driven despatch systems also allow prioritisation according to clinical need rather than on a first come first served basis. This allows the most serious cases,

e.g., cardiac arrest, to receive the most prompt treatment and avoids unnecessary "lights and sirens" potentially dangerous ambulance responses (Clawson 1987). The then Chief Medical Officer of England, Sir Kenneth Calman led a review which advocated the introduction of such systems in the UK. Amongst others, Derby, Essex and the South East Wales Region of the Welsh Ambulance Trust already have such systems in place.

The economic evaluations of such systems is still in its infancy but a cost-effectiveness evaluation specifically focused on dispatcher CPR instruction suggested that the additional cost per year of life saved for a patient experiencing ventricular fibrillation outside hospital was $560 (1992 figures). The authors concluded that telephone CPR represented a cost-effective addition to a two tier emergency medical response system. (Valenzuela et al 1992).

What factors inhibit bystanders from attempting CPR?

Not all of those trained in CPR will always intervene in an emergency. A number of pieces of research have tried to explain why this might be and what factors predict unwillingness to respond. For example, in an innovative piece of research an actor "victim" either "bled" or did not "bleed" from the mouth on a subway carriage. Help was significantly slower and less frequent in the victim who "bled". It is interesting to note that this research occurred in the pre-AIDS era (1972) and one would anticipate results may be even more marked now. (Piliavin et al 1972).

Reservations about intervening in emergencies are not restricted to lay people. Medical house staff in California said they would be unwilling to perform mouth to mouth resuscitation (MMR) in the majority of cases of even in hospital cardiac arrest. (Brenner et al 1994a). Only 45% would perform MMR on an unknown patient, 39% on someone who was elderly, 16% on a casualty with a small amount of blood on the lips and 7% on a patient presumed to have AIDS.

It seems intuitively likely that this reluctance would be even greater in the out of hospital environment where less is known about the victim and where a lower degree of professional responsibility may be felt. Yet when 42 bystanders who had actually performed CPR in a real situation were questioned no less than 59% of patients had one or more disagreeable characteristics. Thirty three percent had vomited, 33% wore dentures, 4% had a breath smelling of alcohol and 7% had visible blood (McCormack et al 1989). Despite this, no bystander interviewed indicated hesitancy in performing CPR. Some admitted feeling unprepared for such eventualities and the authors conclude that explaining the possibility of such occurrences should occur as part of basic CPR training. The self reported nature of the rescuers post hoc opinions must be taken into account here and it would have been interesting, but methodologically difficult, to interview non-interventionist witnesses from the 86 of 121 (71%) of cases where bystander CPR did not occur.

The likelihood of intervention also appears to depend on the racial background of the victim. African Americans are significantly less likely to receive bystander CPR (Cowie et al 1993 & Thompson et al 1979) than their white counterparts, and their chances of survival are adversely affected. The targeting of CPR training programmes and the more widespread adoption of telephone CPR instruction in an emergency maybe a possible solution.

Interestingly, characteristics of the rescuer as well as the victim also appear to affect the likelihood of intervention. Thus male homosexuals in Los Angeles say they are willing to perform mouth to mouth resuscitation (MMR) on an unknown victim in 93% of cases if they , the rescuer were HIV-ve and 85% of cases if they were HIV+ve. (Brenner, 1994b) This contrasts starkly with the previously reported reluctances of hospital house staff to perform MMR (Brenner 1994a) and may relate to differences in the perception of risk.

Our groups own work with school children in Cardiff suggest a gradient of likely response from immediate family to stranger and from standard victim to victim with objectionable features (personal communication Carolyn Lester). Interestingly peer tutoring of 11 year old boys seems less likely to lead them to intervene than teacher led training. The same is not true of girls (personal communication Carolyn Lester). This

may be a product of differing levels of emotional and intellectual maturity at this age, between girls and boys.

In summary, characteristics of the victim and the rescuer and possibly the rescuers training affect whether a bystander will intervene. However, the value of bystander intervention is undoubted with many studies demonstrating benefit. Dispatcher assisted CPR shows promise as a means of increasing intervention but an effect on outcome is still to be demonstrated.

The importance of early defibrillation

As covered in the section dealing with out of hospital cardiac arrest survival, time from collapse to delivery of first defibrillatory shock is a key predictor of favourable outcome. The technological advance which resulted in the manufacture of so called "semi-automatic" defibrillators has important implications in terms of who can use them. No longer is it necessary to be able to diagnose the presenting rhythm and on that basis make a decision whatever or not to administer a shock. Semi automatic machines will monitor rhythm through the defibrillatory panels and only allow a shock to be given if the patient is either in ventricular fibrillation or fast ventricular tachycardia. In addition advances in battery technology have made modern machines more reliable, and considerably lighter. Such devices can therefore be easily portable and can be left for

fairly prolonged periods of time at strategic places. Most require little servicing and many are self checking.

Emergency medical technicians and paramedic staff were the first healthcare staff other than doctors to regularly use such devices in the community. Coronary care nurses paralleled this development on specialist units in cases of in hospital arrest. The value of such an approach has been demonstrated in Europe and in North America (Eisenberg et al 1984a), particularly in and around Seattle (Cummins 1987). However some have pointed out that the isolated introduction of defibrillators has of itself only marginal effect; a 1% reduction in community cardiac mortality in one study (Leslie et al 1996) and the need for the public to call early and then deliver CPR is stressed. Of course, sometimes in the UK, the public call their general practitioner (GP) either before or as well as the emergency ambulance service. Hence the British Heart Foundation's advocacy of dual GP/ambulance attendance (Colquhoun et al 1995) and their policy of equipping GP's with defibrillators.

Extending the usage of such machines to groups other then healthcare staff has also proved possible and effective. Police are an obvious choice as they may be able to attend an incident more rapidly than the ambulance service. This was indeed the case in Pennsylvania (Mossesso et al 1993a) where police with semi-automatic external defibrillators arrived on average 3.5 minutes before the ambulance services and allowed the police officers to defibrillate 17 cases of Ventricular Fibrillation/ Ventricular

Tachycardia resulting in a return of spontaneous circulation in nine (53%). Such studies rely heavily upon the accurate recording of time intervals for evaluative purposes (Mossesso et al 1993b). Evidence exists that this can be done (White et al 1994) if a concerted effort is made to synchronise all clocks from which times are derived. The recent introduction of highly accurate clocks based upon a radio time signal may further help tackle this difficulty.

Lay people can also be successfully taught how to use a semi-automatic defibrillator (Moore et al 1987) although such initiatives raise a number of important issues in terms of training and emotional and psychological impact on those who are expected to use such equipment often on a close relative at a time of stress if not panic (Cummins et al 1985a).

The American Heart Association have organised a number of major conferences on the topic of Public Access defibrillation (Weisfeldt et al 1995) and it seems likely that technological progress resulting in greater safety and ease of use and lower costs will result in continued expansion of the number of individuals who are able to utilise these life saving devices. For it to be reliable however, the evaluation of their efforts must be done in a system specific way (Cummins et al 1985b) as rapid defibrillation is only one part of the chain of survival.

Advanced Cardiac Life Support

Advanced Cardiac Life Support which may involve; the administration of analgesic, antiarrhythmic and other drugs, endotracheal intubation and intravenous cannulation, is practiced in the UK by trained paramedics or medical or nursing staff. The only interventions of undoubted value are defibrillation in Ventricular Fibrillation/ Ventricular Tachycardia and the giving of atropine in bradycardia or asystole. The role of antiarrhythmics remains unclear and attempts to formally compare lignocaine with Bretylium with placebo originally ran into difficulties with the current UK Medicines Act which restricts those drugs available for paramedical use.

Much further work is needed in this area (Pepe et al 1994), particularly in terms of formalised trials of drug and other interventions in the pre-hospital setting. Meanwhile, the wider role of paramedics in dealing with other medical emergencies and trauma must be borne in mind (and indeed also evaluated more thoroughly!).

Evaluation of Emergency Medical Services Systems Effectiveness

Having reviewed the evidence supporting each individual component of the chain of survival concept, it is relevant to consider work which is focused upon looking at the effectiveness of Emergency Medical Services systems as a whole. Not only is this important because of the interdependency of the various stages and actions, but also

because it is on a system basis that such programmes are normally funded and experienced by patients, relatives and communities.

A landmark paper in this area is that by Eisenberg and colleagues (Eisenberg et al 1990) in which 39 emergency medical services programmes from 29 different locations were reviewed in a structured fashion. Survival from out of hospital cardiac arrest was used as a marker condition for effectiveness and systems were classified into one of two types. These were either single response systems (basic emergency medical technician (EMT), EMT-defibrillation (EMT-D) or paramedic) or double response systems (EMT/paramedic or EMT-D/paramedic). Considerable variation in survival rates occurred within and between groups, but dual response systems appeared more effective at handling community cardiac arrests.

Whilst such a comprehensive review of systems was ground-breaking, the reporting of the results of individual systems was not new and credit in this area must go to Pantridge (Adgey et al 1969) who as long ago as 1969 was detailing the effects of his work in Belfast. His "system" involved a medically staffed mobile coronary care unit, a philosophy still followed by some countries in Europe, e.g., Germany, despite the fact that their own research shows no survival advantage over the use of trained technicians (Baskett et al 1982). Most others in Europe (White et al 1973), North America and elsewhere now utilise ambulance staff with augmented training (e.g., Emergency Medical Technicians - defibrillation) or greatly extended training, (e.g., paramedics).

The call for the introduction of paramedics into the UK was linked with the demand that all front line ambulances should carry defibrillators. The Scottish Ambulance Service was the first to take up this challenge with its "Heartstart Scotland" initiative. This initiative (Cobbe et al 1991) demonstrated that such a scheme was effective, could be rapidly introduced, and had only limited training and cost implications. Detailed results (Marsden 1995) re-emphasised the importance of bystander CPR and short collapse to first shock time.

Given Scotland's trailblazing attitude in this area, the willingness of key workers to challenge the now prevailing paradigm is commendable, yet itself open to challenge. Guly and colleagues (Guly et al 1995) suggested that "paramedics and technicians are equally successful at managing cardiac arrest outside hospital". This assertion was coupled with a short editorial piece which stated that such patients were "best treated" by technicians and which called into question the requirement of having a paramedic on every vehicle. Arguably such conclusions cannot be safely drawn from the study data due to methodological difficulties, e.g., studying only admissions, studying paramedics who were not allowed to give drugs, the non-random allocation of attending crew type and the analytical complexity of some double attendances. (Weston et al 1995). Indeed, the authors may not initially have intended to draw the conclusions involved in the accompanying editorial piece as they made it clear their paper did not "diminish the role of paramedics". A point that was made by other respondents (Marsden & Cobbe 1995b). Unfortunately, the original conclusions but not the methodological challenge was subsequently quoted in a BMJ editorial (Cooke et al 1996) which raises the

interesting point as to whether editorialists should be required to citation search articles they intend to quote in order to expose themselves to the results of post publication challenge as well as to the original articles. Whilst attractive, such a requirement could be difficult to enforce (Personal communication, Richard Smith, Editor BMJ).

The debate of paramedics versus augmented training technicians is far from restricted to Scotland. Work by the Nottingham group demonstrated that existing ambulance personnel could be effectively trained (Rowley et al 1985) to use defibrillators and that such a training initiative in isolation of enhancing other skills such as intubation was defensible as a means of rapidly deploying life saving defibrillators in the community (Rowley et al 1987). The evidence of paramedic benefit over Emergency Medical Technicians not allowed to defibrillate (EMT) is clear (Eisenberg 1980). Enhancing ambulance staff or emergency (Vertesi et al 1983) medical technician staff skills through training in defibrillation appears effective (Eisenberg et al 1984b) and uncontroversial and equally applicable in city and suburbs (Eisenberg et al 1980b) and rural (Stults et al 1984) environments.

More controversial is whether skills additional to defibrillation, e.g., intubation and drug administration, confer significant additional benefit in the specific case of out of hospital cardiac arrest. Certainly the most important skill is defibrillation (American Heart Association 1992b) and additional skills, whilst competently applied when required, are used in less than one quarter of cases (Weston et al 1992). Evidence of incremental benefit is limited (Shuster et al 1994). In addition, variations in crew deployment in the

UK are marked (Weston et al 1992) and spreading the specialist workload amongst more individuals as more paramedics are trained could conceivably dilute experience. This could be an argument for a dual response system where triage is done on the telephone by trained dispatchers to determine appropriate attendance (Stratton 1992 & Wright et al 1992). Additional specialist crews can be summoned if subsequently found to be required.

On the other hand, the frequency with which the need for unexpected advanced life support (ALS) procedures are encountered (11.7% of triaged non ALS calls in one study) (Wilson et al 1992) could argue in favour of single tier paramedic response.

Subsidiary issues in this area include the willingness of ambulance leaders to formalise their staff's acquisition of skills and to professionalise the service (Richardson et al 1995) and the desirability of full-time specialised physician supervision of ELS programmes (Pepe et al 1993). In comparing EMS systems, the importance of accurate time recording (Cordell et al 1994) and tight and standardised case definition (Valenzuela et al 1992) cannot be over-estimated, and the previously mentioned Utstein protocols (Cummins et al 1991b) are clearly to be recommended.

Evaluating CPR learning and retention

Evaluating the skills of clinical staff

Intuitively anaesthetists would be expected to be competent resuscitators because of the nature of their clinical practice and appropriateness of their skills. This has been borne out by Quincey et al who found 79% of anaesthetists of varying grades competent to UK resuscitation council standards when tested against 3 pre-determined scenarios (Quiney et al 1995). However, as Winchell and Safar (1996) have pointed out:

> "Most emergencies leading to airway obstruction, apnoea or cessation of circulation in potentially salvable persons, outside the operating rooms, occur in the absence of a physician"

This requires all healthcare staff to have their skills regularly updated and assessed.

The training needs of nurses and physicians may differ (Gass et al 1983) because of the separate roles they tend to play in dealing with an in hospital arrest. The attainment and rehearsal of those skills is organisationally time consuming and the call for the appointment of dedicated resuscitation training officers (O'Donnell et al 1993) has now been acted upon by many NHS Trusts facilitated by British Heart Foundation funding. The atrophy of clinical skills in basic cardiac life support described elsewhere is mirrored by that in basic trauma life support (Werman et al 1990). Attempts to evaluate performance using the presence of a skilled observer do not appear to affect skills

performance (Bondesson et al 1993). But clearly the ultimate test of the impact of clinical in hospital training programmes is do they beneficially affect outcome? Data from New York State would seem to demonstrate this (Bernhard et al 1979) with an organised in hospital training programme in a 500 bedded city hospital improving the restoration of circulation rates from 38.6% to 50.4%.

Evaluating the resuscitation skills of the lay public

Whilst the contribution made by lay bystanders in out of hospital cardiac arrest is undisputed (Sampsom 1978), so is the fact that their ability to perform adequately, declines quickly following training (Weaver et al 1979), (Berden et al 1994). This decline in ability can be delayed with practice and review (Moser et al 1990) and is mirrored by the skill decay in lay people trained in defibrillation which can be reversed with a short retraining (Cummins et al 1989a). Some have speculated that the problem of poor skill retention may lie as much with the instructor as with the learner (because of non standard teaching, subjective over positive assessment and lack of student practice) (Kaye et al 1991) and yet the use of lay instructors is widespread and arguably both inevitable and desirable if large numbers of lay individuals are to be trained (Ramirez et al 1977).

Attempts to standardise CPR assessment techniques

The discrepancy between subjective, often instructor performed, assessment of CPR trainees performance and the more objective, observer performed, criteria based evaluation has been noted by several authors (Kaye et al 1991 & Martin et al 1983) and as a result, calls for the simplification of basic life support guidelines, teaching programmes and assessment protocols are not new (Kaye et al 1985). Indeed attempts have been made to introduce such objective systems (McSwain et al 1979 & Berden et al 1992). However, no system has thus far been universally or even widely adopted, for whilst the use of recording manikin printouts provides useful documentary evidence which may be objectively analysed, the dependence on an observational check list, for other aspects of basic life support, reintroduces subjectivity.

The solution may lie in a combining of facilities of recording mannequin technology with the use of video recording to document otherwise unrecorded actions. Video has been used to audit management of real arrests (Weston et al 1992) and as a research tool in, for example, recording patient or mock patient interviews (Roland 1983) but the innovation of using it to record mannekin resuscitation attempts is new (Lester 1997, Donnelly 1998). (See Methodology section - the development of the test instrument).

Recruitment strategies for CPR training cohorts

A variety of stratagems around the world have been deployed to recruit people to train in cardiopulmonary resuscitation (CPR). Schemes have been based on word of mouth, community groups, work-place training, newspaper and radio and television advertising.

Common to all methods are incomplete and selective response. People's reasons for non-attendance have been studied in Belgium (Lejeune et al 1987) where the elderly were less likely to attend and where non-attenders expressed a willingness to attend on another occasion if training was arranged at a more convenient location, for example, at their workplace or social meeting place.

Responses to incomplete attendance and the need to recruit those most likely to be able to use their skills have included initiatives in schools and the targeting of relatives of those with ischaemic heart disease.

Schools initiatives aim for comprehensiveness and to create a basis of life long skill attainment and retention (Lester et al 1994a, 1995). Many would advocate the inclusion of basic life support on the national curriculum (Baskett, 1985). Rescue breathing has been taught in Norway for many years and high school students must learn CPR to graduate in King County, Washington. The evidence that children can learn at least as well as adults is compelling (Vanderschmidt et al 1975) and research into how best to teach them suggests traditional teacher-led methods with restricted but highly supervised

manikin practice may, perhaps surprisingly, be most effective (personal communication, Caroline Lester).

Attempts at targeting those most likely to be able to use CPR skills have included an innovative scheme involving the Women's Institute teaching women in their sixties and seventies (Handley, personal communication). More specific still is the attempt to teach relatives of those with a history of heart disease basic life support skills. General practitioners seem divided on this subject. Perhaps they are concerned about imposing additional stress upon already concerned relatives. Certainly the evidence here is conflicting and inconsistent. Dracup and colleagues (Dracup et al 1986) have demonstrated that cardiac patients (although not relatives) anxiety is increased when relatives are trained. This conflicts with the findings of McLaughlan and colleagues from the UK who found no increase in anxiety with a similar intervention in either patients or relatives. (McLauchlan et al 1992) One can speculate that the way in which the educational intervention is managed may materially affect the result. That relatives can successfully learn is clear, although the elderly, those who are depressed, and males learned less well in one study (Dracup et al 1989).

Television has been used before as a successful means of reaching untrained members of the public. The Save a Life campaign in 1986 achieved UK population awareness of almost 50% with 7% being able to spontaneously name it (Marsden 1988). As a result of the campaign 125,000 individuals attended an instruction session. Seventy percent of those responding were female and most were from social groups ABC1.

Television has also been used as a means of attempting to reduce the delay that occurs before people summon an ambulance during a cardiac emergency. The authors concluded (Ho et al 1989) that whilst a short duration educational campaign may increase public knowledge with regards to the signs and symptoms of acute myocardial infarction it does not seem to affect behaviour.

One of the most interesting influences of television is the indirect affect it has through its portrayal of medical emergencies and resuscitation attempts in medical dramas. The paper by Diem and colleagues (Diem SJ et al 1996) in the New England Journal pointing out that television drama resuscitation may be misleading in that the outcome is so frequently successful led to a flurry of correspondence; some partially supportive of the authors (Markert et al 1996) on the basis of additional relevant data; others supportive of the television producers on the basis that medical practitioners are no more wedded to facts than dramatists! (Malcahy, 1996). Many seem agreed that such dramas are successful in stimulating public interest in learning the skills and may indeed convey some of those skills (Troy 1996, Wotton 1996) although concerns remain about how well they are learned by such methods (Borowsky 1996).

