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Cardiopulmonary Resuscitation: Improving the Weakest Link in the Chain of Survival for Out-of-hospital Cardiac Arrest

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CARDIOPULMONARY RESUSCITATION

Improving the Weakest Link in the Chain of Survival for

Out-of-hospital Cardiac Arrest

By

Christian Vaillancourt MD, FRCPC

Thesis submitted to

the Faculty of Graduate and Postdoctoral Studies

in partial fulfilment of the requirements for the

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ABSTRACT 1 (150 words)

Background: Bystander CPR is associated with improved survival from cardiac arrest, the first cause of mortality in Canada

Objectives: To improve bystander CPR rates and survival from out-of-hospital cardiac arrest.

Methods: A retrospective and prospective analysis of data on cardiac arrest, a systematic review of bystander CPR, a trial designed for improving survival from out-of-hospital cardiac arrest.

Results: 7707 out-of-hospital cardiac arrests (1995-2000) with bystander CPR rate (16.5%) and overall survival to discharge (4%). Cardiac arrests are in residential locations (84.7%). Increasing bystander CPR rates could significantly improve survival in residential dwellings (OR 3.6; 95%CI 2.9-4.6). We systematically reviewed 221 publications to plan the intervention for our suggested cluster randomized trial. The study is feasible over a 3 to 5-year period.

Conclusions: Public health intervention in the field of bystander CPR will improve survival from cardiac arrest. Our study could significantly affect other international communities equipped with an existing EMS.

ABSTRACT 2

Background

Cardiovascular disease is the primary cause of mortality in Canada and is the leading cause of cardiac arrest. It accounted for 79,942 deaths in 1999, or 35% and 37% of all male and female deaths respectively. Cardiac arrest is a condition afflicting individuals in the prime of their economic productivity, 50% of whom have never had any prior manifestation of heart disease. Over 70% of cardiac arrests occur outside the hospital.

Rapid access to CPR, defibrillation, and advanced cardiac care is essential to survive out-of-hospital cardiac arrest. This concept is better known as "The Chain of Survival". CPR is a crucial yet weak link of the chain. A victim of cardiac arrest is much more likely to survive if a bystander administers CPR. Although bystander CPR rates have remained low over the past ten years in Ontario (14%), higher rates have been reported in similar metropolitan areas such as Calgary (34%) and Seattle (54%).

Objectives

The general objective of this thesis is to improve bystander CPR rates and survival for out-of-hospital cardiac arrest in Ontario. More specifically, we will: Part 1) determine cardiac arrest epidemiology, the potential impact of bystander CPR, and the potential impact of Public Access Defibrillation (PAD) programs; Part 2) review systematically the determinants of bystander CPR; and Part 3) propose a trial designed to improve bystander CPR rates and survival from out-of-hospital cardiac arrest in Ontario.

Methods

In part 1, we performed a retrospective analysis of data prospectively collected as part of the OPALS Study and collected new data on cardiac arrest location using database linkage and chart review. We used numerical and graphic descriptive statistics on cardiac arrest location and performed a descriptive analysis with 95% CI of cardiac arrest patient and system characteristics. We performed univariate analysis and logistic regression analysis to determine respectively the unadjusted and adjusted effect of bystander CPR on survival from cardiac arrest. We developed a mathematical model to predict the impact of various bystander CPR rates on the overall survival to cardiac arrest and the extra number of lives saved within the larger location categories. We determined the potential count of cardiac arrest victims that may be amenable to PAD programs and performed a descriptive analysis with 95% CI of the existing time interval before defibrillation and survival rate in that sub-group.

In part 2, we performed a systematic review of the determinants of bystander CPR and factors associated with successful training in CPR. We included human participants of any age, gender, culture, social status, or geographical area, and reviewed all educational tools applied at the individual, group, or community level. Outcome measures included success in promoting the interest for CPR training, in increasing the proportion of CPR trained individuals in the population, in increasing the bystander CPR rate for cardiac arrest, or in increasing survival from cardiac arrest as a result of an intervention promoting CPR training.

In part 3, we proposed to design a trial of fundable quality with the purpose of improving bystander CPR rates and survival from out-of-hospital cardiac arrest. To design the trial, we followed the Canadian Institutes of Health Research Guidelines for successful completion of a full grant application.

Results

In part 1, we studied 7707 consecutive adult out-of-hospital cardiac arrests between January 1st, 1995 and December 31st, 1999 in the 20 OPALS study communities. The classic cardiac arrest victim is a 69 year-old male, dying at home while his wife awaits EMS arrival. Victims received bystander CPR only 16.5% of the time. Four percent of the overall cardiac arrest population was discharged alive from the hospital. The great majority of cardiac arrests took place in residential locations (84.7%). More precisely, 56.1% occurred in "Single-Residential Dwellings", 22.7% in "Multi-Residential Dwellings", and 5.9% in "Nursing Homes". Unadjusted and adjusted OR for bystander CPR were (OR 3.6; 95%CI 2.9-4.6) and (OR 1.7; 95% 1.3-2.3) respectively. Providing we could reach a bystander CPR rate of 35%, survival to cardiac arrest could reach 5.6% for an additional number of lives saved per year of 24. Similarly, for a bystander CPR rate of 50%, survival to cardiac arrest could reach 7.0% for an additional number of lives saved per year of 47. The greater impact would occur in residential dwellings. Finally, we determined that less that 6.2% of the total number of cardiac arrests could be amenable to PAD programs. It is our opinion that PAD programs will have a limited impact on overall survival from cardiac arrest.