Anecdotal reports of a successful resuscitation by a young girl, who attributed her skills solely to watching a TV medical drama, appeared recently in a UK national newspaper.

In summary, all methods of recruitment have deficiencies in terms of incompleteness and the recruitment of atypical cohorts. Attempts at comprehensiveness through a schools approach, and targeting through approaching specialist groups and the relatives of cardiac patients show promise. Television promotion attracts large numbers with cohorts biased towards professional social groups and females. As a media it is also successful at raising awareness of the need to learn CPR skills but perhaps guilty of over emphasising their likely effectiveness.

V - DEVELOPMENT OF A ROBUST TEST

V DEVELOPMENT OF A ROBUST TEST

Test Development, scoring and assessment

At the commencement of the research the literature was reviewed and various individuals prominent in the field of pre-hospital emergency medical research were contacted to try to ascertain whether a suitable testing instrument was available. The only one of relevance appeared to be that developed by Berden in 1992 (Berden, 1992). However a close examination of this test revealed a number of difficulties.

The first and most significant was that the test had not been designed for use on video subjects. One of the advantages of video based assessment is that the tapes may be stopped, slowed down, rewound and reviewed - scoring decisions do not have to be made in the heat of the moment.

Secondly the same subjects doing the same test can be watched independently by different observers and indeed by the same observer on two different occasions. Thus it is an ideal way for quantitatively estimating and subsequently addressing inter and intra observer variation in a way that was more difficult with the Berden test.

Thirdly, there were some technical difficulties with Berden's test. In particular it is impossible to comply with his directive on the period between compression sets whilst still providing adequate ventilation.

Finally it was felt important that the test should be based upon European Resuscitation Council guidelines which had been further revised since the date of Berden's work.

Thus a commitment was undertaken to develop a robust test which was a valid assessment of compliance with ERC guidelines whilst having a high reliability with minimal inter and intra observer variation.

The first step involved breaking down the process of performing CPR into its constituent parts. Thus the test would consist of an assessment of the approach to the casualty; the evaluation of the casualty's condition; the appropriateness as assessed by video of hand placement for chest compression and finally the effectiveness of chest compression and mouth to mouth ventilation as recorded by the Laerdal Recording Resusci-Anne printout. This would provide information on compression and ventilation rate and depth as well as the ratio of compression to ventilation. It was decided to develop this test in two parts. What was to subsequently become known as the "Cardiff Assessment of Response and Evaluation" (CARE) (Lester et al 1997) would deal with all of those actions up to the point at which chest compression and mouth to mouth ventilation would commence, whilst these two key skills would be tested by what was to become known as "The Video Recording and Anne Printout" (VIDRAP). (Donnelly et al 1998) Taken together CARE and VIDRAP constitute "The Cardiff Test" of manikin basic life support performance.

Within each assessed step were a series of actions which had to be undertaken. Some of these were order critical e.g. opening the airway before attempting to assess respiration or ventilation. Others less so.

Whilst each action would be carefully assessed it become clear that a summary measure of overall performance would be useful; ideally a simple categorical system which emphasised the dual importance of effectiveness and safety. Thus the top category of performance was deemed to be:

1. as ERC guidelines, and thereafter
2. effective and safe but not as ERC recommend
3. effective but possibly injurious
4. ineffective but safe
5. ineffective and possibly injurious
6. no scorable attempt.

THE "CARDIFF ASSESSMENT OF RESPONSE AND EVALUATION" (CARE)

Method

Our multidisciplinary research team consisting of two research officers, a paramedic and a public health physician (the author) separately viewed a series of manikin CPR videos. Impressions were then discussed and a marking schedule drawn up. In doing so discrepancies and points of ambiguity or disagreement were explored and largely reconciled. This required a move from a simple nine item dichotomous check list to one in which, five of the nine items had categories additional to the original performed/not performed options (see Appendix E). This marking schedule was supported by a markers instruction sheet (see Appendix E).

Thus the development process produced a test which was likely to produce reliable results with a minimum of inter and intra observer variation. However to attempt to provide assurance that this was the case, the test was piloted on two groups of life supporters. Twenty seven being tested on the day of instruction and 40 at between six and 18 month post training. The latter group - the retention subjects, were drawn at random from the 'Heartstart Cardiff and the Vale' database and received an unforewarned home visit from two research officers (one male, one female).

They were asked as part of 'a Heartstart quality control exercise' to perform unforewarned video recorded manikin CPR in response to the following scenario,

> *"On entering a room alone, you see a person lying still upon the floor, please describe and demonstrate how you would approach and assess the situation and what action you would then take. I shall not offer any advice or opinion other than to report the condition of the person during your assessment. Please start and continue until I ask you to stop."*

In each case the test scenario was full cardiopulmonary arrest in an adult and the only intervention by the research officers was to provide information on the casualty's condition. For example, if the subject checked for a pulse after five seconds the research officer would say, "there is no pulse". The video recordings were returned to the research centre for viewing. This was carried out independently by three observers. The project manager (who was not one of the markers) then reordered the sequence of the videos and they were remarked by the same three observers.

Unfortunately marking with regards day of training against retention subjects, could not be made blind as it was obvious from the videos whether the test was being done in a home, or training centre. However the repeat viewing of reordered videos and the independence of viewing did allow intra and inter observer variation to be addressed. This was assessed using the Kappa statistic (K) whilst the chi-square (X^2) statistic was used to compare day of training with retention subjects.

Results

All of the 27 newly trained life supporters agreed to be tested. Of the 48 retention subjects approached two refused, three were absent from home on three occasions, two were accidentally forewarned and one was discarded because he knew the person testing and it was felt this may affect either his performance and/or the administration of the test by the tester. Forty retention subjects were thus available for video assessment. Retention subjects were aged from 15-73 (mean 34) and newly trained individuals 18-56 (mean 28). Thirteen (33%) of retention subjects were male and 27 (68%) female whilst 11 (41%) of the day of training subjects were male and 16 (59%) female. Groups differed slightly in terms of employment status. As the day of training subjects had been trained as part of a workplace initiative, all were currently employed, whereas retention subjects included both some who were in full time education and some who were retired.

Table 4, based upon paramedics scoring (as the most experienced assessor) demonstrates that the day of training group were significantly better at making careful approach, casualty assessment and summoning help. The newly trained group were less likely to forget altogether an individual component of the task and more likely to perform it as taught. This is exemplified by the shout for help, omitted by 37 (93%) of retention subjects but by only 17 (63%) of the recently trained (P=0.007) and also by the omission of the emergency telephone call 26(65%) of retention tests compared to 14 (52%) of the newly trained (P=0.006).

More than two thirds of both groups correctly performed the "look, listen and feel" test for breathing although some neglected to first ensure the airway was open. The retention group were more likely ($P<0.001$) to incorrectly check for circulation by feeling for the far carotid pulse. (The importance of this is debatable as the possible compression and obstruction of the airway in so doing seems a theoretical rather than real hazard in such circumstances).

The scoring system recognised gradations of performance and thus gave some credit for actions which whilst not being "as taught" were never the less effective e.g. the one of 17 and eight of 14 in the new and retention groups respectively who opened the airway in a non standard way. Three retention subjects shook the simulated casualty in an over vigorous or dangerous way and disappointingly only 12 (44%) and 5 (13%) of the new and retention subjects respectively remembered to summon an ambulance.

Table 5 demonstrates the Kappa statistic for inter and intra observer variation and gives the standard interpretation of this statistic. (Altman 1991, Landis & Koch 1997)

Table 4

Performance (CARE criteria) at 1 week (n = 27) and at 6-18 months (n = 40) (% in brackets)

Component	Performance	Day 1	6-18 months	P
Approach	Performed	20(74)	15 (38)	0.00714
	Not performed	7 (26)	25 (63)	
Talk	Performed	22 (82)	27 (68)	0.32441
	Not performed	5 (19)	13 (33)	
Shake	Performed	21 (78)	17 (43)	0.01248
	Not performed	6 (22)	20 (50)	
	Potent. dangerous	0 (0)	3 (8)	
Shout	Performed	10 (37)	3 (7)	0.00728
	Not performed	17 (63)	37 (93)	
Clear airway	Performed	12 (44)	6 (15)	0.01703
	Not performed	15 (56)	34 (85)	
Open airway	As taught	16 (59)	6 (15)	0.00000
	Effective	1 (4)	8 (20)	
	Not achieved	8 (30)	4 (10)	
	Not attempted	2 (7)	22 (55)	
Breathing	Effective	21 (78)	26 (65)	0.26159
	Ineffective	3 (11)	3 (8)	
	Not attempted	3 (11)	11 (28)	
Circulation	Near side	21 (78)	8 (20)	0.00003
	Far side	4 (15)	16 (40)	
	Other pulse	1 (4)	1 (3)	
	Not performed	1 (4)	15 (38)	
Phone 999	Ambulance	12 (44)	5 (13)	0.00567
	Phone ambiguous	1 (4)	9 (23)	
	Not performed	14 (52)	26 (65)	

Table 5

Inter-and intra-observer agreement by *k* correlation (CARE criteria)

Component	**Inter-observer**	**Intra-observer**
Approach	0.97-0.91	0.95-0.72
Talk	1.00-0.96	1.00-0.78
Shake	0.94-0.86	0.95-0.85
Shout for help	1.00-0.86	0.88-0.81
Check airway	0.87-0.84	0.90-0.74
Open airway	0.53-0.42	0.80-0.57
Check breathing	0.96-0.86	0.93-0.68
Check circulation	0.93-0.86	0.89-0.82
Phone 999	0.80-0.69	0.95-0.84

k Statistic	Strength of agreement
<0.20	Poor
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.00	Almost perfect

Agreement was perfect or almost perfect in all categories except for airway opening where agreement was only moderate for inter observer variation and moderate to good for intra observer scores. The action of opening the airway was thus the most difficult to assess reliably. Partly this was because many subjects, particularly in the retention group spend little time on casualty assessment and seemed to open the airway more as a part of preparing to ventilate. Under a strict interpretation of the marking guidelines (see Appendix E) this should be marked as omitted - as it was not done as an integral part of casualty assessment. Further subsequent evaluation of ventilating success did not appear related to actions with regard to airway opening at the time of assessment (see VIDRAP section).

Discussion

The CARE test now provided a validated and reproducible tool with which the initial stages of basic life support could be evaluated. This was an important preliminary step in developing the '999' project methodology but also had wider implications. It could, for the first time, allow the evaluation of different life support instruction and revision methods to be compared in a meaningful way. It could also allow the performance and teaching habits of instructors to be inferred and if necessary corrected.

There were of course caveats that applied to the test development. For example, it is established that examination performance is best in a students habitual classroom (Abenathy 1940). With CPR it has been speculated that the difference between the place of instruction and the place of skill deployment may reduce the likelihood of

skill usage (Annelt 1989). So whilst training is often in a large public building, 70% of arrests occur in the home environment (Litwin 1987). Our methodology of development could be criticised on the basis that whilst our retention subjects were tested at home, the week of training subjects were tested in their training environment. Thus the superior performance of the latter group may in part be context specific as well as being related to the recency of their instruction. Their age was also slightly lower (mean 28 vs 34). However these two factors of test locations and age seem unlikely to explain the highly significant differences that existed in performance. We found these results encouraging as they suggested that the CARE test is sensitive enough to distinguish between the recently and less recently taught.

The excellent results for inter and intra observer variation are achieved despite the discounting of chance agreement through the use of the Kappa statistic. The residual issue of ambiguity over airway opening could perhaps be most comprehensively addressed through a manufacturers modification to the recording manikin. This could involve the inclusion of a light which comes on when mechanical movements of the manikin head/neck complex would suggest the likelihood of airway patency.

The alternative strategy of using a retrospective definition of a patent airway as being that through which air can pass at the later point of the administration of expired air ventilation has the attraction of simplicity and immediate introduction. However it seems scientifically less justifiable as it downgrades the importance of casualty assessment and underestimates the importance of establishing and maintaining a clear airway. In practice, our approach was to reinforce the importance of sticking to a strict interpretation of the marking sheet which in practice seems likely to improve

reproducibility by reducing inter observer variation in recording, arguably at the expense of reducing validity in that such a fault may not reduce likelihood of survival in a true cardiac (as opposed to primary respiratory) arrest. This was felt to be justified as the gold standard was not eventual clinical outcome but compliance with European Resuscitation Council (ERC) guidelines.

A careful study of the relevant literature (see literature section) had revealed that few of the ERC or indeed any other CPR guidelines could be said to arise directly and exclusively from high quality specific research. Rather they were based upon a mixture of inference, interpretation and opinion. The difficult decision for test developers researching this area is whether to base scoring upon ERC statements or upon ones own interpretation of the literature. It was concluded that no alternative interpretation of the literature was any more supportable than that of the ERC due to the general paucity of relevant research - so the ERC guidelines remained our gold standard as we proceeded to develop the second part of "the Cardiff test", the "VIDeo and Recording Anne Printout" (VIDRAP).

THE VIDEO AND RECORDING ANNE PRINTOUT (VIDRAP)

Method

The second part of the test instrument "The Cardiff Test", the "VIDeo and Recording Anne Printout" (VIDRAP), was developed to provide a robust evaluation tool for the cardiopulmonary resuscitation elements of basic life support, namely expired air ventilation and manual external cardiac compression. It compliments the "Cardiff Assessment of Response and Evaluation" (CARE) which performs a similar function for those important aspects of basic life support which precede cardiopulmonary resuscitation. Although VIDRAP was originally developed to measure performance to the European (ERC) 1992 guidelines, it can be (and subsequently has been) easily adapted to take account of any changes in performance guidelines, for example those recently suggested by the ERC within the International Liaison Committee on Resuscitation (ILCOR) advisory statement on Basic Life Support (Handley et al, 1997).

Four observers (comprising of, two research officers, a paramedic and a public health physician (the author)) independently viewed video recordings of subjects performing CPR simulations on a Recording Resusci Anne manikin. They compared and discussed their assessments using points of disagreement or discrepancy as a means of identifying areas of marking in need of clarification. Similar discussions surrounded the interpretation of Resusci Anne printouts, when read in conjunction with the video recording.

Eventually, agreement was reached and the resulting marking schedules and guidelines are shown in Appendix E.

Using these agreed guidelines as the marking criteria, three members of the team then independently viewed and assessed videos and printouts of 42 subjects. Following the first assessment, videos and printouts were randomly reordered by an independent individual and re-evaluated by the three assessors to measure intra observer agreement. Of the 42 CPR simulations, 24 were recorded on the day of instruction and the other 18 (the retention subjects) between 6 and 18 months afterwards.

The retention subjects were randomly selected from the Heartstart Cardiff and the Vale database and visited at home, without forewarning, by two research officers. The subject was asked to perform basic life support on a recording Resusci Anne manikin whilst being video recorded. Immediately before filming commenced the individual was read an instruction similar to that used in developing the CARE component of the test. In each case the scenario to be examined was an adult cardio respiratory arrest. The candidate was not informed of the diagnosis but was expected to deduce the casualty's condition by assessment and to provide the appropriate treatment. The research officer only gave information in response to an assessment procedure: for example, if the life supporter was observed to attempt to palpate for a pulse the researcher would say "there is no pulse". No further comment or coaching was offered.

Video tapes and Recording Anne printouts were returned to the centre for marking according to the ERC 1992 guidelines. Independent, and blind repeat markings were

then performed as previously described and intra and inter observer variation tested using the Kappa statistic. The chi-squared test was used to compare post training and retention scores.

CPR attempts were categorised according to their potential effectiveness for an adult casualty in cardiac arrest, and the criteria for inclusion in each category appear as table 6. To clarify the marking of hand positions in the potentially injurious category; this is defined by a combination of observation from the video and the recording strip. A dot will only appear on the strip if pressure is directed to any place on the chest other than the lower half of the breastbone. It therefore follows that if the observer marks the hand position as so poor as to be ineffective and no dots appear on the recording strip, then the position will be so far from the recommended site as to be potentially injurious. During the development stage of VIDRAP, the majority of trainees in this category were compressing the abdomen rather than the chest.

The VIDRAP categories were now as follows:-

ERC	An attempt conforming to the ERC ILCOR 1997 statement
Effective	An attempt which, though not conforming strictly to the ERC statement, may be of some benefit to the casualty.
Effective/potentially injurious	An attempt which may be of some benefit to the casualty, but having some potentially injurious components.
Ineffective	An attempt which is unlikely to benefit the casualty, but which has no potentially injurious components.
Ineffective/potentially injurious	An attempt which is unlikely to benefit the casualty and has some potentially injurious components.

Results

Intra and inter observer variations are shown in tables 7a and 7b respectively. Kappa scores of between 0.81 and 1.00 indicate almost perfect agreement, with 0.61-0.80 and 0.41-0.60 indicating good or moderate agreement respectively. Agreement was therefore almost perfect or good in each category for intra observer variation. However, inter observer variation was only moderate in two of the three paired subjective assessments (A/B and B/C) for compression measurement (i.e. measuring correctly before positioning hands for chest compression). Visual placement of the hands which was also subjective, again had lower Kappa scores with one pair (B/C) showing moderate agreement, but the remaining two pairs showing only fair agreement. There was, however, a high level of agreement for the objective recording strip measurements.

Table 8 compares the performance of newly trained subjects with those who were trained between six and 18 months previously. For all components except compression depth, the performance of the newly trained was significantly superior. The performance categories for the newly trained and retention subjects are shown in table 9. Of the recently trained 16 (67%) were classed as ERC standard or effective, compared with only four (22%) of the retention group ($p<0.01$). However, of those who were effective, eight of the newly trained and two of the retention group also gave at least one compression of more than 51 mm.

There were two (8%) newly trained life supporters and six (33%) of the retention group who performed CPR in a way that was classed as both ineffective and

potentially injurious ($p<0.05$). Of the newly trained, in all ineffective and potentially injurious performances, the injurious element was over compression, but in five of the six ineffective and potentially injurious retention tests, the cause was a very poor hand position (on the abdomen rather than the chest) and in only one was it over compression. Only 8 (33%) new trainees and 2 (11%) of the retention group performed to ERC standards or effectively with no potentially injurious elements.

Table 6: Criteria for inclusion in VIDRAP categories

Component	ERC	Effective	Effective/ injurious	Ineffective	Ineffective/ injurious
Ventilation (litres)	0.5-1.2 and	>0, <2 and	>0 and	0 and/or	>2 and/or
Compression (millimetres)	38-51 and	30-51 and	30-51 and	<30 and/or	>51 and/or
Ratio	2:15* and	at least 5 comps. to each vent. and	at least 5 comps. to each vent. and	<5 comps. to each vent. and	<5 comps. to each vent. and
Hand Position	visually correct or effective	visually correct or effective	visually ineffective with no dots	visually correct or effective	visually ineffective with no dots.

* 2:14 and 2:16 acceptable

Table 7: Kappa scores for intra and inter observer variation

7a) Intra observer scores

	A	B	C
Breathing volume	0.89	0.94	0.88
Airway faults	0.86	0.74	0.79
Comp. measure	0.82	0.58	0.71
Visual placement	0.71	0.63	0.92
Strip dots	0.94	0.91	0.85
Comp. rate	0.84	0.75	0.86
Comp. depth	0.91	0.90	0.94
Ratio	0.86	0.95	0.95

7b) Inter observer scores

	A/B	A/C	B/C
Breathing volume	0.91	0.80	0.80
Airway faults	0.61	0.67	0.65
Comp. measure	0.51	0.70	0.52
Visual placement	0.37	0.37	0.41
Strip dots	0.82	0.80	0.79
Comp. rate	0.79	0.83	0.81
Comp. depth	0.88	0.90	0.87
Ratio	0.86	0.91	0.86

Table 8: Second cycle of CPR - newly trained and retention tests

Component	Newly trained (n=24)	Retention (n=18)	Significance
Airway open for vents	21 (88%)	10 (55%)	p<0.05
Breathing volume			
0.8-1.2 litres	10 (42%)	2 (11%)	p<0.05
0.5-1.2 litres	15 (63%)	3 (17%)	p<0.01
Comp. measurement			
as taught	5 (21%)	1 (6%)	NS
attempted	21 (88%)	8 (44%)	p<0.01
Hand placement			
visually correct	21 (88%)	7 (39%)	p<0.001
visually effective	24 (100%)	11 (61%)	p<0.001
incorrect strip	6 (25%)	8 (44%)	p<0.05
Compression rate			
80-100 per minute	10 (42%)	1 (6%)	p<0.01
>59 per minute	20 (83%)	8 (44%)	p<0.025
Compression depth			
38-51 mm	7 (29%)	3 (17%)	NS
30-51 mm	16 (67%)	8 (44%)	NS
Ratio correct	21 (88%)	5 (28%)	p<0.001

Table 9: VIDRAP categories in post training and retention tests (n=42)

	ERC	Effective	Effective/ injurious	Ineffective	Ineffective/ injurious
Post training	2 (8%)	6 (25%)	8 (33%)	6 (25%)	2 (8%)
Retention	0 (0%)	2 (11%)	2 (11%)	8 (44%)	6 (33%)
Total	2 (5%)	8 (19%)	10 (24%)	14 (33%)	8 (19%)

ERC+effective+effective/injurious, new *vs* retention	$p<0.01$
Ineffective/injurious, new *vs* retention	$p<0.05$

Discussion

Instructors do not make objective assessors (Brennan et al 1995) they tend to overlook performance errors. In particular when forced to make real time assessments, they tend to evaluate a candidate's performance against the previous candidates (Forgues 1994) rather than against objective criteria. The use of a combination of video and manikin printout removed the need to assess under pressure and should improve objectivity. This was demonstrated in recent research into the resuscitation skills of general practitioners (Jansen et al 1997); for whilst 97% of candidates were judged satisfactory by observation, only 47% passed a printout based assessment. Checklist type scoring remains essential however for those actions prior to the commencement of ventilation and chest compression. Hence the development of 'CARE' (- see

earlier). Video recording also improves inter-observer reliability in trained assessors (Jansen et al 1997).

The combination of video and manikin printout is particular powerful at detecting subtle but potentially injurious errors, e.g., poor hand positioning, over-compression or both. A further advantage of video and manikin recording is the creation of a reviewable research archive. At a latter date; an action or lack of it may be reviewed, external researchers could independently assess performance, distinct scoring schedules could be applied to exsiting study samples. For all of these reasons the advantages of video and recording Anne printout over real time assessment are difficult to overstate. Such an approach may act as an agent for scientific progress in the field of resuscitation and the CARE and VIDRAP marking schedules and performance categories which together constitute the "Cardiff test" of manikin CPR performance could form the basis for subsequent basic life support studies. It provided us with the robust test instrument we required to carry out the BBC 999 study, a description of the methodology of which now follows.

VI - METHODOLOGY OF THE 999 STUDY

VI METHODOLOGY OF THE 999 STUDY

Recruitment

The '999' television programmes were broadcast on BBC 1 on ten consecutive Friday evenings between 8th April 1994 and 16th June 1994, from 9.30 pm until 10.20 pm.

Midway through each programme the training course to be held two weeks later was advertised. Thus in all ten courses were held at the following venues:- Edinburgh, Middlesborough, Preston, Sheffield, Norwich, London, Exeter, Bristol, Swansea and Londonderry.

Viewers were encouraged to phone and register their interest. These calls (an estimated mean of 2,000 per show) were handled by automated systems, with callers name and address being recorded. After 800 calls (each of which may have booked places for a number of individuals) a recorded message by Michael Buerk, the programme presenter, told callers that all places had been filled and they were invited to contact the voluntary organisations independently to make alternative arrangements for training.

Training Arrangements

Of those offered a place, over 75% turned up for training. Training venues were generally large sports halls or similar public arenas.

The administration was handled by the BBC but with their co-operation the BBC 999 souvenir packs were handed out only after training and completion of our questionnaire, thus ensuring a high response rate.

The voluntary organisations who provided training were responsible for ensuring the content and quality of their input. The syllabus was written by the British Heart Foundation and British Red Cross, based on a course developed by Heartstart Cardiff and the Vale which followed European Resuscitation Council guidelines (see appendix A). This helped to ensure comparability of trainees throughout the 999 Roadshows and with those trained in other community programmes.

Training lasted about 150 minutes and involved a video, short talk, demonstration and practice session utilising a Laerdal Resusci Anne manikin. No formal test of competence was performed although instructors were encouraged to intervene and correct obviously inappropriate techniques.

Data Collection on Site

Data was collected by means of manual form completion by course participants (see Appendix A). Assistance was on hand for those who found completion difficult and the completed forms were then packaged for forwarding to the research centre.

Respondents were asked to complete and sign a second document giving name, address, telephone number and consent to their being contacted with a view to further participation in research. The BBC insisted that the anonymity of potentially sensitive

socio-economic and family data should be preserved, so we were unable to link questionnaire data to research permission forms by means of an identifying number.

Once received at research headquarters data was encoded and input into the SPSS programme, utilising an IBM compatible personal computer. Analysis was performed utilising the SPSS summary and statistical facilities. Graphs were produced using Excel.

The Video "Cold-Call" technique

To fully assess the ability of subjects to perform cardiopulmonary resuscitation, without notice and whilst under stress a new assessment technique needed to be designed, validated and tested for reliability. To that end an assessment based upon the unforewarned video recording of people performing manikin CPR in their own homes was chosen.

Briefly, a subject was chosen as detailed below, and an unsolicited and unforewarned call was made at their address 6 months following their training. Two researchers (one male, one female) showed the person their identity cards along with the permission for further research card which the individuals had completed at the time of their initial training. The purpose of the visit was then explained.

Subjects were invited to perform manikin CPR without time for reflection or preparation whilst being video recorded. They were presented with a standard scenario which was read to them before the test began:-

> *On entering a room alone you see an adult lying still on the floor. There is no sign of trauma or drowning. Please describe and demonstrate how you would* ***approach*** *and* ***assess*** *the situation and what* ***action*** *you would take. I shall not offer any advice or opinion other than to report the status of the person during your assessment. Please start and continue until I ask you to stop.*

They were then asked to commence their assessment and treatment of the manikin "casualty". They were not coached in any way although pieces of clinical information were conveyed as appropriate., e.g., if the subject said they would feel for a pulse - one of the researchers would say after 5 seconds "there is no pulse present". Subjects were allowed to continue until they had completed two cycles of CPR or until it was clear that their efforts to do so were complete.

The resulting video tapes and accompanying printouts from the Recording Resusci-Anne - the result of 9 city visits throughout the UK were then returned to research headquarters, viewed and scored, utilising the Cardiff test of manikin CPR (CARE and VIDRAP components) as described in the section "developing the test instrument."

Subject Selection

Possible subjects for video cold call testing were defined as those who had attended for training and completed a card authorising further research. These cards were sampled in a systematic fashion with every seventeenth card being selected. The starting point for the first card selection was generated utilising random number tables. The subject's card gave a home telephone number. If the subject lived a considerable distance from the tester's local base - for example in a distant village, a phone call was made to check that the individual still lived at that address and was in. If there was no reply this process was repeated twice more before an alternative was chosen. This was defined as the card 5 cards further on. The phone call was made in such a way that the person was not forewarned of the impending CPR test. However with the majority of subjects it was deemed unnecessary to call as they lived within a few miles of the local tester's base. If there was no answer, the house was revisited on two further occasions before a substitute was generated in the same way as before.

The advantages and disadvantages of the methodology are discussed in Section IX.

VII - RESULTS OF RECRUITMENT

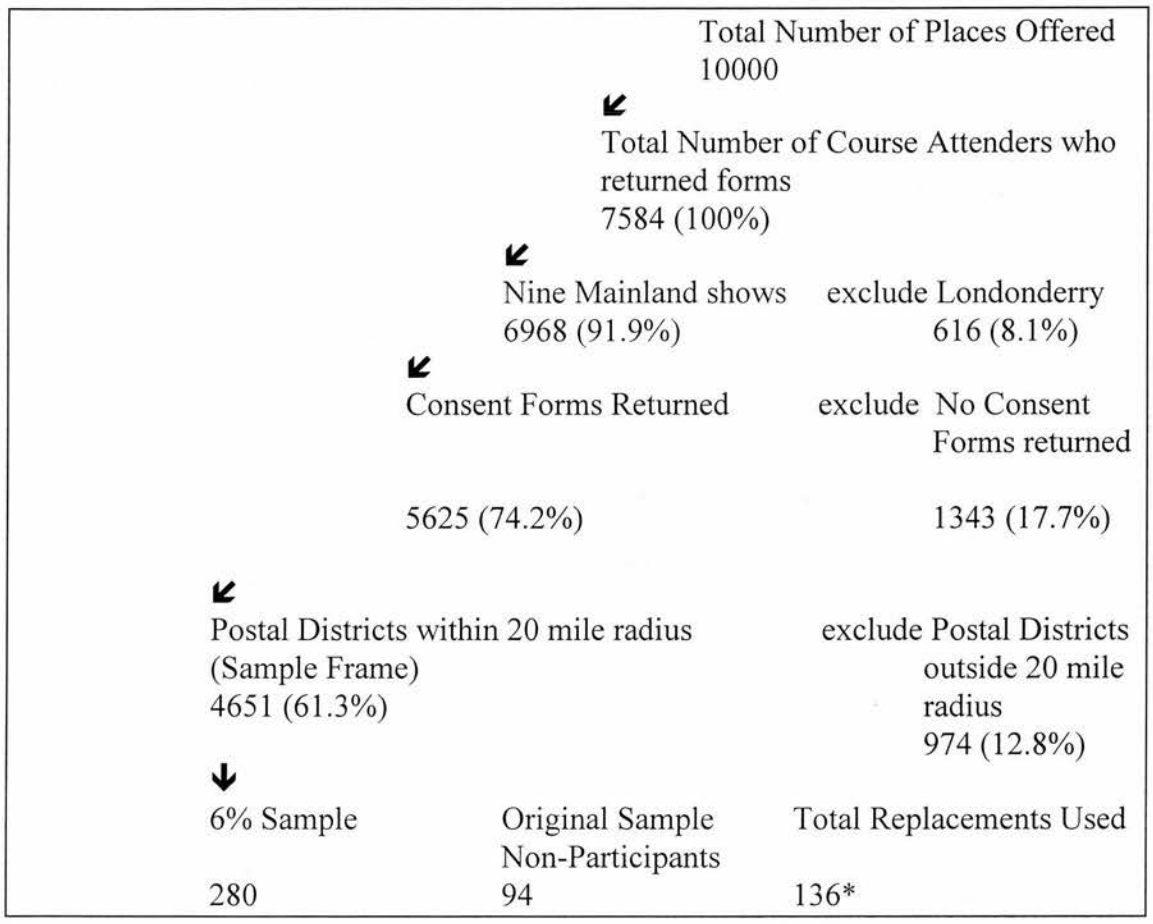
VII RESULTS OF RECRUITMENT

This section analyses the age, sex and social class make up of the recruited "999" training group and compares their composition to that of training groups recruited in different ways.

Numbers

Each training weekend was heavily oversubscribed. The mechanism of answering calls did not allow the BBC to collect precise figures on the number of people volunteering for training. However their estimate was that there were over 50,000 callers chasing 10,000 training places. Of those who were offered places on a course 7584 (75.8%) turned up, were trained and completed our questionnaire. It is impossible to be sure how many turned up, were trained and left without completing the questionnaire, but we believe these numbers to be very low - principally because the completion of the questionnaire was an integral part of the training package which culminated in the presentation of the BBC 999 souvenir information pack. The numbers of people agreeing to participate in further research and subsequently being selected for video testing are shown in Figure 2.

Fig 2: Course attenders and test sample selection



* In some instances the replacement was also non participant and further replacement was required.

2 Cohort Composition

The number of attendees at each course location and the number and percentage later video tested are shown on table 10. Figure 3 shows the 10 UK training locations

The composition of the recruited cohort in terms of age, sex and social class is shown in tables 11, 12 and 13.

Table 10

BBC 999 Roadshow - course attendees and number sampled by venue.

Course Location	Number Attending	Number (%) tested at 6 months
Edinburgh	762	33 (4.3%)
Middlesborough	639	31 (4.9 %)
Preston	759	30 (4.0%)
Sheffield	878	32 (3.6%)
Norwich	797	38 (4.8%)
London	750	31 (4.1%)
Exeter	720	26 (3.6%)
Swansea	793	34 (4.3%)
Bristol	869	38 (4.4%)
Derry	616	* 0 (0%)
TOTAL	**7583**	**280 (3.7 %) †**

* NB Testing was not carried out in Londonderry on the advice of the Royal Ulster Constabulary who warned against making unsolicited home visits in certain areas of the city after dark.

† when calculated as a percentage of the Sample Frame, the result is 280/4651 i.e. 6%. The variation in the percentage tested in each location represents differences in the proportions of those attending caught within the sample frame. (see Figure 2)

Figure 3
Map of the United Kingdom showing
999 Roadshow Locations

Table 11

Age structure of UK population, 999 television show audience and study participants

Age	% UK Pop	999 Audience	% 999 Audience	Audience Ratio	Course Attenders	% Attenders	Course Ratio1	Course Ratio2
4-9	9.1	409,400	4.3%	46.7	85	1.1%	12.3	26.4
10-15	8.8	777,700	8.1%	91.8	725	9.6%	108.6	118.4
16-24	11.6	664,200	6.9%	59.5	944	12.4%	107.3	180.4
25-34	15.1	1,551,700	16.1%	106.7	2755	36.3%	240.6	225.4
35-44	14.6	1,599,800	16.6%	113.8	1766	23.3%	159.5	140.1
45-54	13.4	1,592,600	16.5%	123.4	938	12.4%	92.3	74.8
55-64	10.8	1,246,900	13.0%	119.9	296	3.9%	36.1	30.1
65+	16.4	1,786,100	18.6%	113.1	66	0.9%	5.3	4.7
Missing Data					9	0.1%		
Grand Total	100	9,628,400	100%	100	7584	100%	100	100

Table 12

Sex Structure of UK population, 999 television audience and study participants

Age	%UK Pop	999 Audience	% 999 Audience	Audience Ratio	Course Attenders	% Attenders	Course Ratio1	Course Ratio2
<16	18	1,187,500	12.3%	68.5	810	10.7%	59.3	86.8
Male	38.6	3,782,000	39.3%	101.7	2022	26.7%	69.1	67.8
Female	43.4	4,658,900	48.4%	111.4	4221	55.7%	128.2	115.0
Missing Data					531	7.0%		
Total	100	9,628,400	1	281.7	7584	100%	100.00	100.0

Table 13

Social Class structure of UK population, 999 television audience and study participants

SEG	%UK Pop	Audience	% 999 Audience	Audience Ratio	Course Attenders	% Attenders	Course Ratio1	Course Ratio2
AB	18.0%	1,632,300	17.0%	94.2	2562	33.8%	187.7	199.3
C1	26.8%	2,478,700	25.7%	96.1	1152	15.2%	56.7	59.0
C2	24.8%	2,561,400	26.6%	107.3	1695	22.3%	90.1	84.0
DE	30.4%	2,956,200	30.7%	101.0	1192	15.7%	51.7	51.2
Missing Data					983	13.0%		
Grand Total	100.0%	9,628,600	100.0%	100.00	7584	100.0%	100.00	100.00

Notes on data sources and interpretation

1. UK population, age, sex and social class structure from ONS census data, 1991

2. 999 Audience numbers supplied by JICTAR ratings organisation

3. Audience ratio = $\frac{\text{estimated total viewers in age band}}{\text{total UK pop in age band}}$ x 100 - An audience rate of 100 therefore shows exact representation of the age group in the shows audience. Ratios above and below 100 demonstrate over representation and under representation respectively. Similarly with sex and social class.

4. Course Ratio 1 = $\frac{\text{course attendees in age bracket}}{\text{\% UK population in age bracket}}$ similarly with sex and social class.

5. Course Ratio 2 = $\frac{\text{course attendees in age bracket}}{\text{\% of TV audience in age bracket}}$ similarly with sex and social class.

Cross tabulations relating the groups age, sex, and social class categories of participants to that of the programme audience and the UK population are shown in tables 14 to 19.

Table 14: Course Attenders compared to Audience by Age

	0-44	**45+**	**Total**
Attended	6275 (82.8)	1300 (17.2)	7575
Not Attended	4,996,525 (51.9)	4,624,300 (48.1)	9,620,825
Total	5,002,800 (51.9)	4, 625,600 (48.1)	9,628,400
		Chi2 = 2896	p<0.001

Table15: Course Attenders compared to Audience by Sex

	Male	Female	Total
Attended	2022 (32.4)	4221 (67.6)	6243
Not Attended	3,779,978 (44.8)	4,654,679 (55.2)	8,434,657
Total	3,782,000 (44.8)	4,658,900 (55.2)	8,440,900
		Chi2 = 390	p<0.001

Table 16: Course Attenders compared to Audience by Socio-Economic Group

	ABC1	C2DE	Total
Attended	3714 (56.3)	2887 (43.7)	6601
Not Attended	4,107,286 (42.7)	5,514,713 (57.3)	9,621,999
Total	4,111,000 (42.7)	5,517,600 (57.3)	9,628,600
		Chi2 = 497	p<0.001

Table 17: Course Attenders compared to UK Population by Age

	0-44	45+	Total
Attended	6275 (82.8)	1300 (17.2)	7575
Not Attended	31,386,301 (59.3)	21,528,068 (40.7)	52,914,369
Total	31,392,576 (59.3)	21, 529,368 (40.7)	52,921,944
		Chi2 = 1779	p<0.001

Table 18: Course Attenders compared to UK Population by Sex

	Male	Female	Total
Attended	2022 (32.4)	4221 (67.6)	6243
Not Attended	20,463,978 (47.1)	23,026,779 (52.9)	43,490,757
Total	20,466,000 (47.1)	23,031,000 (52.9)	43,497,000
		Chi2 = 539	p<0.001

Table 19: Course Attenders compared to UK Population by Socio-Economic group

	ABC1	C2DE	Total
Attended	3714 (56.3)	2887 (43.7)	6601
Not Attended	23,52,830 (44.8)	29,268,569 (55.2)	53,021,399
Total	23,756,544 (44.8)	29,271,456 (55.2)	53,028,000
		Chi2= 351	p<0.001

The socio-demographic profile of the cohort recruited by the 999 television show is now compared to that of two cohorts generated in alternative ways. Firstly with that of a campaign run by our group in conjunction with a local evening newspaper (the South Wales Echo) and secondly that of a cohort generated largely by word of mouth passing through work and social peer groups. (labelled "community") The results are shown in tables 20, 21 and 22.

Table 20: Number (%) recruited by television, newspaper and community word of mouth by age.