In part 2, we reviewed systematically 2254 potentially relevant publications on bystander CPR determinants. We included 221 publications in the systematic review. Findings can be summarized in the following way:

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

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

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

Where – Perhaps the most attractive intervention to increase bystander CPR rates is providing CPR instructions over the phone to callers reporting a

victim of cardiac arrest. There is clear evidence that such an action is associated with increased survival from cardiac arrest.

Why – The lack of motivation to leave the house and register for a CPR class seem to be a major determinant of low bystander CPR rates, perhaps more so than the fear of disease transmission or litigation. We need to consider measures that will actively recruit individuals such as teaching CPR on television or mandatory training at the time of renewing a driver's license.

In part 3, we suggested a cluster randomization design to plan a study with the objectives to improve bystander CPR rates and survival from cardiac arrest. We suggested a preliminary framework for a multiple interventions trial. We also determined that such a study could be feasible within a 3 to 5-year period.

Conclusions

We have suggested that further improvements in rapid defibrillation via the implementation of PAD programs may not have the impact on survival people have been hoping for. We have demonstrated the potential impact of various bystander CPR rates on survival from cardiac arrest, we have studied the determinants of bystander CPR in a systematic review of the literature, and we are proposing the first large scale Canadian multiple interventions trial with the objective of improving bystander CPR rates and survival from cardiac arrest on Ontario.

The proposed study should provide clear evidence that a systematic public health intervention in the field of bystander CPR will improve survival from

cardiac arrest. We expect our results the help the Provincial and Federal Ministry of Health take decisions with regards to the implementation of our program at a Provincial and Federal level. Similarly, the results of our study could significantly affect other international communities equipped with an existing EMS.

À mes parents,

Pour m'avoir encouragé

et avoir cru en moi dès le tout début.

To Karen, Emma, and my daughter to be,

Shall the success in my professional ambitions

always be second to that as a husband, father, and friend.

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LIST OF ABBREVIATIONS

ACD:	Active Compression Decompression
ACLS:	Advanced Cardiac Life Support
ACR:	Ambulance Call Report
ACT:	Advanced Coronary Treatment
AED:	Automated External Defibrillator
AHA:	American Heart Association
ALS:	Advanced Life Support
ARIS:	Ambulance Response Information System
BCLS:	Basic Cardiac Life Support
BLS-D:	Basic Life Support-Defibrillation
CI:	Confidence Interval
CORE:	Cardiac Outcomes Related to Economics
CPR:	Cardiopulmonary Resuscitation
EMS:	Emergency Medical System
EMT:	Emergency Medical Technician
ERC:	European Resuscitation Council
GEE:	Generalized Estimating Equations
IF:	Inflation Factor
ILCOR:	International Liaison Committee on Resuscitation
MONICA:	Monitoring of Trends and Determinants in Cardiovascular Disease
MPAC:	Municipal Property Assessment Corporation
NENA:	National Emergency Number Association
OPALS:	Ontario Prehospital Advanced Life Support (study)
OR:	Odds Ratio
PAD:	Public Access Defibrillation
PEA:	Pulseless Electrical Activity
RCT:	Randomized Controlled Trial
VF:	Ventricular Fibrillation
VT:	Ventricular Tachycardia
WHO:	World Health Organization

1. INTRODUCTION

Cardiac arrest is defined as *"...the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness, and apnea (or agonal, gasping respiration)".*[1] The victim collapses when the cardiac mechanical activity becomes too limited to provide adequate blood flow and oxygen to the brain and muscles. The victim is perceived to be lifeless if no vital signs (responsiveness, pulse, respiration) are detectable. Disorganized electrical cardiac activity (fibrillation) seen on a cardiac monitor may become the only sign of vital activity. In the absence of cardiopulmonary resuscitation (CPR) and/or electrical defibrillation, such electrical cardiac activity disappears and is followed by death in a matter of minutes.

Cardiovascular disease is the primary cause of mortality in Canada and is the leading cause of cardiac arrest. It accounted for 79,942 deaths in 1999, or 35% and 37% of all male and female deaths respectively.[2] The incidence rate for out-of-hospital cardiac arrest reported in the medical literature ranges between 36 and 128 per 100,000.[3]

Over 70% of cardiac arrests occur outside the hospital.[4] Compared to in-hospital cardiac arrest, out-of-hospital cardiac arrest cases are less likely to be witnessed, experience longer delays before CPR or advanced cardiac care are administered, and are associated with a smaller survival rate (Table 1.1).[5]

Table 1.1 Characteristics of In-hospital versus Out-of-hospital Cardiac Arrest Victims*