Age	Television	Newspaper	Community	Newspaper Ratio	Community Ratio
15-19	265 (3.9)	38 (6.3)	910 (15.8)	160.	403
20-24	679 (10.0)	23 (3.8)	668 (11.6)	38	115
25-29	1351 (20.0)	56 (9.2)	675 (11.7)	46	59
30-34	1404 (20.8)	45 (7.4)	705 (12.2)	36	59
35-39	1027 (15.2)	61 (10.1)	576 (10.0)	66	66
40-44	739 (10.9)	57 (9.4)	564 (9.8)	86	90
45-49	619 (9.2)	67 (11.1)	498 (8.6)	121	94
50-54	319 (4.7)	59 (9.7)	347 (6.0)	206	128
55-59	199 (2.9)	67 (11.1)	238 (4.1)	376	140
60-64	97 (1.4)	46 (7.6)	236 (4.1)	529	285
65-69	38 (0.6)	29 (4.8)	157 (2.7)	852	485
70-74	21 (0.3)	23 (3.8)	111 (1.9)	1222	620
75-79	4 (0.1)	6 (1.0)	47 (0.8)	1674	1378
080-84	0 (0)	29 (4.8)	24 (0.4)	**	**
85+	0 (0)	0 (0)	9 (0.2)	**	**
Total	6762 (100)	606	5765	100	100

Table 21: Number (%) recruited by television, newspaper and community word of mouth by sex.

Sex	Television	Newspaper	Community	News Ratio	Community Ratio
Male	2022 (32.4)	191	2304	101	81
Female	4225 (67.)	391	3458	99	113
Total	6247	582	5762	100.0	100.0

Table 22: Number (%) recruited by television, newspaper and community word of mouth by social class.

Social Class	Television	Newspaper	Community	Newspaper Ratio	Community Ratio
I	431	23	257	68	87
II	1922	120	1555	79	118
IIIN	1672	127	1016	96	88
IIIM	1103	121	717	139	95
IV	607	67	427	140	102
V	122	6	50	63	60
Armed Forces	35	2	32	73	133
Total	5892	466	4054	100.0	100.0

Newspaper ratio = $\frac{\%\text{ in category in newspaper cohort}}{\%\text{ in category in TV cohort}}$

A news ratio of 100 indicates an attendance at the newspaper courses in exact proportion to those attending the television courses - similarly with "community" word of mouth ratio.

Tables 23, 24 and 25 present results comparing the three aforementioned recruitment methods as means of generating cohorts of people who live with an individual with a history of heart disease.

Table 23: Those living with a person with a history of heart disease, television compared to newspaper.

	Television (%)	Newspaper (%)
Live with IHD patient	321 (4.7)	99 (17)
Not living with IHD patient	6451 (95.3)	483 (83)

Chi Square = 150 $p<0.00001$

Table 24: Those living with a person with a history of heart disease, television compared to community.

	Television (%)	Community (%)
Live with IHD patient	321 (4.7)	696 (12.1)
Not living with IHD patient	6451 (95.3)	5069 (87.9)
	Chi Square = 225	p<0.00001

Table 25: Those living with a person with a history of heart disease, newspaper compared to community.

	Newspaper (%)	Community (%)
Live with IHD patient	99 (17)	696 (12.1)
Not living with IHD patient	483 (83)	5069 (87.9)
	Chi Square = 11.8	p=0.0006

These results are discussed in Section IX.

VIII - RESULTS OF CPR PERFORMANCE

VIII Results of CPR performance

Analysis of videos and recording strips was carried out to agreed criteria by a research officer using the marking schedule and marker guidelines described for the "CARE" and "VIDRAP" components of "the Cardiff test" described in the development of a robust test instrument section of this dissertation. The abbreviated categories for effectiveness and potential injury are shown in table 26. A second research officer working in the same criteria, independently checked a 10% random sample of the database and the inter rate agreement is shown in table 27.

Ninety four of the originally selected 280 subjects (34%) did not take part in the study for the reasons shown in table 28. The total of 136 replacements were required to complete the remaining 94 tests as some of the replacements themselves refused or were excluded. The number of subjects performing each procedure, with the type of performance where appropriate is shown in table 29.

Table 26

European Resuscitation Council's Guidelines and Study Criteria for Effective & Potentially Injurious Resuscitation

	Guidelines	**Effective**	**Potentially Injurious**
Breathing volume (l)	0.8-1.2	0.1-2	>21
Compression depth (mm)	38-51	30-51	>51
Compression rate (No/min)	80-100	>60	NA
Ratio of breaths to compressions	2:15	1.5 (minimum)	NA
Hand position during compression	Concentrated on centre of chest, two fingers above xiphisternum	Concentrated on lower third of sternum	Any other hand position
NA = Not applicable			

Table 27

Agreement between raters on effectiveness of procedures in 10% sample of cohort

Procedure	**Percentage agreement**	**Kappa statistic**
Careful approach	73	0.46
Talk to patient	97	0.92
Shake patient	93	0.84
Shout for help	93	Not calculable
Clear or check airway	93	0.71
Open airway	90	0.93
Check for breathing	87	0.68
Check for circulation	87	0.79
Telephone emergency services	70	0.68

Table 28

Reasons why 94 subjects needed to be replaced in study cohort, with numbers of replacement subjects required to complete test for each reason

Reason for replacemnet	**No. of replacement subjects (n = 136)**
Refused	38
Out on three occasions	21
Incapable owing to physical injury	4
Possibly forewarned	42
Address not found, illegible, or insufficient	3
Moved with no forwaridng address or outside the area	15
Tests invalid owing to:	
Equipment failure	7
Prompting from another person	8

Table 29

Numbers of subjects (n = 280) performing each procedure, with type of performance when appropriate

Procedure Name	**Number not performed procedure**	**Missing data**	**Resuscitation performed:**			
			According to guidelines	**Effectively**	**Ineffectively**	**Dangerously**
Careful approach	196	6	78	NA	NA	NA
Talk to patient	180	4	96	NA	NA	NA
Shake patient	190	4	84	NA	NA	2
Shout for help	268	4	8	NA	NA	NA
Check airway	242	0	38	NA	NA	NA
Open airway	230	0	32	12	6	NA
Check for breathing	40	0	210	NA	30	
Check for circulation	69	0	25	162	24	NA
Telephone emergency services	250	0	27	NA	3	NA NA
Breathing volume	9	0	68	94	101	8
Breathing interval	21	0	80	17	162	NA
Hand position during compression	17	0	91	103	NA	69
Compression rate	17	0	55	91	117	NA
Compression depth	17	0	71	90	44	58
NA = not applicable						

Disappointingly only 78 (28%) demonstrated a careful approach and although 210 (75%) appeared to check for breathing 173 (82.4%) of these had not first opened the airway. Only 27 (10%) of subjects spontaneously said they would call an ambulance before beginning cardiopulmonary resuscitation but when questioned at the conclusion of the test about how long they would continue doing CPR for, almost half 138 (49%) stated that they would continue until an ambulance arrived. The remaining 142 (51%) were split between continuing for a defined period 51 (36%) and continuing until the patient showed signs of revival 55 (39%). A 57% (n=60) subset of the 106 who initially suggested criteria other than ambulance arrival to discontinue CPR provision were asked a second question tailored to their response, i.e., what would they do at the end of their defined period or if the patient failed to respond. In reply to this, a further 19 (32%) said they would await the arrival of the ambulance whilst 29 (48%) now said they would phone for an ambulance. The remainder made either no response or alternatively no classifiable response.

Overall CPR performance is shown in table 30. Although none of the 280 subjects performed to ERC standards, 19 (6.8%) performed in a way that was deemed by the agreed criteria (see table 26) to be effective and safe. A further 14 individuals marred their otherwise effective performance by the inclusion of one or more actions that was deemed potentially injurious. This left 87% of subjects (243) performing ineffectively of whom 110 (45%) also did something potentially injurious.

Younger people were more likely to give effective CPR (see table 31) with 31 (14%) of those aged under 45 performing effectively compared with only two (4%) of those aged 45 or over ($p<0.05$). Sex and social class did not affect performance but confidence predicted better performance, with 20% (26 of 133) of those confident doing well compared to 6% (7 of 127) ($p<0.005$) of those who were unsure or lacked confidence. Subsequent training appeared to confer an advantage with 40% (8 of 20) who had attended a subsequent course achieving effective results against 10% (25 of 256) who had not.

Women performed in a manner deemed to be safe more frequently than men. 62% vs 42% ($p<0.005$) but age and social class were not relevant for safety, neither was pretest confidence.

To summarise the CPR evaluation, only 33 (12%) of 280 trainees could perform effective CPR in an unforewarned video test carried out at home 6 months after training. Of these, 14 (5%) performed one or more procedures in a potentially injurious way and thus only 19 (7%) of subjects were able to provide safe and effective intervention. Large numbers of subjects failed to shout for help, effectively assess patient status or alert the emergency ambulance service. Those under the age of 45 were more effective as were those who had attended a subsequent CPR course or who were initially more confident in their ability. Females were less likely to carry out a procedure in a potentially injurious way.

Table 30: Overall rating of cardiopulmonary resuscitation performed by 280 subjects

Rating	No. of subjects
Conforming to guidelines	0
Performance:	
Effective	19
Effective but potentially injurious	14
Ineffective	133
Ineffecfive & potentially injurious	110
Resuscitation not performed	4

Table 31

Effectiveness and safety of performance of cardiopulmonary resuscitation by age, sex, social class, subsequent training, and confidence before test. Values are numbers (percentages) of subjects*

	Effective	Ineffective	P value	Safe	Potentially injurious	P value
0ge (years):						
<45 (n = 219)	31(14)	188(86)		127(58)	92(42)	
>45 (n = 53)	2(4)	51(96)	0.04	26(49)	27(51)	0.25
Sex:						
Male (n = 82)	10(12)	72(88)		34(41)	48(59)	
Female (n = 190)	23(12)	167(88)	0.79	117(62)	73(38)	0.002
Social class:						
I, II, IIIN (n = 153)	18(12)	135(88)		83(54)	70(46)	
IIIM, IV, V (n = 98)	9(10)	89(91)	0.52	55(56)	43(44)	0.77
Subsequent course:						
Attended (n = 20)	8(40)	12(60)		13(65)	7(35)	
Not attended (n = 256)	25(10)	231(90)	<0.0001	140(55)	116(45)	0.37
Confidence before test:						
Confident (n = 133)	26(20)	107(81)		68(51)	65(49)	
Not confident or unsure (n = 127)	7(6)	120(95)	0.001	76(60)	51(40)	0.16

* Four subjects did not attempt cardiopulmonary resuscitation and so are excluded from this analysis. In addition, some subjects completed the sociodemographic questionnaire incorrectly or social class could not be coded.

These results are discussed in Section IX.

IX DISCUSSION

IX DISCUSSION

Discussion of Methodology

Recruitment

All of those recruited for training were of necessity volunteers, and volunteers tend to be unrepresentative of the population as a whole. In this instance of course those volunteering were themselves already a population subset - namely those who were watching the particular television programme. As part of our work with Heartstart Cardiff and the Vale we have generated training cohorts in various ways - by word of mouth, by contacting large employers and by utilising local newspaper campaigns. In the results section the cohorts generated are compared. The BBC 999 programme proved a highly effective way of generating large training cohorts with the courses being heavily oversubscribed and the maximum non attendance rate being under 25% which compares with a typical Heartstart (community programme) no show rate of 20%.

The use of systematic sampling

Systematic sampling was applied to subject cards pre-sorted into postcode areas. Some may argue that a truly random sample on unpre-sorted cards is desirable. However we had to contend with two imperatives. Firstly we did not wish, even by chance, to test two individuals from the same household as the unsolicited, unforewarned nature of the test would be affected. Secondly we needed to create a

testing workload that was logical, coherent and manageable, that worked its way through particular areas of identified cities and didn't have our researchers needlessly spending time travelling between randomly generated but widely disseminated addresses. I do not believe that the methodological compromise that we in the end accepted seriously biased our sample.

The use of telephone calls for far-flung addresses

This was a further methodological compromise but again I think justifiable and done in a way to avoid affecting subject performance and hence result interpretation. In brief, to avoid researchers having to make a potentially fruitless journey to selected individuals who happened to live remotely, they were permitted to make a phone call to ascertain whether the relevant individual still lived at that address and was in at the time of the call. (This was deemed preferable to substituting out such individuals, as those living more remotely may well not be typical of our sample population).

Of course the call had to be made in a manner which neither forewarned individuals of the nature of the business nor caused alarm amongst those receiving the calls. Aware that many organisations now routinely market via the telephone using databases which identify potential clients by both name and address, we felt it permissible to ask for an individual by name when the phone was answered. If that individual had moved away we merely apologised for troubling the individual answering. If another household member answered the phone we questioned when our target individual was likely to be contactable at that number. A house call was then made at that time.

If the individual we were targeting was available, the researchers then needed to politely terminate the phone call without forewarning them of the imminent house call. Various methods were discussed for achieving this. In the end a ploy of pretending to be selling an expensive piece of household equipment was used. Subjects would then terminate the call without our researchers having to reveal their true identity. Some may find such behaviour odd, however it achieved the aim of identifying our targets without forewarning them, and most importantly, without alarming those answering our call. In every case at the subsequent visit the deliberately deceptive call was admitted and in no instance did any of the subjects object.

Discussion of results of 999 study (recruitment)

Television backed training roadshows were shown to be successful at recruiting large numbers of volunteers. An estimated 50,000 callers chased 10,000 training places, with 7,584 individuals actually attending and completing our forms. It is difficult to be certain how many more attended and failed to complete a form, although the numbers are unlikely to be large for the reasons given previously.

The age, sex and social class structure of this 7,584 person cohort are shown in tables 11, 12 and 13. These tables also compare these dimensions between the recruited cohort and the UK population as a whole and the 999 audience in particular.

In summary, these tables show that whilst the 999 audience of nearly 10 million individuals broadly reflects the UK population as a whole, those who attended the

course are a typical. They are more likely to be female, young and professional. When analysed as dichotomous groupings, i.e., under or over 45, male or female, ABC_1 or C_2DE, it can be shown that in every case the difference between course attenders and both the audience and the UK population is highly significant. (Tables 14-15).

Tables 20 to 22 compare this television recruited cohort with ones generated by either word of mouth or local newspaper appeal. By comparison with television recruitment, the newspaper campaign was much more successful at recruiting older people and those from social classes IIIM and IV. It shared with television a bias in bringing forward women. Community word of mouth also attracted older people, but to a lesser extent that newspaper recruitment. It was even more biased towards females but not dissimilar to television in terms of social class recruitment.

To summarise this section of the results; when compared to television recruitment, local newspapers recruit older people from lower social classes, community word of mouth recruits older people, neither approach solves the bias towards females.

These results are of course generalisable only to programmes with similar television audiences, local papers with similar readership profiles and word of mouth campaigns channeled through similar voluntary agencies. However, it seems reasonable to assume that such biases in terms of recruitment may recur in other similar campaigns. This raises the interesting and important question of "who do we want to train anyway?" The easy answer, is simply to reply "everyone, the more the better". However given the reasonable imperative to train those most likely to need these skills

first, it would seem logical to particularly target middle-aged and elderly women in lower socio-economic groups. Prevalence of ischaemic heart disease is highest amongst their spouses and three quarters of cardiac arrests occur at home. These considerations may make some combination of a local newspaper campaign plus the targeting of women's community groups particularly worthwhile. Ethnic groups were under-represented in the TV cohort just as they are in our newspaper and community word of mouth groups. One answer pursued locally is the targeting of religious leaders, for example, at the local Hindu temple, whose personal endorsement not only aids recruitment, but may also help to overcome religious taboos, e.g., mouth to mouth contact.

It was possible to specifically enquire about whether our television cohort lived with someone with a history of heart disease. Four point seven percent did so as compared to 12.1% recruited by community word of mouth and 17% recruited via the newspaper. (Tables 23-25). This is in large part a product of the different age groups attracted by each method.

Discussion of results of 999 (effectiveness)

There is no proof that proficiency at manikin CPR predicts proficiency in a real life situation, but we were forced, as have been others (Cobb et al 1982), into that assumption. In this study a determined attempt was made to simulate a real life event by using unforewarned testing in people's homes with the added stress of video recording. As over 70% of arrests occur at home (Hearne et al 1988, Litwin et al 1987 & Weston et al 1994) this seemed logical.

It is disappointing that under such conditions only 12% of our trainees were able to perform what we considered to be effective CPR. Of course our definition of effective is of necessity arbitrary and there is evidence that even CPR judged retrospectively to have been poor may improve survival changes if ambulance response is rapid (Hearne et al 1988 & Kowalski et al 1984).

We are not sure whether the performance of trainees is due to inadequate instruction, poor retention or both. Proficiency certainly decreases over time (Fossel et al 1983 & McKenna et al 1985) and those who had been retrained performed better. Others have questioned whether the retrained are in some way distinct - perhaps having originally greater motivation to learn and retain (Kalmthout et al 1985 & Cobb et al 1980).

The 2½ hour course may have been too short and the course content too ambitious. Instructors came from a number of different voluntary agencies and anecdotally at least some introduced extraneous and confusing material into the already overcrowded syllabus. Similar problems were reported by the Save a Life Campaign (Hughes et al 1988) and longer courses secure better retention (Gombeski et al 1982). Whilst extraneous material and inconsistent instruction have been shown to lead to poor performance (Kaye et al 1991). The BBC is attempting to rectify these problems in its current road-shows.

Safety in CPR can only be a relative concept; for the ultimate unsafe CPR is no CPR as chances of recovery then decline rapidly. However, it is important to try and instruct people in a fashion which maximises the chances of them making a correct

assessment whilst minimising the possibility of collateral damage. Even correct CPR may cause a variety of complications (Jones et al 1994). Inappropriately commenced CPR is much less common and the results apparently benign (Cummins et al 1985). This is despite the fact that anywhere between 30% and 80% of individuals fail to establish pulelessness in manikin studies (Fossel et al 1983 & Weaver et al 1979), (32% in our study). It is possible that this is a test induced artifact, with test subjects being keen to demonstrate their ability to act and therefore assuming the diagnosis (Martin et al 1985).

Another area of potential concern involves the worrying possibility that CPR knowledge may lead to well meaning interventions at the expense of the early alerting of the emergency services. Certainly only 27 (10%) of our subjects remembered to do this before commencing CPR. This is most likely also test artifact. Evidence from other studies is inconclusive; an American study found that those who attempt CPR are more likely to summon an ambulance whilst a local study suggested those without formal training were more likely to call for ambulance assistance (David Assar, personal communication). Further research needs to be done on this aspect to make sure ambulance arrival is not inadvertently delayed. Our work in this area has now been quoted and built upon by an American group who have shown that including a telephone in the training kit helps reinforce this important aspect in most age groups.

In summary we were pleasantly surprised by our cohorts willingness to be subjected to an unforewarned test in their own homes but disappointed by their inability to perform safe and effective CPR 6 months after training. The roadshow approach is very successful at recruiting large cohorts and the BBC is now turning its attention to

improving the quality and consistency of training. Retraining must also be considered as must the possibilities of reducing syllabus content, increasing training time or simplifying CPR protocols.

X CONCLUSIONS

X Conclusions

The following conclusions can be drawn from the development of the Cardiff test of manikin CPR.

- it is possible to develop a robust test of manikin CPR performance with minimum intra and inter observer error

- this is facilitated by, and based upon, a combination of video recording and manikin print-out

- it is important to robustly assess the pre-ventilation/compression actions, e.g., approach and assessment (C.A.R.E.) and the psychomotor skills of CPR (V.I.D.R.A.P.) Together these two elements along with the making schedules and guidance constitute the Cardiff test of manikin CPR.

The following conclusions can be drawn from the BBC 999 study.

- television is a very effective way of generating a large cohort of volunteers for CPR training

- this cohort is not typical of the television audience or the UK population; specifically females, youngsters and professionals are over-represented

- when tested at 6 months post training, unforewarned, only 12% can perform CPR effectively

- 39% perform CPR in a potentially injurious way which could complicate casualty recovery

- those who had retrained showed better performance

- the Cardiff test of manikin CPR can be effectively used in a multicentre evaluation of lay person CPR performance.

Additionally, comparison of the 999 cohort with other Heartstart cohorts allows conclusion that.

When compared to television, a local newspaper campaign recruits older people and more from lower social classes. A word of mouth community campaign also attracted older people.

Areas requiring further research

A number of intriguing questions are raised by these studies?

1. Is the problem poor training, poor retention or both?
2. How can training in a mass setting be improved?
3. How can retention be improved?

4. How do we attract a greater diversity of trainees?

5. Does possession of a little knowledge lead to a delay in calling an ambulance?

6. Do these results illustrate the need to simplify greatly existing CPR guidelines?

Our Cardiff based pre-hospital care research group have now moved on to address some of these questions.

XI - APPENDICES

APPENDIX A

999 COURSE SYLLABUS AND QUESTIONNAIRE

BBC

999 LIFESAVER ROADSHOW RESEARCH PROJECT

In association with:

The Centre for Applied Public Health Medicine, University of Wales College of Medicine.

SHOW 5

Please complete all sections

FOR OFFICE USE ONLY

Date of Birth ☐☐/☐☐/☐☐ Postcode ☐☐☐☐☐☐☐ Male ☐ Female ☐

Which of the following are you? *tick one box only*

Employed	☐	Student	☐
Self employed	☐	Housewife / House Husband	☐
Unemployed	☐	School Pupil	☐
Retired	☐	Other	☐

Main Wage Earner in your household

(a.) Are you the main wage earner in your household? Yes ☐ No ☐

(b.) If you answered **No**, in (a.) please state your relationship to the main earner (ie. are you their Husband, Wife, Son, Daughter) _____

(c.) **If you answered Yes, in (a.) please fill in the following about yourself**
If you answered No, in (a.) please complete about the main wage earner
If the main wage earner is now retired or at present unemployed state main job in last 10 years

Full Job Title

Main things done in job

Description of Employers Business

Approximate number of employees

How would you describe your ethnic origin?

White	☐	Indian	☐
Black-Caribbean	☐	Pakistani	☐
Black-African	☐	Bangladeshi	☐
Black -Other	☐	Chinese	☐
		Any other ethnic Group	☐

If Black-Other Please describe

If other please describe

Why do you want to be trained in Emergency Life Support (CPR)?
You may tick more than one box

I live with somebody who has had a heart attack or has a history of heart disease . ☐
There is a history of heart disease in my family. ☐
I saw somebody collapse and was unable to help. ☐
I want to be prepared. ☐

Have you ever been trained in Emergency Life Support (CPR) before? Yes ☐ No ☐

If Yes when Under 1 year ☐ 1 to 2 years ago ☐ 2 to 3 years ago ☐ over 3 years ago ☐

Who trained you?

The Red Cross	☐	The Royal Life Saving Society	☐
St John Ambulance	☐	Work	☐
St Andrew Ambulance	☐	School / College	☐
A Community Scheme	☐	The Armed Forces	☐
The Ambulance Service	☐		

Other (*please state*)_____

Would you carry out emergency life support incuding mouth to mouth breathing on:
You may tick more than one box

135

A Relative ☐ A Friend ☐ A Stranger ☐ A Person who has collapsed and vomited ☐

for information: David Acton, Headstart, Cardiff and the Vale, Temple of Peace and Health, Cardiff CF1 3NW

ERC Protocols for Emergency Life Support

2 Hour Life Supporter Course - A Guide for Instructors - (Adult Resuscitation)

(i) 15mins. **Registration:**

Life supporters are requested to fill in the registration forms. The forms will enable the *Heartstart Research Team* to collate necessary data, including socio-economic and demographic information. Heartstart can then target specific groups at high risk within the community. For a full explanation of the data collection Instructors should refer the Life Supporters to the appropriate handout.

Welcome and Warnings:
A Welcome to the Life Supporters, Instructors should read out the standard warnings:-

Trainees should only do the practical training if they feel physically capable of doing so; they should not risk any injury to themselves.

Mouth to mouth ventilations and chest compressions must only be practised on a training manikin, never on another trainee.

In teaching the techniques for relieving choking or an obstructed airway, abdominal thrusts should only be used in an emergency, and never practised on another trainee.

(ii) 5mins **What is Emergency Life Support?**

Instructors should give a brief explanation that this is not a first aid course and bandaging techniques etc. will not be covered.
Emergency Life Support (ELS) covers the acute life threatening situations that can be dealt with using Basic Life Support Skills (BLS).
Answer any Questions.

(iv) 5mins **Bleeding:**

The treatment for severe bleeding (Direct Pressure and Elevation).
Direct pressure to stem the flow of blood.
Elevation to aid coagulation (slow down and aid the clotting process)
Treatment for 'Shock' (Care of the Casualty)
Warnings about tourniquets (Never apply)

(vi) 5mins **Choking in the Conscious Casualty:** (Causes of, and treatment for choking).

Encourage coughing.
Demonstrate back slaps (Five)
Demonstrate abdominal thrusts (Five)

(iii) 20mins **Assessment Procedures: {See Flow Chart}**

Instructors should first demonstrate, then guide the Life Supporters through the assessment procedures. (Student Practise)
1. Assess for Danger (Personal Safety)
2. Assessment of the Casualty (Assess for Consciousness)
3. Assess for Breathing.

(v) 20mins **The Unconscious Casualty (Who is Breathing)**

The Recovery Position:

Never leave an unconscious casualty on their back, explain why, and the possible consequences of failing to turn a casualty into the Recovery Position.

Examples:

The tongue falling backwards, blocking the airway.

The risk of vomit.

Demonstrate the Recovery Position (*No Change*) followed by Life Supporter practice.

(Remember the casualty must be turned, even in a suspected spinal case, although great care should be exercised)

(vii) 10mins **The Obstructed Airway in Unconsciousness:**

Following the assessment procedures attempt ventilations (rescue breathing) x 2.

If unsuccessful: Re-adjust airway (head tilt chin lift) and attempt a further 2 x breaths.

If unsuccessful: Perform abdominal thrusts, up-to a maximum of 5 in each cycle.

Check airway, remove any obvious obstruction with a finger sweep.

Attempt ventilations again. (Positive Pressure Ventilations)

(viii) 5mins **Signs and Symptoms of an MI / Causes of Death.**

Why do this in one set of circumstances - why do that in another?

Explain the difference between a VF (Ventricular Fibrillation) collapse and other causes, Trauma, Drowning, Infant and Child etc.

(ix) 30mins **Cardiac Arrest / Circulatory Failure: {See Flow Chart}**

Cardio-Pulmonary Resuscitation (CPR) does not restart the heart in Cardiac Arrest:- (Ventricular Fibrillation - VF)

CPR can restart the heart in Circulatory Failure. (Hypoxia in origin)

Full assessment procedures followed by treatment according to the scenario.

Instructors will follow the relevant flow chart for:

Infant and Child.

Adult in Respiratory / Circulatory Failure

Adult in Cardiac Arrest

(x) 5mins **Questions and Answers**

Close of Course

Resuscitation Guidelines: Flow Chart for 'Recovery' Position (Unconsciousness)

All of the algorithms below refer to adult resuscitation. There are different guidelines for infants and children. If the likely cause of unconsciousness is due to trauma or drowning do *not* leave the casualty to get help until resuscitation has been attempted for at least one minute.

The Rescuer: Careful approach.	*Action:* Look for danger, the safety of the rescuer is paramount.	*Examples:* Electricity, deep water, other vehicles, falling masonry etc.
Talk to the casualty.	Talk from a distance as you approach the casualty. *"Are you all right"*	Be aware of aggressive behaviour, possible feigning.
Gently shake the shoulders and talk louder to the casualty.	Kneel at the side of the casualty 'square on' gently shake the shoulders and speak again loudly: *"Are you all right"*	Using verbal and physical stimuli will assist in the assessment for consciousness.
Shout for help.	Try and attract someone's attention.	A second rescuer can go and get professional help.
Head tilt and chin lift. * Avoid head tilt if trauma (injury) to the neck is suspected.	Steady the head and apply pressure on the forehead, at the same time lift the chin with finger tips until the airway is open.	Be aware of possible neck injuries and adapt the technique accordingly.
Check for breathing.	Look listen and feel for breathing, do this for: 10 seconds.	Look at the chest and abdomen for any movement, listen and feel at the mouth for breath sounds and air movement.
If the casualty *is* breathing.	Turn the casualty onto their side. 'Recovery' Position.	This will allow drainage from vomit and prevent the tongue from falling backwards and obstructing the airway. Check for continued breathing.
Get Help! Ambulance 999	Ensure professional / qualified help is on its way.	Stay with the casualty. Check for continued breathing.

* If trauma to the neck is suspected avoid head tilt. Use chin lift only.

Resuscitation Guidelines for Respiratory Arrest

The Rescuer:	*Action:*	*Examples:*
Careful approach.	Look for danger, the safety of the rescuer is paramount.	Electricity, deep water, other vehicles, falling masonry etc.
Talk to the casualty.	Talk from a distance as you approach the casualty. *"Are you all right"*	Be aware of aggressive behaviour, possible feigning.
Gently shake the shoulders and talk louder to the casualty.	Kneel at the side of the casualty 'square on' gently shake the shoulders and speak again, loudly. *"Are you all right"*	Using verbal and physical stimuli will assist in the assessment for consciousness.
Shout for help.	Try and attract someone's attention.	A second rescuer can go and get professional help.
Head tilt and chin lift. **Avoid head tilt if trauma (injury) to the neck is suspected.**	Steady the head and apply pressure on the forehead, at the same time lift the chin with finger tips until the airway is open.	Be aware of possible neck injuries and adapt the technique accordingly.
Check for breathing.	Look listen and feel for breathing, do this for **10** seconds.	Look at the chest and abdomen for any movement, listen and feel at the mouth for breath sounds and air movement. If there is ***no*** breathing:
Get Help! **Ambulance 999**	If there is *no* breathing a lone rescuer should leave the casualty and ensure medical help is on its way.	On your return, begin effective rescue breathing.
Rescue breathing.	Remove any visible obstruction from the victims mouth. If the airway is clear start rescue breathing.	Maintain head tilt and chin lift, give **2** x effective rescue breaths. If you are successful in ventilating the victim:
Check pulse.	Feel for a nearside neck pulse, do this for no more than **10** seconds, looking for signs of life.	Locate the 'Adams Apple' with two fingers and move them into the natural hollow in the side of the neck. If you are confident there ***is*** a pulse:
Continue ventilations.	Continue with effective rescue breathing, checking the neck pulse about every minute, looking for signs of life	If the victim begins to breath spontaneously, turn into the Recovery Position whilst waiting for help to arrive. Check for continued breathing.

The Obstructed Airway and Circulatory Failure.

Head tilt and chin lift. **Avoid head tilt if trauma (injury) to the neck is suspected.**	Steady the head and apply pressure on the forehead, at the same time lift the chin with finger tips until the airway is open.	Be aware of possible neck injuries and adapt the technique accordingly.
Check for breathing.	Look listen and feel for breathing, do this for **10** seconds.	Look at the chest and abdomen for any movement, listen and feel at the mouth for breath sounds and air movement.
Get Help! **Ambulance 999**	If there is ***no*** breathing a lone rescuer should leave the casualty and ensure medical help is on its way.	On your return, begin effective rescue breathing.
Rescue breathing.	Remove any visible obstruction from the victims mouth. If the airway appears clear start rescue breathing.	Maintain head tilt and chin lift, attempt **2** x effective rescue breaths. If you have difficulty achieving an effective breath:
Re-adjust airway	Recheck the victims mouth and remove any obstruction. Recheck that there is adequate head tilt and chin lift.	Including the above make up to **5** x attempts in all to achieve **2** x effective breaths. If unsuccessful, move on to assessment of circulation.
Check for a neck pulse.	Feel for a nearside neck pulse, do this for **10** seconds.	Locate the 'Adams Apple' with two fingers and move them into the natural hollow in the side of the neck.
If there is *no* pulse or you are in any *doubt*:	Locate the correct position on the sternum and administer **15** chest compression at a rate of **100** per minute.	The chest compressions may have assisted in clearing any obstruction in the airway. Recheck the airway and continue with **2** x effective rescue breaths. If you are successful:
Continue with Cardio-Pulmonary Resuscitation (CPR)	Continue with CPR (2:15) without interruption until: Professional / qualified help arrives. The victim shows signs of life. You become exhausted.	If the airway is not clear use the obstructed airway protocols after another **2** x attempts at rescue breathing.

Centre for Applied Public Health Medicine.

Resuscitation Guidelines for the Obstructed Airway (Adult)
Approach etc. as per preceding algorithms depending on protocol:

Head tilt and chin lift. **Avoid head tilt if trauma (injury) to the neck is suspected.**	Steady the head and apply pressure on the forehead, at the same time lift the chin with finger tips until the airway is open.	Be aware of possible neck injuries and adapt the technique accordingly.
Check for breathing.	Look listen and feel for breathing, do this for **10** seconds.	Look at the chest and abdomen for any movement, listen and feel at the mouth for breath sounds and air movement.
Get Help! **Ambulance 999**	If there is ***no*** breathing a lone rescuer should leave the casualty and ensure medical help is on its way.	On your return, begin effective rescue breathing.
Rescue breathing.	Remove any visible obstruction from the victims mouth. If the airway appears clear start rescue breathing.	Maintain head tilt and chin lift, attempt **2** x effective rescue breaths. If you have difficulty achieving an effective breath:
Re-adjust airway	Recheck the victims mouth and remove any obstruction. Recheck that there is adequate head tilt and chin lift.	Including the above make up to **5** x attempts in all to achieve **2** x effective breaths. If unsuccessful, move on to assessment of circulation.
Check for a neck pulse.	Feel for a nearside neck pulse, do this for **10** seconds.	Locate the 'Adams Apple' with two fingers and move them into the natural hollow in the side of the neck.
If there *is* a pulse.	If there is a pulse and you have been unsuccessful in your attempts at rescue breathing:	Assume the victims airway is obstructed and perform abdominal thrusts.
Perform abdominal thrusts.	Kneel astride or at the side of the casualty and thrust downwards and upwards toward the victims head.	Attempt up to **5** x abdominal thrusts to remove the obstruction from the airway.
Re-check airway.	Remove any visible obstructions.	Take another breath and attempt rescue breathing again. * PPV

*** Consider Positive Pressure Ventilation (PPV)**

Resuscitation Guidelines for Circulatory Failure / Cardiac Arrest

The Rescuer:	*Action:*	*Examples:*
Careful approach.	Look for danger, the safety of the rescuer is paramount.	Electricity, deep water, other vehicles, falling masonry etc.
Talk to the casualty.	Talk from a distance as you approach the casualty. *"Are you all right"*	Be aware of aggressive behaviour, possible feigning.
Gently shake the shoulders and talk louder to the casualty.	Kneel at the side of the casualty 'square on' gently shake the shoulders and speak again, loudly. *"Are you all right"*	Using verbal and physical stimuli will assist in the assessment for consciousness.
Shout for help.	Try and attract someone's attention.	A second rescuer can go and get professional help.
Head tilt and chin lift. **Avoid head tilt if trauma (injury) to the neck is suspected.**	Steady the head and apply pressure on the forehead, at the same time lift the chin with finger tips until the airway is open.	Be aware of possible neck injuries and adapt the technique accordingly.
Check for breathing.	Look listen and feel for breathing, do this for **10** seconds.	Look at the chest and abdomen for any movement, listen and feel at the mouth for breath sounds and air movement. If there is ***no*** breathing:
Get Help! **Ambulance 999**	If there is no breathing a lone rescuer should leave the casualty and ensure medical help is on its way.	On your return, begin effective rescue breathing.
Rescue breathing.	Remove any visible obstruction from the victims mouth. If the airway is clear start rescue breathing.	Maintain head tilt and chin lift, give **2** x effective rescue breaths. If you are successful in ventilating the victim:
Check pulse.	Feel for a nearside neck pulse, do this for no more than **10** seconds, looking for signs of life.	Locate the 'Adams Apple' with two fingers and move them into the natural hollow in the side of the neck. If there is ***no*** pulse, or you are in any ***doubt:***
Continue with Cardio-Pulmonary Resuscitation (CPR)	Locate the correct position on the sternum and administer **15** chest compressions at a rate of **100** per minute	Continue with CPR (2:15) without interruption until: Professional / qualified help arrives. The victim shows signs of life. You become exhausted.

APPENDIX B

PHOTOGRAPH OF "THE CARDIFF TEST"

BEING ADMINISTERED

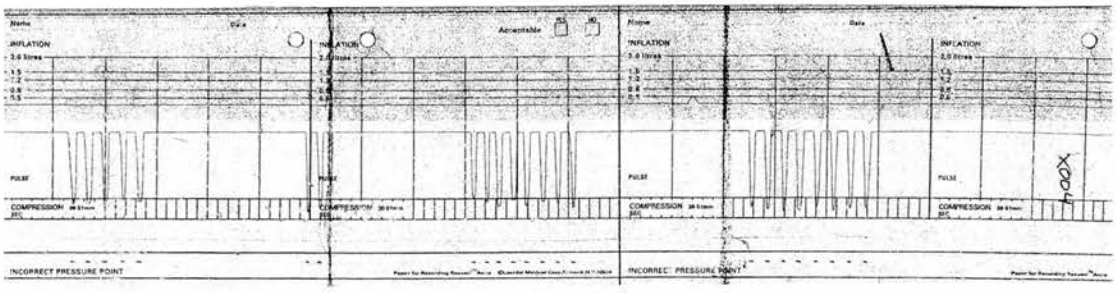
Carrying out a test

APPENDIX C

EXAMPLE MANIKIN PRINTOUT

Examples of Recording Manekin Printouts

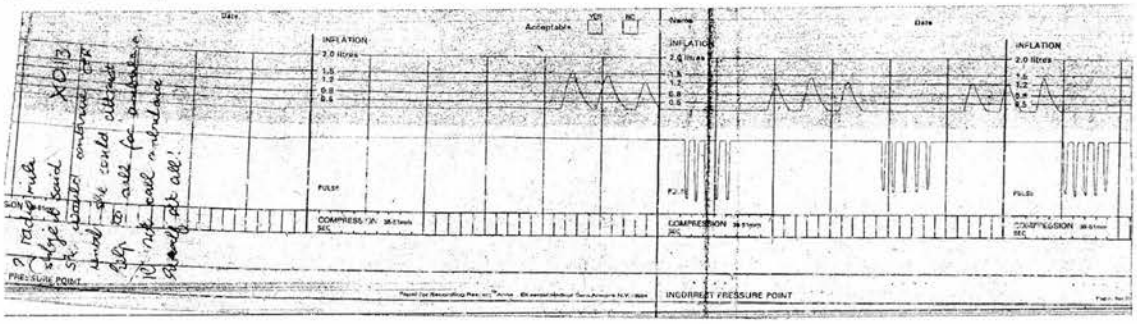
Example 1



Note:

Little or no evidence of ventilation with compressions, which although adequate in depth are too slow.

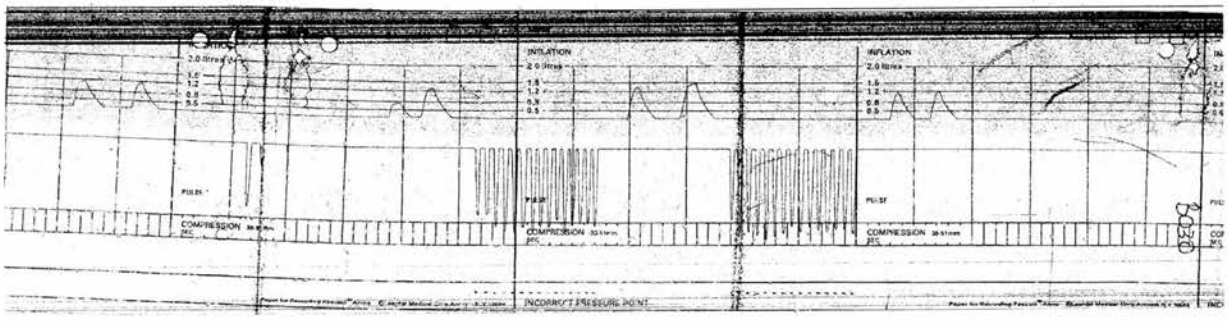
Example 2



Note:

Good ventilations (three given rather than required two) with shallow and slow compressions.