	In-hospital (n=368)	Out-of-hospital (n=510)
Age (SD) [range]	69 (14) [18-101]	68 (15) [17-100]
Male, No. (%)	211 (57)	318 (62)
Witnessed arrest, No. (%)	292 (79)	287 (56)
Initial rhythm, No. (%)		
Ventricular Fibrillation or Tachycardia	113 (31)	168 (33)
Pulseless Electrical Activity	152 (41)	102 (20)
Asystole	102 (28)	213 (42)
Time to treatment, min†		
Collapse to any CPR	1.4 (1.2)	5.1 (4.0)
CPR to ACLS	0.9 (2.3)	16.2 (6.7)
CPR to defibrillation	7.7 (8.5)	10.9 (10.2)
Survival to hospital discharge, No. (%)	42 (11.4)	19 (3.7)

*SD indicates standard deviation; CPR, cardiopulmonary resuscitation; and ACLS, advanced cardiac life support.

†Values are mean (SD)

Adapted with permission of the author from the original table appearing in JAMA 1996;275(18):1419.

Rapid access to CPR, defibrillation, and advanced cardiac care is essential to survive out-of-hospital cardiac arrest. This concept is better known as "The Chain of Survival". CPR is a crucial yet weak link of the chain. A victim of cardiac arrest is much more likely to survive if a bystander administers CPR (Odds Ratio (OR) 3.7; 95% Confidence Interval (CI) 2.6–5.1).[6] Although bystander CPR rates have remained low over the past ten years in Ontario (14%)[6, 7], higher rates have been reported in similar metropolitan areas such as Calgary (34%)[8] and Seattle (54%).[9]

In this thesis, we will review the evidence pertaining to the role of bystander CPR and propose a methodology that will address the issue of low bystander CPR rates and low survival to cardiac arrest. More specifically, we will: 1) determine cardiac arrest epidemiology; 2) review systematically the

determinants of bystander CPR; and 3) propose a trial designed to improve bystander CPR rates and survival from out-of-hospital cardiac arrest in Ontario. Our work could guide decision makers in the direction that will achieve significant improvement in survival to cardiac arrest.

2. BACKGROUND

2.1 Cardiac Arrest

2.1.1. Etiology of Cardiac Arrest

Seventy-five percent of cardiac arrest cases are caused by mechanical or electrical cardiac dysfunction. Coronary artery disease is the most frequent condition leading to such cardiac dysfunction.[10] In 25% of cases, cardiac arrest is of non-cardiac origin.[11]

Mechanical dysfunction can occur from lack of sufficient oxygen delivery to muscle fibres resulting in myocardial infarction, inability for the muscle to contract, and pump failure. This can follow a sudden increase in the workload of a heart supplied by chronically hardened and narrow coronary arteries that are unable to supply the extra oxygen demand, or from a sudden break in a cholesterol plaque leading to the formation of a thrombus and an acute total obstruction of blood flow.

Electrical dysfunction can cause an inadequate contraction of the heart. Oxygen deprivation is the primary cause of abnormal depolarization of the myocardial cells responsible for the organized and rhythmic contraction of the heart. Although less frequent, such abnormal depolarization may also occur as a result of senile degeneration of the heart's electrical system, dilated cardiomyopathy from valvular disease or chronic hypertension, hypertrophic cardiomyopathy, familial "long QT syndrome", or rare infiltrative diseases such as amyloidosis or hemochromatosis.

This abnormal depolarization can result in four different abnormal rhythms: 1) ventricular fibrillation (VF), or chaotic rhythm originating from the ventricles; 2) ventricular tachycardia (VT), or rapid, organized rhythm originating from the ventricles; 3) pulseless electrical activity (PEA), or apparently normal cardiac electrical activity albeit not accompanied by a palpable pulse; and 4) asystole, or absence of any electrical activity. Those abnormal rhythms are dynamic in time and may result in asystole if no therapy in instituted.[12]

Less than 25% of all cardiac arrests are believed to be of non-cardiac origin.[10] Some of those conditions are respiratory arrest (airway obstruction, hypoventilation), loss of vascular tone (hemorrhage, sepsis, neurogenic), metabolic electrolyte abnormalities (potassium, calcium, magnesium), intoxication (prescribed or illicit drug), and environmental (electrocution, drowning, hypothermia).

Fifty percent of all deaths from cardiac arrest occur suddenly and constitute one's first manifestation of heart disease.[2] Because of the often-unpredictable nature of cardiac arrest, it is important to recognize the limitation of interventions intended solely for known sufferers of heart disease. We need to invest efforts in interventions that will target the whole population.

2.1.2. Out-of-hospital Cardiac Arrest Interventions

Tales of resuscitation efforts date back to the Old Testament. Although Boehm published the first description of closed-chest cardiac massage in 1874 [10], Kouwenhoven was the first to demonstrate its efficacy in 1960.[13] At the same time, Safar and colleagues were working on artificial mouth-to-mouth

ventilation.[14] In the beginning, only physicians could apply chest compressions and mouth-to-mouth ventilation to cardiac arrest victims. In 1966, the National Academy of Science-National Research Council recommended the training of other health care professionals,[15] and encouraged the practice of CPR by lay public at a second national conference in 1973.[16, 17] Many efforts have been made to promote bystander CPR since that time.