Example 3



Note:

Initially ventilation with few compressions but in second and third cycles reasonable attemps at both ventilation and compressions.

APPENDIX D

DETAILS OF PROJECT TEAM

AND AUTHORS CONTRIBUTION

APPENDIX D

Our team started work on this project in 1994 and completed it in late 1997.

This MD was written up during 1998 and early 1999.

The team consisted of:	Dr Peter Donnelly (PD)	Medical Director (author)
	Mr David Assar (DA)	Project Manager
	Mrs Carolyn Lester (CL)	Research Officer
	Mr Chris Morgan (CM)	Research Officer
	and various short term temporary research assistants employed on a casual basis.	

In addition Mr Steve Leaves (Resuscitation Training Officer) provided assistance with video test piloting and video analysis. He also helped design the courses which the BBC used as the basis of their 999 training programme.

All of us had a part-time commitment to this project with other work running parallel.

My role specifically involved:

- Study design (with DA and CM)
- First named grant applicant and grant holder
- Overall control of project
- Development of novel testing instruments (with CL and CM)
- Data collation and analysis (with CM and CL)
- Data interpretation and MD write-up

APPENDIX E

COPIES OF PUBLISHED PAPERS ARISING FROM DISSERTATION

APPENDIX E REFS

The following original articles have arisen from this work (reprints follow with kind permission of co-authors).

Donnelly P.D., Lester CA, Morgan CLl., Assar D. Evaluating CPR Performance in basic life support : the VIDRAP Protocol *Resuscitation* 1998; 36: 51-57

Lester C.A., Morgan C.L., **Donnelly P.D.,** Assar D. Assessing with CARE : An innovative method of testing the approach and casualty assessment components of basic life support, using video recording. *Resuscitation* 1997; 34:43-49.

Morgan C.Ll., **Donnelly P.D.,** Lester C.A., Assar D.H. Effectiveness of the BBC's 999 training roadshows on cardiopulmonary resuscitation : video performance of cohort of unforewarned participants at home six months afterwards. *British Medical Journal* 1996; 313:912-6.

We being co-authors of the above published papers agree to Dr Peter D Donnelly including reprints of them as required by University regulations in this appendix to his MD submission.

Caroline A Lester .....

Christopher Ll Morgan .....

David H Assar .....

ELSEVIER

Resuscitation 36 (1998) 51–57

RESUSCITATION

Evaluating CPR performance in basic life support: the VIDRAP protocol

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Abstract

This paper presents the second part of the validated Cardiff test for one rescuer basic life support skills, based on observation of video recording combined with the Recording Resusci Anne printout (VIDRAP). The authors believe that this is a robust evaluation tool which is capable of assessing the potential value to a casualty of a simulated resuscitation. The adoption of a widely accepted test methodology would facilitate comparison of research in different centres, which is not possible at present. © 1998 Elsevier Science Ireland Ltd.

Keywords: Basic life support; Assessment; Video; Manikin printout

1. Introduction

We know that early cardiopulmonary resuscitation (CPR) following cardiac arrest saves lives [1–3] and that the higher the quality of CPR, the greater the chances of survival [4–6]. It is also clear that, whilst the public wish to learn CPR [7–10], their initial learning is poor and their retention worse [11–14]. The wide variety of evaluation techniques and criteria for acceptable performance make comparison between studies difficult [15–19], and for this reason, the authors have been working to develop a standard test for basic life support skills—the Cardiff test. The first part of that test, the Cardiff assessment of response and evaluation (CARE) [20], provides a valid and reproducible method of evaluating all of those actions central to the performance of basic life support which precede the commencement of expired air ventilation and chest compression. This paper records the development of the second part of the test, based on a combination of Video and Recording Anne Printout (VIDRAP). This allows performance of the key psychomotor skills of expired air ventilation and chest compression to be examined in a reproducible way, using a standard set of performance criteria based on international guidelines. This in turn facilitates an assessment of the potential value to a casualty and international comparison of test results.

The testing system was originally developed to measure performance to the 1992 European Resuscitation (ERC) guidelines [21], but was easily adapted to take account of changes in performance guidelines, namely those recently suggested by the ERC within the International Committee on Resuscitation (ILCOR) advisory statement [22]. The Cardiff test is currently being used by this research group to study the effect of training to the ERC/ILCOR 1997 statement.

2. Method

Four observers (two research officers, a paramedic and a medical practitioner) viewed, independently of each other, video recordings of subjects performing

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Table 1
Criteria for inclusion in VIDRAP categories

Component	ERC	Effective	Effective/?injurious	Ineffective	Ineffective/?injurious
Ventilation (litres)	0.5–1.2 and	>0, <2 and	>0 and	0 and/or	>2 and/or
Co p. depth (millimetres)	38–51 and	30–51 and	30–51 and	<30 and/or	>51 and/or
Comp. rate (per minute)	80–100 and	>59 and	>59 and	<60 and/or	<60 and/or
Ratio	2:15[a] and	≥5 comps to each vent. and	≥5 comps. to each vent. and	<5 comps. to each vent. and	<5 comps. to each vent. and
Hand position	visually correct or effective	visually correct or effective	visually ineffective with no dots	visually correct or effective	visually ineffective with no dots

[a] 2:14 and 2:16 acceptable.

CPR simulations on a Recording Resusci Anne manikin. They compared and discussed their assessments, using points of disagreement or discrepancy as a means of identifying areas of marking in need of clarification. Similar discussions surrounded the interpretation of the Resusci Anne printouts when used in conjunction with the video recordings. Eventually agreement was reached and the resulting marking schedule and guidelines are shown as Appendix A.

Using these agreed guidelines as the marking criteria, three members of the team then viewed and assessed videos and printouts of 42 subjects independently. Following the first assessment, videos and matched recording strips were reordered randomly by an independent individual and re-evaluated by three assessors to measure inter and intra observer agreement. Of the 42 CPR simulations, 24 were recorded on the day of instruction and the remaining 18 (the retention subjects) between 6 and 18 months after training. Of the newly trained 8 (33%) were male and 16 (67%) female, compared with the retention subjects where 8 (44%) were male and 10 (56%) female. Those assessed on the day of instruction were slightly younger with a mean age of 29, compared with a mean of 34 years in the retention subjects.

The retention subjects were selected randomly from the Heartstart Cardiff and the Vale database and visited at home, without forewarning, by two research officers. The subject was asked to perform basic life support on a Recording Anne manikin whilst being video recorded. Immediately before recording commenced, the subject was read an instruction (Appendix B) which had been modified from the original [20] to take account of the new ILCOR statement [22]. In each case the scenario to be examined was adult cardiorespiratory arrest and three cycles of CPR were recorded. The candidate was not informed of the diagnosis, but expected to deduce the casualty's condition by assessment and to respond appropriately. The researcher only gave information in response to an assessment procedure; for example, if the life supporter was observed to palpate for a pulse, the researcher would say, "There is no pulse". No further comment or prompting was offered.

Video tapes and printouts were returned to the research centre for marking according to the ERC 1992 guidelines. In all cases the second cycle was used for assessment, on the grounds that minimal transient memory lapses in the first cycle would be corrected in the second. The third cycle was disregarded as, despite instruction, some candidates did not continue until asked to stop. Independent and blind repeat markings were then performed as previously described and intra and inter observer agreement tested using the Kappa statistic. The χ^2 test was used to compare post training and retention subjects.

CPR attempts were categorised according to their potential effectiveness for an adult casualty in cardiac arrest, using a system developed for assessment of trainees from the BBC 999 Roadshows [23]. The criteria for inclusion in each category appear in Table 1. To clarify the marking of hand positions in the potentially injurious category, this is defined by a combination of observation from the video and the recording strip. A dot will only appear on the strip if pressure is directed to 'any place *on the chest* other than the lower half of the breastbone' [24]. It therefore follows that, if the observer marks the hand position as so poor as to be ineffective and no dots appear on the recording strip, then the position will be so far from the recommended site as to be potentially injurious. During the development stage of VIDRAP, the majority of subjects in this category were compressing the abdomen rather than the chest.

The VIDRAP categories are now as follows:

ERC: conforming to the ERC ILCOR 1997 statement

Effective: not conforming strictly to the ERC ILCOR statement, but may be of some benefit to the casualty

Effective/?injurious: may be of some benefit to the casualty, but has some potentially injurious components

Table 2
Kappa scores for intra and inter observer variation

(a) Intra observer scores

	A	B	C
Ventilation volume	0.89	0.94	0.88
Airway faults	0.86	0.74	0.79
Ratio	0.86	0.95	0.95
Comp. measure	0.82	0.58	0.71
Visual placement	0.71	0.63	0.92
Strip placement	0.94	0.91	0.85
Comp. rate	0.84	0.75	0.86
Comp. depth	0.91	0.90	0.94

(b) Inter observer scores

	A/B	A/C	B/C
Ventilation volume	0.91	0.80	0.80
Airway faults	0.61	0.67	0.65
Ratio	0.86	0.91	0.86
Comp. measure	0.51	0.70	0.52
Visual placement	0.37	0.37	0.41
Strip placement	0.82	0.80	0.79
Comp. rate	0.79	0.83	0.81
Comp. depth	0.88	0.90	0.87

<0.20 poor; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 good; 0.81–1.00 almost perfect.

Ineffective: unlikely to benefit the casualty, but has no potentially injurious components
Ineffective/?injurious: unlikely to benefit the casualty and has some potentially injurious components

3. Results

Intra and inter observer variations are shown in Table 2. Kappa scores of between 0.81 and 1.00 indicate almost perfect agreement, with 0.61–0.80 and 0.41–0.60 indicating good or moderate agreement, respectively. Agreement was therefore almost perfect or good in each category for intra observer variation with the exception of one observer for compression measurement. However, inter observer variation was only moderate in two of the three paired subjective assessments (A/B and B/C) for compression measurement (i.e. measuring correctly before positioning the hands for chest compression). Visual placement of the hands, which was also subjective, again had lower Kappa scores with one pair (B/C) showing moderate agreement, but the remaining two pairs showing only fair agreement. There was, however, a very high level of agreement for the objective recording strip measurements.

Table 3 compares the performance of newly trained subjects with those who were trained between 6 and 18 months previously. For all components except compression depth, the performance of the newly trained was significantly superior. The performance categories for the newly trained and retention subjects are shown in Table 4. Of the recently trained 16 (67%) were classed as ERC standard or effective, compared with only four (22%) of the retention group ($P < 0.01$). However, of those who were effective eight of the newly trained and two of the retention group also gave at least one compression of more than 51 mm.

Table 3
Second cycle of CPR—newly trained and retention tests

Component	Newly trained ($n = 24$)	Retention ($n = 18$)	Significance
Airway open for ventilations	21 (88%)	10 (55%)	$P<0.05$
Breathing volume			
0.8–1.2 l	10 (42%)	2 (11%)	$P<0.05$
0.5–1.2 l	15 (63%)	3 (17%)	$P<0.01$
Compression measurement			
As taught	5 (21%)	1 (6%)	NS
Attempted	21 (88%)	8 (44%)	$P<0.01$
Hand placement			
Visually correct	21 (88%)	7 (39%)	$P<0.001$
Visually effective	24 (100%)	11 (61%)	$P<0.001$
Incorrect strip	6 (25%)	8 (44%)	$P<0.05$
Compression rate			
80–100 per minute	10 (42%)	1 (6%)	$P<0.01$
>59 per minute	20 (83%)	8 (44%)	$P<0.025$
Compression depth			
38–51 mm	7 (29%)	3 (17%)	NS
30–51 mm	16 (67%)	8 (44%)	NS
Ratio correct	21 (88%)	5 (28%)	$P<0.001$

Table 4
VIDRAP categories in post training and retention tests ($n = 42$)

	ERC	Effective	Effective/ ?injurious	Ineffective	Ineffective/ ?injurious
Post training	2 (8%)	6 (25%)	8 (33%)	6 (25%)	2 (8%)
Retention	0 (0%)	2 (11%)	2 (11%)	8 (44%)	6 (33%)
Total	2 (5%)	8 (19%)	10 (24%)	14 (33%)	8 (19%)

ERC + effective + effective (potentially injurious), post training versus retention, $P < 0.01$.
Ineffective (potentially injurious), post training versus retention, $P < 0.05$.

There were two (8%) newly trained life supporters and six (33%) of the retention group who performed CPR in a way that was classed as both ineffective and potentially injurious ($P < 0.05$). Of the newly trained, in all ineffective and potentially injurious performances, the injurious element was over compression, but in five of the six ineffective and potentially injurious retention tests, the cause was a very poor hand position (on the abdomen rather than the chest) and in only one was it over compression. Only eight (33%) new trainees and two (11%) of the retention group performed to ERC standards or effectively with no potentially injurious elements.

4. Discussion

Assessment from recordings has distinct advantages over real time assessment. Video and manikin printout obviate the necessity for decision making under pressure which may lead to errors when an observer marks what he/she believes occurred rather than what actually happened. A confident approach to CPR can give the impression of effectiveness and cause important errors to be overlooked. A study of workplace CPR training has questioned the role of instructors as assessors, and using video recording, the researchers demonstrated that instructors overlooked errors in performance [25]. When making a number of real time assessments there is a risk that evaluation could be against the performance of the previous candidate rather than to a 'gold standard' [26]. Evaluators may have a vested interest in demonstrating that their training scheme is effective and objectivity may suffer, but this is less likely to happen when a hard record is present and when assessors are not under pressure to make an immediate decision.

The superiority of manikin printout over checklist scores for CPR has been discussed in recent research into the resuscitation skills of general practitioners [27]. Ninety-seven per cent of candidates had been judged satisfactory by observation, whilst only 47% passed according to the print based scoring system. These researchers noted, however, that checklist scoring was necessary for the diagnostic procedures before commencing CPR. Using real time assessment, inter observer reliability was high for marking based on the recording strip, but much lower for general impression, and for components such as opening the airway and hand placement for compression. These results produced by general practitioners who were trained as assessors indicate that video recording may be capable of improving inter observer reliability.

The advantages of video and Recording Anne printout over real time assessment cannot be over emphasised. A real time assessment, even when carried out by an experienced person, will fail to observe errors which can be identified by pausing or replaying a video alone, or combined with reading a printout. This is especially advantageous in areas where fairly subtle errors may cause resuscitation to be less effective than the optimum, ineffective or even potentially injurious to the casualty. Examples of errors which might endanger the casualty by causing damage prejudicial to recovery are inaccurate measurement for hand position and over compression, especially when these two errors are combined.

Having a viewable record of performance can make studies more flexible, as observers can return to the recordings to study an action or timing which does not appear on the standard marking sheet. This could act as an agent for scientific progress, as researchers need not be restricted by their predecessors' marking schedules in order to compare results. We would, however, recommend that the existing VIDRAP marking schedule and categories form the basis of subsequent basic life support studies.

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Appendix A

A.1. VIDRAP—Assessment by video and Recording Anne Printout

Cycle 1

Ventilation volume

1 0 **2** <0.5 litres **3** 0.5-0.79 litres

4 0.8-1.2 litres **5** >1.2-1.5 litres **6** >1.5-2 litres

7 >2 litres **8** not attempted

Airway open

1 yes **2** no **3** no ventilations

Observed faults

0 no faults **1** poor seal **2** inadequate volume

3 other (specify)..... **4** not attempted

Ratio

Please specify (e.g. 15:2, 1:5, 0:15, etc.).....:.....

Compression measurement

1 correct **2** incorrect **3** not performed

Visual placement of hands

1 correct/effective **2** incorrect/effective **3** ineffective **4** not performed

Strip placement of hands

1 clear **2** dotted **3** not performed

Compression rate

1 <60 **2** 60-79 **3** 80-100 **4** 101-120 **5** 121-139

6 >139 **7** <5 compressions (rate not calculated) **8** none attempted

Compression depth

1 <30 **2** 30-37 **3** 38-51 **4** >51 **5** none attempted

Breathing interval

1 <8 **2** 8-12 **3** >12 **4** stopped

A.2. Guidelines for VIDRAP assessment

A.2.1. Ventilation volume

This is assessed from the recording strip, taking the most common volume, unless a 'dangerous' volume in excess of 2 l is recorded. If there are an equal number of ventilations in more than one category, the 'best' volume is taken. The following order therefore applies:

0.8–1.2	touches 0.8 line, between 0.8 and 1.2 lines, or touches 1.2 line
0.5–0.79	touches 0.5 line, between 0.5 and 0.8 lines, not touching 0.8 line
1.21–1.5	crosses 1.2 line, between 1.2 and 1.5 lines, touches 1.5 line
1.51–2	crosses 1.5 line, between 1.5 and 2 lines, touches 2 line
<0.5	more than 0, but not touching the 0.5 line
0	nothing recorded
2	crosses 2 line

A.2.2. Airway open

'No' can be selected if the airway is not fully open and the volume is less than 0.5 l.

A.2.3. Observed faults

If a volume of 0.5 l or more is recorded, then 'no faults' should be marked.

For a volume of less than 0.5 l, a fault must be recorded, unless airway not open has been selected. If airway not open has been selected, an additional fault may be marked.

A.2.4. Ratio

The ratio is the number of ventilations and compressions and the order in which they occur.

If rescue breaths have been performed correctly, on return to the casualty, the rescuer should begin with 15 compressions, so the first ratio should be recorded as 0:15.

If the rescuer returns to the casualty and ventilates twice before beginning compressions, the first ratio should be recorded as 2:15.

A.2.5. Compression measurement

A correct measurement is one in which the subject slides his/her fingers up the costal margin to find the sternum, places two fingers on the xiphisternum and places the heel of the other hand above and adjacent to the fingers. An incorrect measurement is any other attempt. Not performed is marked when no attempt is made to measure for the position before beginning the compressions.

A.2.6. Visual placement

This is assessed from observation only.

Correct/effective is a hand position which concentrates the force of the compression through the heel of the hand onto the lower third of the sternum. The hand on the chest must be on the lower third of the sternum.

Incorrect/effective is a hand position which, whilst concentrating most force on the lower third of the sternum, also diffuses some force over a wider area, i.e. to the side(s), above or below the lower third of the sternum.

Ineffective is a hand position in which minimal or no compression force is concentrated on the lower third of the sternum.

Not performed is recorded if no compressions are attempted in the relevant cycle.

A.2.7. Strip placement

Any black dot is recorded as dotted.

A.2.8. Compression rate

This is calculated from the recording strip, using the formula number of compressions times 60, divided by seconds taken to complete the compression cycle. Time is rounded up or down to the nearest 0.5 s. Rate is not calculated if less than five compressions are recorded in a cycle.

A.2.9. Compression depth

The most common depth in the cycle is recorded, unless any compression exceeds 51 mm, which then takes priority.

<30	does not reach the 30 mm line
30–37	touches 30 mm line, between 30 and 38 mm lines, does not touch 38 mm line
38–51	touches 38 mm line, between 38 and 51 mm lines, touches 51 mm line
>51	crosses 51 mm line

A.2.10. Breathing interval

The number of seconds between the end of one compression cycle and the start of the next.

Appendix B. Standard instruction to be read to video assessment candidates

On entering a room alone you see an adult lying still on the floor. There is no sign of trauma or drowning. Please describe and demonstrate how you would 'approach' and 'assess' the situation and what 'action' you would take.

I shall not offer any advice other than to report the status of the person during your assessment.

Please start and continue until I ask you to stop.

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RESUSCITATION

Assessing with CARE: An innovative method of testing the approach and casualty assessment components of basic life support, using video recording

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Abstract

The resuscitation community is now moving towards a set of basic life support guidelines but different countries and training centres have their own individual methods of instruction. It would be advantageous if a universal testing method were available to facilitate intercentre comparison. This could lead to an international course which had been rigorously assessed and evaluated. Taking this as a starting point, the Cardiff Assessment of Response and Evaluation (CARE) was developed. CARE is an innovative assessment technique using video recording for testing the preliminary steps of life support as outlined by the European Resuscitation Council. The assessment was validated by testing 67 members of the public who had been trained in cardiopulmonary resuscitation, 27 shortly after instruction and 40 between 6 and 18 months after instruction. All subjects were tested without prior warning and video recorded for independent scoring by two researchers and a paramedic training officer. Scores were compared using the κ correlation which showed a high level of agreement between observers. Video recording and marking using the CARE schedule and guidelines is a reliable method for assessing the preliminary steps in life support.

Keywords: Cardiopulmonary resuscitation; Skill retention; Testing; Video recording

1. Introduction

Early cardiopulmonary resuscitation (CPR) saves lives [1–3]; high-quality CPR improves survival [4–6]; the public want to learn CPR [7–10]. These three well-researched facts must give hope to all those working in the field of resuscitation, but across the world learners are failing to reach the required standards. CPR research must move on to the new questions of how to teach, how people learn, and how to maximise the number of people who come forward for training. Until these questions can be answered, the 'chain of survival' will be unable to achieve its potential for saving lives.

Currently, research in this field paints a bleak picture of poor initial learning and worse retention [11–14]. It is also difficult to draw comparisons between studies because of different evaluation techniques [15–19]. Several research groups have devised tests to assess both the effectiveness of initial instruction and long-term retention of CPR skills, but many omit what might be seen as equally important aspects of the European Resuscitation Council (ERC) guidelines [20], namely those actions which should precede a resuscitation attempt.

An effective assessment should be capable of identifying whether or not an action has been performed, the order of performance in relation to other components of basic life support and the quality of performance. The assessment was therefore developed using the work

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study techniques of task analysis. A 'real time' assessment is difficult because the individual steps preceding CPR, when performed efficiently, necessarily follow each other rapidly. This means that the second or so needed for the assessor to look down to mark an assessment schedule may mean that an action is missed or misinterpreted. This will be a minor problem when actions are performed in the order in which they should occur but in the case of retention tests especially, incorrect and/or out of sequence actions render accurate marking almost impossible.

To overcome these difficulties, the researchers decided to use video recording, which would avoid the danger of inadvertent prompting if an assessor had to question a life supporter to verify intention, or to ask for an action which might have been missed to be repeated. Recording means that the candidate can perform assessment, summoning help and CPR without interruption as they would in an emergency situation. The recording can later be analysed in detail by more than one assessor, rewinding if necessary, to determine whether or not an action has been performed adequately.

2. Method

2.1. Developing the test

Four observers (two research officers, a paramedic resuscitation training officer and a doctor) independently viewed a batch of films which they assessed, compared and discussed, using points of disagreement or discrepancy to improve the marking schedule. The starting point was a simple tick sheet listing nine items which the assessor ticked as 'performed' or 'not performed' making notes on any difficult or dubious point. It soon became apparent that a simple performed/not performed dichotomy was inadequate to describe some components and the schedule was developed through several versions before reaching its present form which includes some gradations of performance (Appendix A). To avoid the possibility of misinterpretation, an instruction sheet was developed for assessors which briefly set out the marking criteria (Appendix B).

The final part of the assessment was an analysis of the printout from the Recording Resusci Anne, together with observation of CPR from the video. This paper, however, concentrates on assessments of the actions involved in approach, assessing the casualty and summoning help.

2.2. Test procedure

Following the development stage, the research team was satisfied that the marking schedule and instruction sheet were likely to produce meaningful results with minimum inter- and intra-observer variation, and two groups of life supporters were used to validate the marking system and guidelines. Twenty-seven were tested on the day of instruction and 48 between 6 and 18 months after training. The group for retention testing was randomly drawn from the 'Heartstart Cardiff and the Vale' database and visited at home by a research officer and assistant (one male and one female). All were tested without prior warning. The researcher explained that as part of a quality control exercise for the training scheme, he/she would like the life supporter to perform appropriately using the Recording Anne (Laerdal). The life supporter was read a short scenario before filming began (Appendix C) and asked to proceed in accordance with what he/she had been taught. In all cases the scenario being tested was cardiac arrest. Prompts were given by the research officer where appropriate to confirm the casualty's condition, e.g. if the life supporter was seen to be feeling for a pulse, after 5 s the research officer would encourage progression to the next step by saying "There is no pulse". Video tapes were returned to the research centre for analysis by the research team, using the CARE schedule and marking criteria. The two groups could not be marked blind as it was obvious from the videos which tests had been carried out in the candidate's home and which at the training venue.

The assessment schedule (Appendix A) and guidelines (Appendix B) were used to mark the video recordings, firstly by three observers (two research officers and a resuscitation training officer) independently. The video tests were then rearranged in random order by the project manager who was not involved in testing, reassessed 1 week later by the three observers and compared with their previous marking.

Statistical tests used were χ^2 to compare post training and retention scores and κ correlation for inter- and intra-observer variation [21].

3. Results

3.1. Comparison of the two test groups

None of the newly trained life supporters refused to be tested, but of the 48 approached for retention tests, three were not at home on three occasions, two refused, two were forewarned of testing, and one was discarded because he was known to the person administering the test. This left 40 retention videos to be assessed. The age ranges were as follows: retention tests 15–73 years with a mean age of 34 years and newly trained 18–56 years with a mean age of 28 years. In the retention group, 13 (33%) were male and 27 (68%) female, and of the newly trained, 11 (41%) were male and 16 (59%)

female. The newly trained had been instructed at their place of work, so all were currently employed, whereas those in the retention group included some in full-time education and some retired people.

Table 1 shows that recently trained life supporters were significantly better at making a careful approach, assessing the casualty and summoning help. For the purposes of this table, we have taken the resuscitation training officer's ratings (the most experienced observer) but, as subsequent results will show, there was very little inter-observer variation.

Those recently trained were less likely to omit a component altogether and more likely to perform it 'as taught' than those trained 6–18 months previously. For example, in 37 (93%) of the retention tests, the shout for help was omitted, compared with 17 (63%) of those of the newly trained ($P = 0.007$); an emergency telephone call was omitted in 26 (65%) of retention tests compared with 14 (52%) newly trained tests ($P = 0.006$, when compared with 'not performed' and ambiguous phone call categories).

Table 1
Performance at 1 week ($n = 27$) and at 6–18 months ($n = 40$)

Component	Performance	Day 1	6–18 months	P
Approach	Performed	20 (74)	15 (38)	0.00714
	Not performed	7 (26)	25 (63)	
Talk	Performed	22 (82)	27 (68)	0.32441
	Not performed	5 (19)	13 (37)	
Shake	Performed	21 (78)	17 (43)	0.01248
	Not performed	6 (22)	20 (50)	
	Potent. dangerous	0 (0)	3 (8)	
Shout	Performed	10 (37)	3 (7)	0.00728
	Not performed	17 (63)	37 (93)	
Clear airway	Performed	12 (44)	6 (15)	0.01703
	Not performed	15 (56)	34 (85)	
Open airway	As taught	16 (59)	6 (15)	0.00000
	Effective	1 (4)	8 (20)	
	Not achieved	8 (30)	4 (10)	
	Not attempted	2 (7)	22 (55)	
Breathing	Effective	21 (78)	26 (65)	0.26159
	Ineffective	3 (11)	3 (8)	
	Not attempted	3 (11)	11 (28)	
Circulation	Near side	21 (78)	8 (20)	0.00003
	Far side	4 (15)	16 (40)	
	Other pulse	1 (4)	1 (3)	
	Not performed	1 (4)	15 (38)	
Phone 999	Ambulance	12 (44)	5 (13)	0.00567
	Phone ambiguous	1 (4)	9 (23)	
	Not performed	14 (52)	26 (65)	

Figures in parentheses represent percentages.

Checking for breathing was not significantly different, as in both groups more than two thirds performed 'look, listen and feel' correctly, though some had failed to open the airway first. For circulation checks, comparing those who checked the near-side carotid pulse, far-side carotid pulse, another pulse or who failed to check for circulation, the difference between the groups was highly significant ($P = 0.000$). In checking for circulation, four (15%) of the newly trained and 16 (40%) of the retention group checked the far side.

The marking schedule provides for gradations of performance where appropriate, allowing the assessor to record attempts which did not conform to ERC guidelines. Three people in the retention group shook the casualty in a manner which was potentially dangerous, i.e. either too vigorously, or holding the head rather than the shoulders. Of those who opened the airway before checking for breathing, one out of 17 in the newly trained group and eight out of 14 in the retention group did not use the recommended method. Errors included lifting the neck from beneath rather than using 'head tilt, chin lift'. It was disappointing to find that only 12 (44%) of the newly trained remembered to phone for an ambulance and that this was even worse in the retention group where only five (13%) remembered.

3.2. Inter- and intra-observer variation

Table 2 shows the κ correlation for inter- and intra-observer variation for each component assessed. Guidelines state that a κ value of 0.81–1.00 indicates almost perfect agreement, 0.61–0.80 substantial, and 0.41–0.60 moderate agreement [21,22]. According to these criteria, agreement was almost perfect or good to almost perfect for all assessments, except opening the airway, where agreement was only moderate for inter-observer and moderate to good for intra-observer scores.

Opening the airway as part of the casualty assessment was the most difficult component to mark as, even with the aid of video recording, it is sometimes difficult to be certain that the airway has been opened adequately. As the guidelines (Appendix B) show, to be credited with opening the airway in CARE, the candidate has to perform the manoeuvre as part of casualty assessment and not just prior to ventilation. In some cases, particularly retention tests, subjects performed either perfunctory or virtually no assessment and it was difficult to distinguish whether opening the airway was carried out as part of the assessment or as preparation

Table 2
Inter- and intra-observer agreement

κ Correlation		
Component	Inter-observer	Intra-observer
Approach	0.97–0.91	0.95–0.72
Talk	1.00–0.96	1.00–0.78
Shake	0.94–0.86	0.95–0.85
Shout for help	1.00–0.86	0.88–0.81
Check airway	0.87–0.84	0.90–0.74
Open airway	0.53–0.42	0.80–0.57
Check breathing	0.96–0.86	0.93–0.68
Check circulation	0.93–0.86	0.89–0.82
Phone 999	0.80–0.69	0.95–0.84

κ Statistic	Strength of agreement
<0.20	Poor
0.21–0.40	Fair
0.41–0.60	Moderate
0.61–0.80	Good
0.81–1.00	Almost perfect

Strength of agreement adapted from Altman [21] and from Landis and Koch [22].

for ventilation. The absence of objective criteria for this action added to the difficulty, as achievement or failure in ventilation did not necessarily relate to the state of the airway during assessment.

4. Discussion

In developing CARE and its accompanying assessment criteria, we have attempted to provide a valid means of comparing different instruction and revision methods. Though the assessment was designed with lay people in mind, it could well be applied to those with a medical background, as it has been reported that they are equally prone to poor retention of CPR skills [13,16]. However, the test examines only compliance with ERC guidelines for basic life support and not what might or might not be effective in particular circumstances. Medical staff can sometimes choose to deviate from guidelines without detriment to the patient, but for lay people it is advisable to proceed exactly as taught. The basic marking system therefore seeks to avoid this type of judgement and only considers whether or not the subject is performing actions in the manner and order in which he/she was taught. In community CPR schemes, the evaluator may have a vested interest in demonstrating that the scheme is working and objectivity may suffer. It has been shown that instructors are more likely to believe that their trainees are competent than are independent evaluators [12,14]. It cannot be assumed that those testing will apply the same criteria to each assessment and without a strict marking schedule there is a danger that credit could be given for the candidate's supposed intentions, or that evaluation could be against the performance of the previous candidate rather than to a 'gold standard' [23].

The test can also provide a check on the performance of CPR instructors, e.g. if most members of a group taught by the same person forget to perform an action, this will indicate that the instructor has not given it sufficient emphasis. Likewise, if a group of co-trainees should be marked for airway 'opened — other', it is possible that the instructor has taught them to open the airway in a manner other than that currently recommended. This means that the instructor can be corrected promptly before poor techniques are passed on to more life supporters. Previous research has indicated that the problem of poorly retained skills may lie with instructors [14] and if life supporters' assessments indicate that this is so, it may be advisable to test and, if necessary, retrain the instructor.

Our method of testing life supporters at home without prior warning may to some extent simulate the stress of a medical emergency and provide a proxy for likely performance in such an event. This method was only possible for the retention testing group who had a wide time range post-instruction. As we wished to test new trainees promptly in order to avoid loss of skills since instruction, they were tested in the same building, but not necessarily in the same room in which they were originally taught, as it would have been difficult to test a similar number at home without notice within this time.

It is a well-established fact that students do better in examinations if they are tested in their habitual classroom [24]. In the case of CPR, skills may not be effectively deployed because the context in which they are tested (or indeed that in which an emergency occurs) differs from the learning context [25]. CPR courses are often held in large public buildings such as community centres or schools with the support of instructors and fellow trainees, whereas 70% of cardiac arrests occur at home [26] with a close relative often the only witness. The new trainees may, therefore, have performed significantly better than those taking retention tests, not only because they were recently taught, but also because the testing environment more closely resembled the teaching environment. The mean age of 28 for new trainees was slightly lower than that of 34 for retention tests and but this small difference is unlikely to have been a source of bias, as it has been observed that CPR skills are not dependent on age [12,18].

Inter- and intra-observer agreement using our marking schedule and criteria guidelines were excellent, as demonstrated by the high κ correlations [21,22]. The

simplest way to present these results would have been to show on how many occasions the observers agreed, but such a presentation would take no account of where the agreement was or of the amount of agreement which would have occurred by chance. The κ correlation takes both of these into account and produces a statistic with a maximum of 1.00 for perfect agreement, zero for no better than chance and negative values showing worse than chance agreement. The Kappa statistic can be interpreted as the 'chance corrected proportional agreement' [21], and is considered by statisticians to be the best approach for presenting the amount of agreement between observers for categorical variables.

Those with experience of assessing basic life support some months after instruction will know that skills are not only forgotten and omitted but can also be performed in the wrong order. In some cases, this will make little difference to effectiveness, but in others order can be crucial, and this forms the logic underlying the division of CARE into numbered steps which should be completed before progression to the next. If a candidate performs steps in the wrong order, or inserts one step into the next, this could be detrimental to the rescue attempt and would be marked as 'not performed/attempted' if it is not carried out in the correct order. An example of this would be if the rescuer began to look for danger to him/herself (Step 1), when the initial assessment (Step 2) had been started. Likewise, if the airway was opened (Step 3) before checking for obstruction (Step 2), this could result in an undetected foreign body falling back into the trachea, thus rendering ventilation very difficult or impossible.

Opening the airway was the one component in the assessment where only moderate to good agreement was achieved. Because, at this stage, it was being marked as part of the assessment only, there was no objective measure of whether or not opening had been achieved. It was not possible to make a decision according to whether or not ventilation was later successful, as many subjects repositioned the head directly before ventilation to ensure that the airway was open, whilst others who had appeared to open the airway successfully during assessment allowed the head to slip forward again before ventilation. With the equipment currently available, it is difficult to determine whether or not the airway has been opened adequately as part of the casualty assessment. To overcome this, an adjustment could be made whereby a signal would appear when the airway had been opened correctly.

In 1982, Martin and colleagues [27] found that 3 months after training, only 52% of life supporters opened the airway correctly as part of the casualty assessment and only 24% established lack of pulse. The figure for opening the airway is better than that shown by CARE retention tests and that for establishing lack of pulse is similar to CARE for performing as taught but, as with many other reported tests of life support skills, we do not know the marking criteria of Martin et al. Though the figure of 22% who 'established lack of pulse' is similar to our own for checking the near-side carotid pulse, it is very different from the 60% who checked the near- or far-side carotid. The fact that the criteria could have been near-side carotid only, near- or far-side carotid only, or so broad that it included palpation of wrist, brachial or femoral pulse, emphasises the need for a standardised test. Until researchers use such a test, it will be difficult to make progress in improving teaching methods. The use of video recording need not be cost prohibitive, as some training centres and many volunteer instructors will have access to such equipment. Whilst we would not advocate detailed assessment for every trainee, periodic sampling using CARE in conjunction with video can provide powerful quality control and an effective means of assessing different methods of instruction.

Our research has involved video recording life supporters of varying degrees of competence. These form a recorded data source for error observation and can be used as a teaching aid for instructors, and as a means of furthering standardised assessment. CARE provides a validated test for the preliminary steps of life support and we believe that this is a significant step forward in promoting effective CPR in the community.

The team has now validated an assessment technique for ventilations and compressions, combining analysis of the video recording together with the Recording Anne printout (VIDRAP) and we hope to publish this in due course.

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Appendix A. Cardiff assessment of response and evaluation (CARE)

Step 1. Careful approach			
Performed	[ ]	Not performed	[ ]
Step 2. Initial assessment			
Talk			
Performed	[ ]	Not performed	[ ]

Shake			
Performed	[ ]	Potentially dangerous	[ ]
Not performed	[ ]		
Shout for help			
Performed	[ ]	Not performed	[ ]
Check / clear airway			
Performed	[ ]	Not performed	[ ]
Step 3. Airway, breathing and circulation			
Airway			
Opened as taught	[ ]	Opened — other	[ ]
Visibly attempted	[ ]	Not attempted	[ ]
Breathing			
Effective	[ ]	Ineffective	[ ]
Not performed	[ ]		
Circulation			
Carotid near side	[ ]	Carotid far side	[ ]
Other pulse	[ ]	Not performed	[ ]
Step 4. Phone 999			
Phone ambulance	[ ]	Get help (unspecified)	[ ]
Phone GP/police	[ ]	Not performed	[ ]

Appendix B. Assessment criteria for video testing with CARE

If these guidelines are followed, assessment should be consistent, with minimal inter- and intra-observer variation. Each step should be performed within its numbered section, but need not necessarily be in order within that section, except for opening the airway, which must be performed before checking for breathing. The following are examples of correct and incorrect performance:
Correct: shout for help after checking and clearing airway, but within Step 2, i.e. before open airway, check breathing and circulation (tick correct)
Incorrect: phone for help after commencing CPR (tick not performed)

1. Careful approach	
Performed	Indicates verbally or by actions that safety of the rescuer is being considered
Not performed	No attempt to assess safety
2. Initial assessment	
Talk	
Performed	Talks to casualty before open airway, check breathing and circulation
Not performed	Does not talk to casualty before open airway, check breathing and circulation
Shake	
Performed	Shakes casualty before open airway, check breathing and circulation
Not performed	Does not shake casualty before open airway, check breathing and circulation
Potentially dangerous	Shakes too vigorously or shakes casualty's head
Shout for help	
Performed	Shouts for help before open airway, check breathing and circulation
Not performed	Does not shout for help before open airway, check breathing and circulation
Check/clear airway	
Performed	Checks for obvious obstructions before open airway, check breathing and circulation
Not performed	Fails to check for obstructions or checks after beginning open airway, check breathing and circulation

3. Open airway, check breathing and circulation (NB: Open airway must be performed before checking breathing. If performed after breathing check, it is marked as 'not performed'. However, breathing check performed after failure to open the airway should be marked 'effective' in order to avoid a double penalty for one error. The justification for this is that the test is used to assess what is remembered and performed. Though it is obvious that a breathing check is ineffective without first opening the airway, we need to record whether 'look, listen and feel' has been performed adequately.)