Defibrillation, or the application of an electric current across the chest of a cardiac arrest victim, made its appearance shortly before modern CPR. Zoll reported the first successful defibrillation in a man in 1956.[18] Kouwenhoven actually discovered the effects of closed-chest cardiac massage by accident while researching defibrillation.[19] He noticed the presence of a palpable pulse with the rhythmic application of firm pressure on the electric paddles. Not unlike CPR, defibrillation was a skill first limited to physicians. Emergency medical technicians, nurses, firefighters, and policemen can now administer defibrillation as part of programs under the supervision of a medical director. With the introduction of machines capable of accurately recognizing an abnormal rhythm and automatically administer an electric shock, defibrillation by laymen is now made possible and safe. Public Access Defibrillation (PAD) programs are being implemented in many US states and Canadian cities and make use of these automated external defibrillators (AED).

Advanced Cardiac Life Support (ACLS) includes the use of definitive airway management such as endotracheal intubation, intravenous access, and administration of drugs in addition to CPR and defibrillation. At one time, ACLS

took place only after arrival to the hospital. The term "paramedic" was first associated with trained military medical personnel. They were parachuted in difficult-access locations and provided first aid to victims of the Korean War.[20] Physicians and other health professionals from Belfast were the first to take a mobile intensive care unit to the streets in 1966.[21] New York (1968) and Seattle (1969) soon followed in Belfast's footsteps, using physicians (New York) and paramedics (Seattle) to provide ACLS to civilian victims.[22, 23] Today, advanced life support (ALS) ambulance crews are found in most US and many Canadian communities. Compared to ACLS providers, which implies advanced care for cardiac arrest victims in particular, advanced care and ALS providers take care of cardiac arrest, trauma, and other critically ill victims.

2.1.3. Survival from Out-of-hospital Cardiac Arrest

Ten years ago, the overall survival rate from out-of-hospital cardiac arrest in Ontario was a mere 2.5%.[24, 25] After a series of focussed interventions, survival has now increased to 5.2% (a 2.7% absolute and 51.9% relative increase).[6, 7, 26, 27] The small number of survivors may come as a surprise to the general public, even to medical professionals. The often spectacular and Romanesque dramatization of resuscitation efforts depicted in certain television series may explain such a reaction. The success in bringing patients back to life in this medium has been observed to be as high as 75%, a very unrealistic number.[28-31]

Moreover, the scientific literature reports a range of survival rates to cardiac arrest as broad as 2% to 43%.[32, 33] For example, the city of Seattle

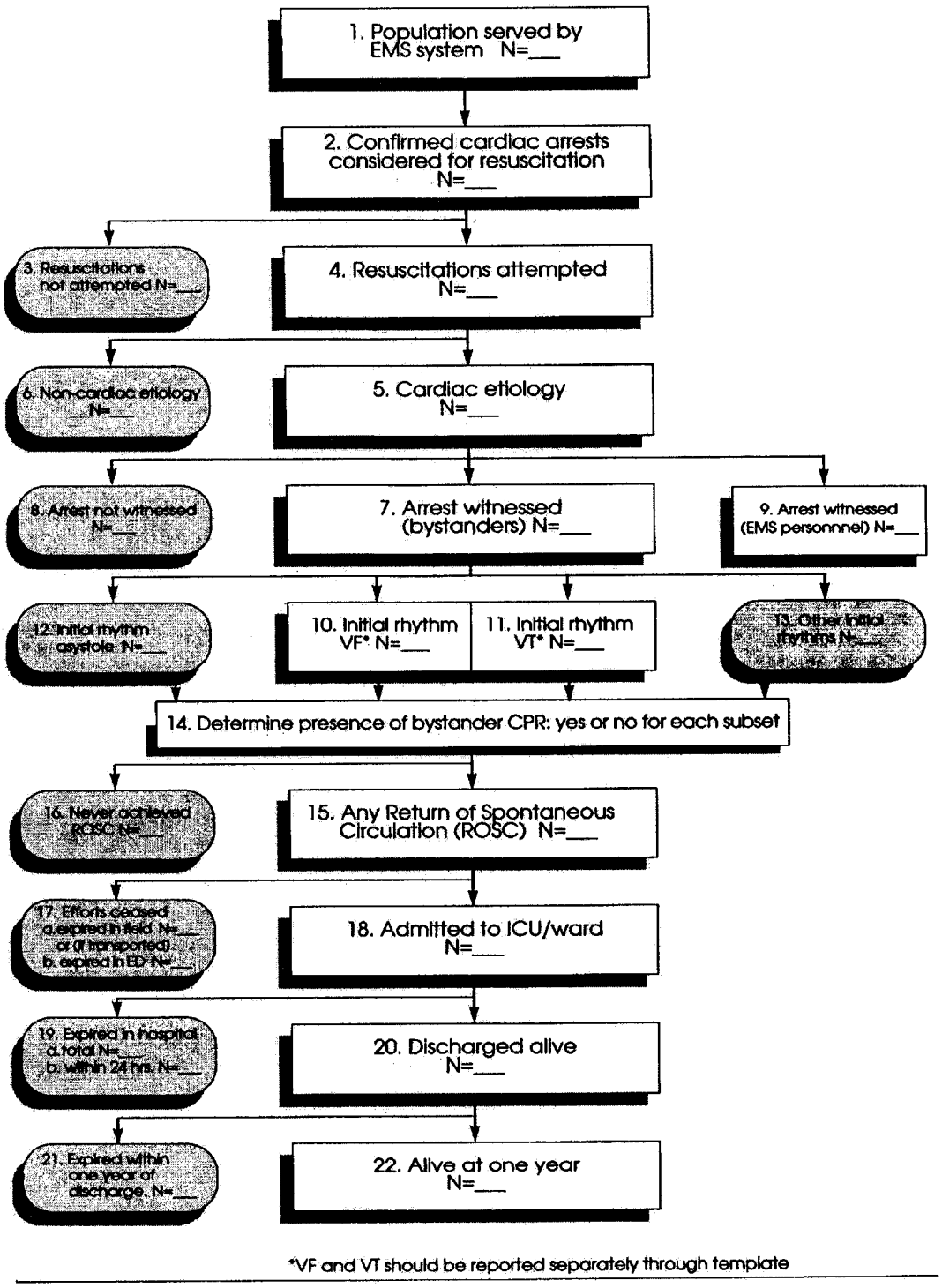
reports survival rates from witnessed cardiac arrests in VF/VT of 30%.[34] The analysis of different subgroups of cardiac arrests can explain such a wide range in survival rates. For instance, survival to cardiac arrest is higher in victims for whom collapse is witnessed and in whom the initial cardiac rhythm is VF or VT. In Ontario, survival to cardiac arrest in that group reaches 13.0%.[27] This illustrates the need to come up with a common language in order to make any significant comparisons.

2.2. Uniform Reporting of Data from Out-of-Hospital Cardiac Arrest

2.2.1. Development of the Recommendations

Representatives from the American Heart Association (AHA) and the European Resuscitation Council (ERC) met in the Norwegian Utstein Abbey in June 1990. They were the first to formally address inconsistencies in reporting data from out-of-hospital cardiac arrest. The Heart and Stroke Foundation of Canada and the Australian Resuscitation Council joined them in December of the same year at a subsequent meeting in Surrey, England. Together, this group of experts developed recommendations on *"core"* and *"supplementary"* data that should be collected when studying cardiac arrest (Figure 2.1). They also proposed standard terminology and time interval definitions for reports on out-of-hospital cardiac arrest. The term *"Utstein style"* was suggested in reference to those recommendations. Since their publication in 1991, they have been widely accepted by the scientific community, and have become the standard method to study and report on out-of-hospital cardiac arrest.[1]

Figure 2.1 Utstein Style Template for Reporting Data on Out-of-hospital Cardiac Arrest



Reproduced with permission. Appeared in Circulation 1991;84(2):964.

2.2.2 Definitions, the Utstein Style

Clear definitions of cardiac arrest terminology (Figure 2.2), time intervals, and outcome measures are major contributions of the Utstein recommendations.[1]

Figure 2.2 Definition of Cardiac Arrest Terminology, the Utstein Style[1]

Cardiac arrest:
The cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness, and apnea (or agonal, gasping respiration).

Cardiac etiology:
Researchers should classify cardiac arrests as presumed cardiac etiology if it is likely, based on available information...do not fit in the more readily defined category cardiac arrest of non-cardiac etiology.

Noncardiac etiology:
Often obvious and easy to determine...subcategories include SIDS, drug overdose, suicide, drowning, hypoxia, exsanguination, CVA, SAH, and trauma." SIDS indicates sudden infant death syndrome; CVA, cerebro-vascular accident; and SAH, sub-arachnoid hemorrhage.

Arrest witnessed:
Patient's collapse was seen or heard by a bystander or emergency personnel or both.

Bystander CPR:
Basic cardiopulmonary resuscitation (CPR) by someone who is not part of an organized emergency response system. This definition was later broadened to include emergency personnel while off-duty.

Cardiopulmonary resuscitation:
Attempt to restore spontaneous circulation.

Return of spontaneous circulation:
Return of any spontaneous palpable pulse and does not require a specific pulse duration.

Basic cardiac life support (CPR):
External compressions of the chest wall, plus expired air inflation of the lungs.

Advanced cardiac life support:
Basic CPR plus advanced airway management and ventilation techniques, defibrillation and intravenous or endotracheal medications.

Discharged alive:
Discharged from the hospital alive

The determination of specific time points of events and time intervals to be recorded in the process of delivery of care to victims of cardiac arrest is essential. The goal of this approach is to avoid such ambiguous terms as "response time" or "arrival at scene". The Utstein Style recommends that the timing of the following events be systematically recorded: CPR started by a bystander, call received, vehicle stops, CPR by emergency medical system (EMS) personnel, first defibrillatory shock, return of spontaneous circulation, and time CPR was abandoned or time of death.