Airway	
Opened as taught	Opens airway using head tilt, chin lift
Opened — other	Opens effectively by other method
Visibly attempted	Attempts but fails to open airway
Not attempted	No attempt to open airway before breathing check
Breathing	
Effective	Checks by look, listen and feel (two out of three allowed)
Ineffective	Checks by other method, e.g. hand near mouth, mirror
Not performed	No attempt to check for breathing
Circulation	
Near side	Checks near-side carotid pulse
Far side	Checks far-side carotid pulse or causes pressure on larynx whilst checking near side
Other pulse	Checks other pulse correctly
Not performed	No attempt to check pulse, or checks totally incorrectly, e.g. head to chest
4. Phone 999	
Phone ambulance	Phones 999 for ambulance before commencing CPR
Get help	Phones for help — ambiguous before commencing CPR
Phone GP/police	Phones GP or police before commencing CPR
Not performed	No attempt to phone for help before commencing CPR

Appendix C. Instructions to be read to test candidate

On entering a room alone, you see a person lying still upon the floor. Please describe and demonstrate how you would approach and assess the situation and what action you would then take.

I shall not offer any advice or opinion other than to report the condition of the person during your assessment. Please start and continue until I ask you to stop.

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Effectiveness of the BBC's *999* training roadshows on cardiopulmonary resuscitation: video performance of cohort of unforewarned participants at home six months afterwards

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Abstract

***Objective*—To examine the competence of a cohort trained in cardiopulmonary resuscitation by the BBC's 999 training roadshows.**

***Design*—Descriptive cohort study applying an innovative testing procedure to a nationwide systematic sample. The test sample received an unsolicited home visit and without warning were required to perform cardiopulmonary resuscitation on a manikin while being videoed. The videos were then analysed for effectiveness and safety using the new test.**

***Setting*—Nine cities and surrounding areas in the United Kingdom.**

***Subjects*—280 people aged between 11 and 72.**

***Results*—Thirty three (12%) trainees were able to perform effective cardiopulmonary resuscitation, but of these 14 (5%) performed one or more elements in a way that was deemed to be potentially injurious. Thus only 19 (7%) trainees were able at six months to provide safe cardiopulmonary resuscitation. In addition, large numbers of subjects failed to shout for help, effectively assess the status of the patient, or alert an ambulance. Significantly better performances were recorded by those under 45 years old (31 (14%) *v* 2 (4%) gave effective performances respectively, P<0.05), those who had attended a subsequent cardiopulmonary resuscitation course (8 (40%) *v* 25 (10%) gave effective performances respectively, P<0.0001), and those confident in their initial ability (26 (20%) *v* 7 (6%) gave effective performances respectively, P<0.005). Females were significantly less likely than males to perform procedures in a harmful way (117 (62%) *v* 10 (12%) performed safely respectively, P<0.005).**

***Conclusion*—Television is an effective means of generating large training cohorts. Volunteers will cooperate with unsolicited testing in their home, such testing being a realistic simulation of the stress and lack of forewarning that would surround a real event. Under such conditions the performance of cardiopulmonary resuscitation was disappointing. However, retraining greatly improves performance.**

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Introduction

Bystander cardiopulmonary resuscitation improves survival in people who have a cardiac arrest outside hospital.[1] Consequently, increased emphasis has been placed on training the public in these techniques as a means of reducing mortality from ischaemic heart disease.[2,3] Since 1994 the BBC has organised annual training roadshows on cardiopulmonary resuscitation throughout the United Kingdom to coincide with the broadcasting of its *999* television programme.

Although the effectiveness of bystander cardiopulmonary resuscitation has been shown, the effectiveness of mass training courses such as the BBC's *999* roadshow is less clear. Much evaluation of cardiopulmonary resuscitation training has been concerned with the performances of medical and allied professional staff rather than the lay public.[4-6] With few exceptions,[7] studies that have tried to evaluate training of the lay public have prewarned subjects of testing either explicitly or immediately before retraining.[8] Despite this, most results have been disappointing.[9] We describe an innovative method of evaluating how an unforewarned lay person trained on a roadshow would perform cardiopulmonary resuscitation should a cardiac arrest occur in their home.

Subjects and methods

At each of the 10 roadshows held between April and June 1994, participants were asked to complete an optional card consenting to take part in further unspecified research. A total of 7584 course attenders completed an anonymised demographic questionnaire, and of these 6123 (81%) completed a consent card. The research entailed "cold calling" on a sample of trainees and video recording a simulated attempt at cardiopulmonary resuscitation using a Laerdal Recording Anne Manikin (Norway). Trainees from Londonderry, Northern Ireland, were excluded owing to the sensitivity at that time of undertaking unsolicited house calls there. Those who lived in a postal district outside a 32 km radius of their training centre were also excluded on logistical grounds. This left 4651 cards, from which a 6% (n = 280) stratified random sample was chosen by

ordering the cards by adjacent postal district and selecting the 16th and 17th card alternately from a starting point generated by computer.

All tests were conducted between 27 and 35 weeks after the initial training. Each test was videoed for later evaluation in conjunction with the manikin recording strip. Two researchers, a man (CLlM) and a woman (see acknowledgements) visited subjects at home, without warning, and, after showing the completed consent card, asked their permission to conduct the test. The manikin and video equipment were prepared while the subject completed two questionnaires on sociodemographic data and attitudes to emergency life support. The subject then read the following passage:

"On entering a room you see a person lying still upon the floor. Please describe and demonstrate how you would approach and assess the casualty and what action you would take. I will not offer any advice or opinion other than to report the status of the casualty during your assessment."

The subject was not informed that the patient was in cardiac arrest but was expected to deduce this by assessment. The only interruption from the researchers was to confirm the status of the casualty after the appropriate assessment—that is, to report that the casualty was unconscious, not breathing, and pulseless. If subjects stated that they would phone for help they were told that help was on its way. Subjects were encouraged to continue cardiopulmonary resuscitation for a maximum of three cycles, after which they were asked when they would have stopped had this been a real life situation.

All videos and recording strips were analysed by one of us (CLlM) using guidelines developed at Cardiff. The test criteria were based on the European Resuscitation Council's guidelines,[10] as these formed the core of the *999* teaching syllabus, with the categories of effective and safe representing what we considered to be reasonable deviations from these guidelines (table 1). A 20% sample was analysed by another of us (CAL) as a check on interobserver variation. All analysis was performed using SPSS for Windows.

Results

Of the original 280 subjects, 186 (66%) took part in the study. To complete the remaining 94 tests, 136 replacements were made for the reasons listed in table 2. The final sample was comparable with the total trained cohort in terms of age, sex, and social class. Table 3 shows the kappa score of inter-rater agreement between the two assessors for the 10% sample.

Table 4 shows the number of subjects performing each procedure and, when appropriate, whether that procedure was effective, ineffective, or potentially injurious according to the European Resuscitation Council guidelines. Of the 210 (75%) who effectively checked for breathing, 173 did not first open the airway.

Twenty seven (10%) subjects said that they would call an ambulance before beginning cardiopulmonary resuscitation, but when subjects were asked when they would stop cardiopulmonary resuscitation in a real situation 138 (49%) stated they would continue until an ambulance arrived. Of the remaining 142 (51%), 51 (36%) said that they would continue for a defined period and 55 (39%) that they would continue until the patient showed signs of revival. Sixty of these 106 (57%) subjects were asked a follow up question about what they would do when either the defined period had elapsed or the patient had failed to respond. Nineteen of them (32%) said that they would wait for the ambulance to arrive while 29 (48%) said that they would leave the patient and telephone for an ambulance after having started cardiopulmonary resuscitation.

The overall performance of cardiopulmonary resuscitation was assessed for effectiveness and safety (table 5). None performed cardiopulmonary resuscitation to the European Resuscitation Council guidelines, but 19 (7%) performed it in an effective and safe manner. A further 14 subjects (5%) were effective but performed at least one procedure that was potentially injurious. Ineffective performances were recorded for 243 subjects (87%); of these, 110 (45%) were also classed as potentially injurious. Four subjects (1.4%) did not attempt ventilation or compression.

Sex and social class had no influence on the effectiveness of cardiopulmonary resuscitation (table 6), but age was a significant factor, with 31 (14%) of those under 45 performing effectively compared with only two (4%) of those aged 45 or over ($P<0.05$). Those who felt confident before testing performed more effectively (26 out of 133, 20%) than those who were not confident or unsure (seven out of 127, 6%) ($P<0.005$). Subsequent training also improved performance, with eight of the 20 (40%) who had attended a subsequent course giving an effective performance against 25 of the 256 (10%) who had not. The numbers were, however, too small to make this result conclusive.

There was no difference by age group or social cla in those performing safe cardiopulmonary resuscitat but only 34 (42%) men performed resuscitation s compared with 117 (62%) women ($P<0.005$).

Table 1—*European Resuscitation Council's guidelines[10] and study criteria for effective and potentially injurious resuscitation*

	Guidelines	Effective	Potentially injurious
Breathing volume (l)	0.8-1.2	0.1-2	>21
Compression depth (mm)	38-51	30-51	>51
Compression rate (No/min)	80-100	≥60	NA
Ratio of breaths to compressions	2:15	1:5 (minimum)	NA
Hand position during compression	Concentrated on centre of chest, two fingers above xiphisternum	Concentrated on lower third of sternum	Any other hand position

NA = not applicable.

Table 2—*Reasons why 94 subjects needed to be replaced in study cohort, with numbers of replacement subjects required to complete test for each reason*

Reason for replacement	No of replacement subjects (n = 136)
Refused	38
Out on three occasions	21
Incapable owing to physical injury	4
Possibly forewarned	42
Address not found, illegible, or insufficient	3
Moved with no forwarding address or outside the area	15
Tests invalid owing to:	
Equipment failure	7
Prompting from another person	6

Table 3—*Agreement between raters on effectiveness of procedures in 10% sample of cohort*

Procedure	Percentage agreement	Kappa statistic
Careful approach	73	0.46
Talk to patient	97	0.92
Shake patient	93	0.84
Shout for help	93	Not calculable
Clear or check airway	93	0.71
Open airway	90	0.93
Check for breathing	87	0.68
Check for circulation	87	0.79
Telephone emergency services	70	0.68

Table 4—*Numbers of subjects (n = 280) performing each procedure, with type of performance when appropriate*

Procedure	Resuscitation not performed	Missing data	Resuscitation performed: According to guidelines[10]	Effectively	Ineffectively	Dangerously
Careful approach	196	6	78	NA	NA	NA
Talk to patient	180	4	96	NA	NA	NA
Shake patient	190	4	84	NA	NA	2
Shout for help	268	4	8	NA	NA	NA
Check airway	242	0	38	NA	NA	NA
Open airway	230	0	32	12	6	NA
Check for breathing	40	0	210	NA	30	NA
Check for circulation	69	0	25	162	24	NA
Telephone emergency services	250	0	27	NA	3	NA
Breathing volume	9	0	68	94	101	8
Breathing interval	21	0	80	17	162	NA
Hand position during compression	17	0	91	103	NA	69
Compression rate	17	0	55	91	117	NA
Compression depth	17	0	71	90	44	58

NA = not applicable.

Table 5—*Overall rating of cardiopulmonary resuscitation performed by 280 subjects*

Rating	No of subjects
Conforming to guidelines[10]	0
Performance:	
Effective	19
Effective but potentially injurious	14
Ineffective	133
Ineffective and potentially injurious	110
Resuscitation not performed	4

Discussion

METHODOLOGICAL ISSUES

Our methods share with others the underlying assumption that proficiency shown in performing cardiopulmonary resuscitation with a manikin is predictive of proficiency in a real situation.[11] To maximise the realism of the test we gave the subjects no warning and conducted all tests in their home, where over 70% of cardiac arrests occur.[12-14] The presence of two observers and video equipment may have increased the anxiety of the subject and consequently enhanced or impaired performance, although the extent to which this compares with the stress of a genuine emergency is impossible to measure.

Although cardiopulmonary resuscitation from a bystander improves outcome, what constitutes effective cardiopulmonary resuscitation is unproved. Cardiopulmonary resuscitation judged retrospectively to be poor may still be associated with improved outcome, although this may be dependent on a rapid response by the emergency medical services.[12 15] Several studies determining the effect of the quality of cardiopulmonary resuscitation on outcome have considered effective cardiopulmonary resuscitation to be that which is observed to produce a visible expansion of the chest and a palpable carotid or femoral pulse.[16 17] The minimum prerequisite to achieve this is not known, however. As a result, the test criteria must be somewhat arbitrary with the aim of being liberal, such that any performance that could reasonably be considered beneficial will be classed as effective.

POSSIBLE PROBLEMS WITH INSTRUCTION

As there is no record of the degree of competency achieved immediately after training, we could not determine whether our results are due to inadequate instruction, poor retention, or a combination of both. Several comparative studies have shown the time since training to be closely associated with a decrease in proficiency.[5 18] As reported by others, this study indicates that some form of regular retraining is required to maintain adequate skills in cardiopulmonary resuscitation, although those willing to attend retraining courses may be more motivated than those who do not, such motivation possibly affecting initial learning or retention.[8 19]

The organisation of the courses may also have limited the initial absorption of techniques. The structure of the

Table 6—*Effectiveness and safety of performance of cardiopulmonary resuscitation by age, sex, social class, subsequent training, and confidence before test. Values are numbers (percentages) of subjects**

	Effective	Ineffective	P value	Safe	Potentially injurious	P value
Age (years):						
<45 (n = 219)	31 (14)	188 (86)		127 (58)	92 (42)	
≥45 (n = 53)	2 (4)	51 (96)	0.04	26 (49)	27 (51)	0.25
Sex :						
Male (n = 82)	10 (12)	72 (88)		34 (41)	48 (59)	
Female (n = 190)	23 (12)	167 (88)	0.79	117 (62)	73 (38)	0.002
Social class:						
I, II, IIIN (n = 153)	18 (12)	135 (88)		83 (54)	70 (46)	
IIIM, IV, V (n = 98)	9 (10)	89 (91)	0.52	55 (56)	43 (44)	0.77
Subsequent course:						
Attended (n = 20)	8 (40)	12 (60)		13 (65)	7 (35)	
Not attended (n = 256)	25 (10)	231 (90)	<0.0001	140 (55)	116 (45)	0.37
Confidence before test:						
Confident (n = 133)	26 (20)	107 (81)		68 (51)	65 (49)	
Not confident or unsure (n = 127)	7 (6)	120 (95)	0.001	76 (60)	51 (40)	0.16

*Four subjects did not attempt cardiopulmonary resuscitation and so are excluded from this analysis. In addition, some subjects completed the sociodemographic questionnaire incorrectly or social class could not be coded.

roadshows was similar to the Save A Life campaign, which has been criticised for its short training time (2.5 hours) and the fact that instructors come from many different organisations.[20] Retention of cardiopulmonary resuscitation skills was greater among those who attended an eight hour rather than a four hour course.[21] Given the breadth of the syllabus, the 2.5 hours given to the roadshows may be less than required. The provision of training by many organisations may be problematic as different bodies have different training agendas. Anecdotal evidence collected during testing suggested that predefined methods were replaced by techniques idiosyncratic to particular organisations. This caused confusion among trainees, who had been shown a video of the approved procedures, and any variation from the approved techniques may not have helped reinforcement. Some instructors also introduced entirely new components, such as cardiopulmonary resuscitation performed by two people, which took up teaching time and confused trainees. Similar observations were noted in the study of Kaye *et al*, who found that trainees performed poorly on manikins after teaching sessions on cardiopulmonary resuscitation.[22] The BBC has taken measures to rectify this in its current roadshows.

ACTIVATING THE EMERGENCY SERVICES

The most important aspect of emergency life support is activating the emergency services, but, surprisingly, only 27 (10%) subjects did this before initiating cardiopulmonary resuscitation. Although many subjects simply assumed that an ambulance was activated, a sizeable minority either did not mention the emergency services or stated that they would send for an ambulance at an inappropriate stage. An American study found that people who attempt cardiopulmonary resuscitation are more likely to telephone for an ambulance.[14] However, a local population survey showed that on encountering someone in cardiac arrest, 65% of subjects would firstly phone for an ambulance and this increased to 73% among those who had received no formal training in emergency life support.[23] With only ambiguous evidence further study is required to determine whether a false sense of empowerment among trainees may mean that they delay activating the emergency services.

In our study cardiopulmonary resuscitation was initiated by 90 (32%) subjects who did not first establish that there was no pulse; 36 of them (40%) performed at least one potentially injurious procedure. In one study only 20% of medical students checked the pulse effectively[24], whereas in another 70% of lay people established whether there was a pulse.[25] As discussed by others, this may be an artefact of the testing method: subjects are anxious to offer treatment before establishing a diagnosis, which may not apply in a real situation.[26] Over nine years in Seattle only one case was documented in which cardiopulmonary resuscitation was inappropriately performed, and on this occasion no harm was caused.[27]

What constitutes injurious cardiopulmonary resuscitation is arbitrary. Even cardiopulmonary resuscitation considered to be performed correctly may be associated with a wide range of complications.[28] In all, 124 subjects (44%) performed one or more potentially injurious procedures. However, any potential injurious effect must be balanced against the certainty of harm caused by withholding appropriate cardiopulmonary resuscitation.

CONCLUSIONS

We believe that the unforewarned video testing that we used during this study provides a valuable tool for assessing cardiopulmonary resuscitation skills and has wider applications for research in this field. It successfully simulates the stress and lack of warning that would accompany a real event. We have shown that volunteers will cooperate with cold call testing, but under these conditions the performance of cardiopulmonary resuscitation is disappointing; these results are similar to those from studies of medical and nursing staff.[4-6 29]

Thus, the *999* roadshow is undeniably successful at recruiting large cohorts of volunteers, but attention must now turn to improving the standardisation and quality of instruction and to developing retraining strategies.[30] Without such developments the unique opportunities offered by recruitment through television will be lost. These poor results may also indicate a need to simplify resuscitation protocols.

Key messages

- Cardiopulmonary resuscitation from bystanders improves survival rates in people who have had a cardiac arrest outside hospital
- Training for the lay public in cardiopulmonary resuscitation has increased with such initiatives as BBC television's *999* national roadshows, but the effectiveness of this training has not been rigorously evaluated
- In this study 280 people who had attended a roadshow were tested, unforewarned, six months later in their home, their management of a simulated case of cardiac arrest being videotaped for later analysis
- Only 12% of subjects performed cardiopulmonary resuscitation effectively
- As well as performing cardiopulmonary resuscitation ineffectively, 39% of subjects performed one or more procedures in a way that could complicate the recovery of a casualty
- Although the *999* roadshows undoubtedly recruit many lay people, attention should now be given to retraining strategies

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APPENDIX F

GLOSSARY OF TERMS AND ABBREVIATIONS

APPENDIX F

Glossary of terms and abbreviations:

CARE	**C**ardiff **A**ssessment of **R**esponse and **E**valuation - the first part of the Cardiff test of Manikin CPR performance assesses rescuer performance up to but not including the instigation of chest compression and mouth to mouth ventilation.
CPR	**C**ardio**p**ulmanary **R**esuscitation
ERC	**E**uropean **R**esuscitation **C**ouncil
ILCOR	**I**nternational **L**iaison **CO**mmittee on **R**esuscitation
JICTAR ratings	Regularly published analyses of television audience size and composition
Recording Anne®	A commercially available recording Manikin which produces a paper printout demonstrating depth and frequency of both chest compression and ventilation.
"The Cardiff Test"	The combined use of CARE AND VIDRAP to assess manekin CPR performance
VIDRAP	**VID**eo and **R**ecording **A**nne **P**rintout - the second part of the Cardiff test of Manikin CPR performance assesses rescuer performance in terms of chest compression and mouth to mouth ventilation.

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