As suggested above, there can be as many different survival rates as there are different subgroups of cardiac arrest victims. For the purpose of comparison between various EMS services, the Utstein Style recommends the main outcome measure to be the number of individuals discharged alive divided by the number of witnessed victims of cardiac arrest in VF or VT of cardiac origin. The Utstein Style suggests that their survival is most likely to reflect the timeliness of the EMS intervention. Other well-respected authors in the field of out-of-hospital cardiac arrest research suggest that those cases represent only a subset of the whole cardiac arrest population and have chosen to also report overall survival rates.[6, 7, 26] The Utstein Style also suggests separate reporting for cardiac arrests that occurred after the arrival of EMS personnel. For these cases, an analysis cannot be done on the impact of the different time intervals on survival. It has also been demonstrated that these "EMS-witnessed" cases have different characteristics compared to the other victims of cardiac arrest.[35]

2.3. The Chain of Survival Concept

The "Chain of Survival" illustrates important concepts in the treatment of out-of-hospital cardiac arrest (Figure 2.3). The chain metaphor implies that cardiac arrest care is only as strong as its weakest link among "early access", "early CPR", "early defibrillation", and "early advanced care". This pictogram introduced by the American Heart Association is now recognized all over the world. [36-38] In 1998, the Heart and Stroke Foundation of Canada added the following three links: healthy choices, early recognition and early rehabilitation (Figure 2.4). Ultimately, survival to cardiac arrest is dependent upon the "strength" of individual links with each link representing a specific community response to the emergency situation of cardiac arrest.

Figure 2.3 The Chain of Survival According to the American Heart Association

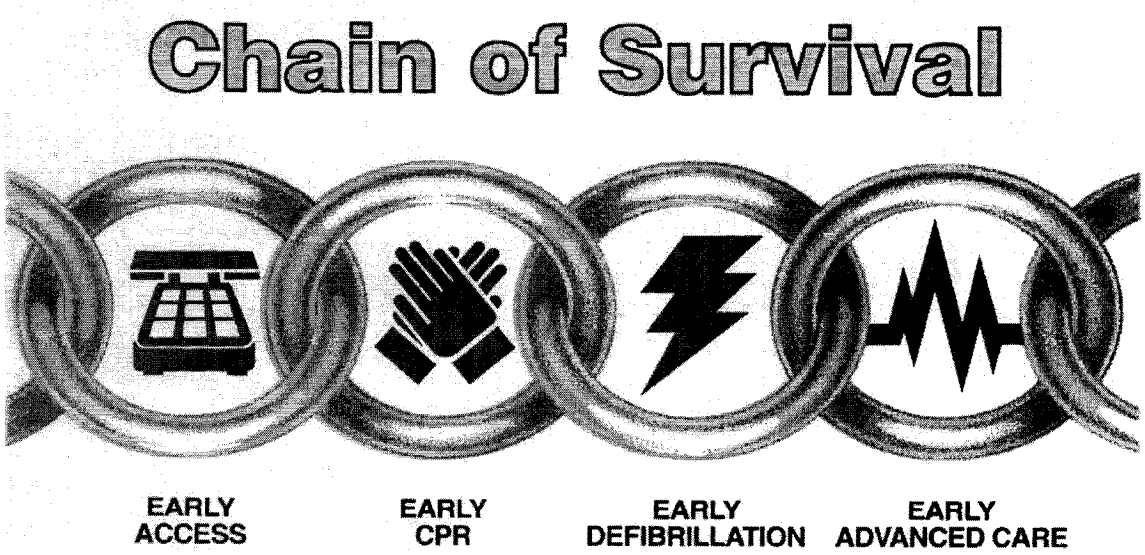


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Figure 2.4 The Chain of Survival According to the Heart and Stroke Foundation of Canada

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2.3.1. Healthy Choices

Prevention of heart disease is an important first step. In an effort to understand the distribution and determinants of heart disease, the population of Framingham, Massachusetts was monitored and examined in an unprecedented longitudinal study. Those observations identified the following risk factors of heart disease: elevated serum cholesterol, high blood pressure, smoking history, and glucose intolerance.[39]

Although mortality from ischemic heart disease is following a decreasing trend all over the world,[40-42] increasing severity of disease in an aging population[40], increasing smoking rates in women, and increasing overall body mass index in the general population[43] may ultimately reverse that reassuring trend.

2.3.2. Early Recognition

Cardiac arrest is often the first manifestation of myocardial infarction, the necrosis of the heart muscle from lack of oxygen delivery. Almost two thirds of people who succumb to a myocardial infarction never reach the hospital alive.[17]

A number of victims will collapse abruptly; some will recognize they are undergoing a myocardial infarction but will pursue their activities "just to finish", failing to appreciate the urgency of the situation; others may be convinced that their symptoms will go away and that "it's just indigestion". Unlike somatic pain that is very precisely mapped and interpreted by the cerebral cortex (e.g. hitting your thumb with a hammer), visceral or cardiac pain enters the spinal cord at many different levels and is usually more difficult to describe.[44] Because early recognition of myocardial infarction symptoms may lead to rapid care and prevention of cardiac arrest, The Heart and Stroke Foundation of Canada teaches basic life support providers to identify early signs of myocardial infarction.[17]

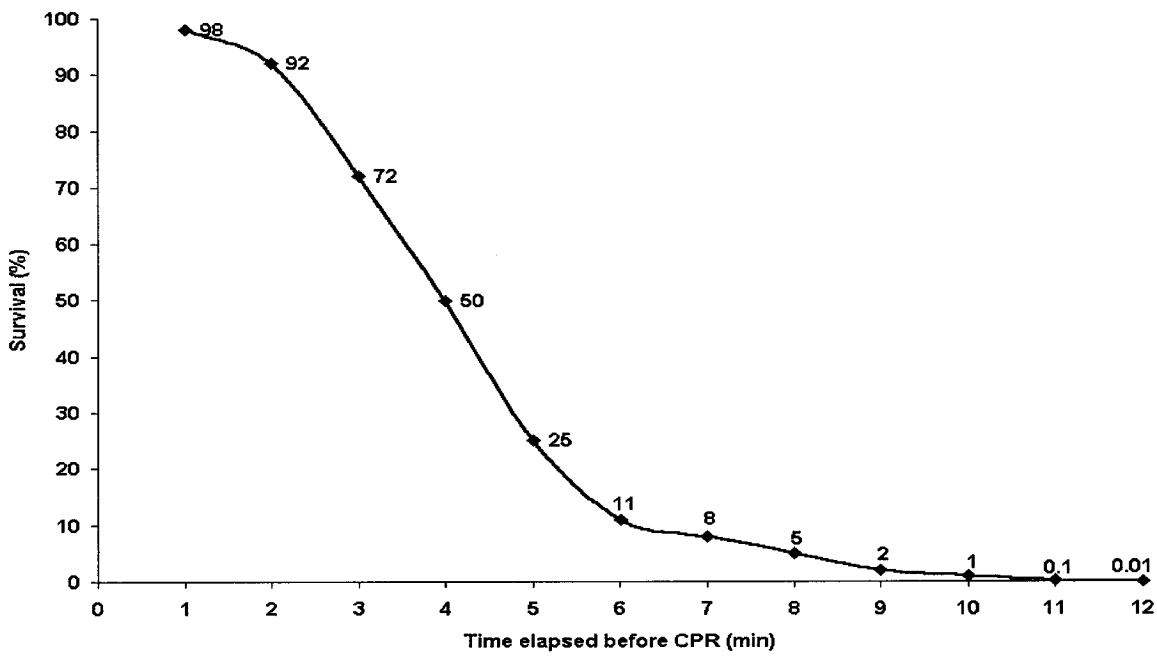
Likewise, appreciating that someone is having a cardiac arrest is not always easy. Lay people and health care professionals alike have been shown to experience difficulties in determining the presence or absence of a palpable pulse.[45, 46] Therefore, it is not expected of lay rescuers to check for a pulse. [17] More reliable and recognizable symptoms of cardiac arrest such as unconsciousness and absence of spontaneous breathing are enough to justify initiating CPR.

2.3.3. Early Access

Brain damage may start after only four minutes of cardiac arrest and irreversible brain damage is certain after ten minutes.[17] Likewise, with every minute-delay in instituting CPR, chances to recover from a cardiac arrest decrease in a non-linear fashion (Figure 2.5). [47] This being said, we can

understand the importance of a universal access number such as 9-1-1. It is not only quick to dial; it is also easy to remember. According to the National Emergency Number Association (NENA), 96% of the geographical US is covered by a 9-1-1 service.[48] Only a handful of Ontario communities do not have access to a 9-1-1 communication centre and those regions should be finished implementing the system by year 2003 (personal communication from the Regional 9-1-1 Manager)[1].

Figure 2.5 Chances of Recovery from Cardiac Arrest with Every Minute-Delay in Onset of CPR



When dialling 9-1-1, a caller is put in communication with personnel that will appropriately dispatch police, firefighters, EMS or all three. In case of a medical emergency, the call will rapidly be transferred to an affiliate dispatch centre. Because Bell Canada's 9-1-1 communication centres automatically display the "billing address" on their computer screen, the dispatch centre will

[1] Mrs. Judy Tottman

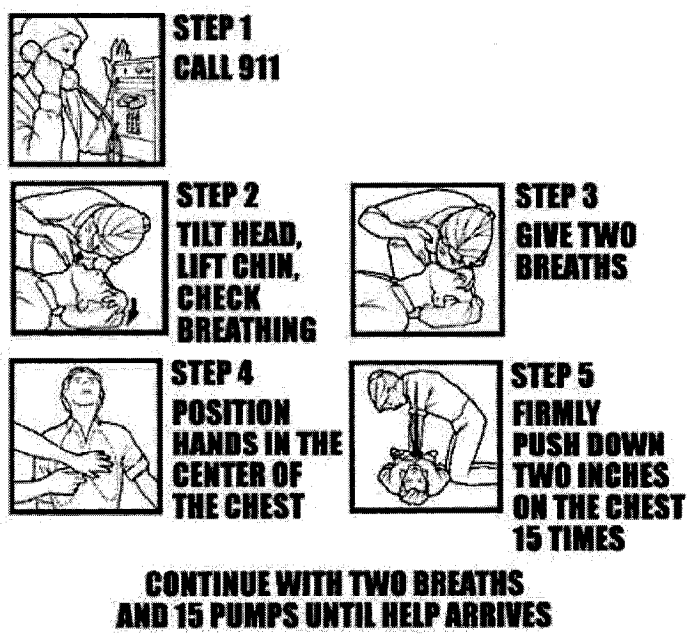
first confirm the location of the patient, will take down information on the nature of the call and dispatch the appropriate EMS unit(s), often as more information is being collected. The whole process should take less than a minute or two.

The Ambulance Response Information System (ARIS) database is an essential component for our data collection in Ontario. This database gathers information on all EMS calls from all regional dispatch centres regardless of the nature of the call. It contains information such as time of events and addresses where cardiac arrests occurred.

2.3.4. Early CPR

Cardiopulmonary resuscitation can be defined as a succession of insufflations and chest compressions performed by a rescuer with the intention to restore spontaneous circulation (Figure 2.6). Since CPR is the main focus of the thesis, it will be addressed in more detail in section 2.4.

Figure 2.6 Steps in Cardiopulmonary Resuscitation



Anonymous. Downloaded from the Google search engine.

2.3.5. Early Defibrillation

Defibrillation occurs when myocardial cells in a chaotic or abnormal electrical rhythm, VF or VT, are depolarized at the same time by the delivery of an electrical current. This results in the re-establishment of a rhythmic and organized heart beat. Defibrillation can only occur when the heart exhibits disorganised electrical activity and is never successful in the case of asystole or PEA.

a. Timeliness of defibrillation

Ideally, defibrillation should occur as soon as possible after the victim's collapse. Through inexpensive optimization of an existing EMS, it has been demonstrated that reducing the time to defibrillation increases overall survival to cardiac arrest from 3.9% to 5.2% ($p=0.03$).[6] In a study of cardiac arrest taking place in casinos, security officers were trained to apply AED to witnessed victims.[49] Such devices are equipped with electrodes that can very simply be applied to the victim's chest. Accurate rhythm analysis is performed automatically and defibrillation is performed when appropriate. In the group who were defibrillated for VF within three minutes, the "Casino" study achieved an unprecedented survival rate of 74%.[49] The authors of that study recognize the limited external validity of their findings; they are involved in an ongoing multicenter trial (the PAD trial) testing the effectiveness of defibrillation by the lay public, or PAD.

b. Public Access Defibrillation programs

PAD has generated much interest by the public, health related organizations and multiple levels of governments. The Heart and Stroke Foundation of Canada included the use of AED within basic teaching of cardiopulmonary resuscitation.[17] Cities such as Toronto, Kingston and Ottawa have placed a number of defibrillation units in public places. In November 1999, the US Senate passed the Cardiac Arrest Survival Act recommending that AEDs be placed in federal and other public buildings across the country, as well as extending the Good Samaritan protections to AED users.

c. Limitations of PAD programs

The potential success of PAD is limited since most cardiac arrests occur in residential venues and not all victims are in VF/VT. An analysis of cardiac arrest location in the urban region of Ottawa estimates that less than 5% of the total cardiac arrest population could benefit from such programs.[50] The potential impact may be even less when including smaller communities. It has been suggested that AED machines should be made available to victims of recent myocardial infarction.[51] Once again, this intervention would be limited to secondary prevention in a small subset of patients. Widespread CPR training of the population may have a greater impact on survival and successful defibrillation in the current EMS system by reaching a much greater proportion of the cardiac arrest population.

2.3.6. Early Advanced Care

Advanced care is defined by the use of definitive airway management such as endotracheal intubation, intravenous access and administration of drugs. Such drugs serve the purpose of: 1) increasing the coronary perfusion pressure by increasing peripheral vascular resistance (epinephrine, vasopressin); or 2) promote arrhythmia termination either alone by acting on myocardial cell electric action potential and/or by facilitating defibrillation (lidocaine, procainamide, amiodarone).

a. Effectiveness of ACLS

Although these drugs are recommended by the American Heart Association and the Heart and Stroke Foundation of Canada, and are taught as part of ACLS training, they have never demonstrated any significant improvement in survival to cardiac arrest.[52-56] There has been much hope for vasopressin and amidarone to improve survival to cardiac arrest. While vasopressin was recently proven not to be of any help,[57] the use of amiodarone remains highly controversial. In a recent study, survival to hospital admission for patients in VF improved from 33% to 44% (OR 1.6; 95% CI 1.1-2.4; p=0.03).[58] The study could not find any difference in survival to hospital discharge.

b. Effectiveness of Paramedics

Typically, Emergency Medical Technicians (EMT) with training in ACLS, otherwise called paramedics, provide advanced cardiac care. Such paramedics, similarly to those in Belfast (1966), New York (1968) and Seattle (1969), staff EMS in most American large cities. Like advanced cardiac care drugs,

paramedics have not clearly been associated with any improvement in survival from cardiac arrest. The Ontario Prehospital Advanced Life Support (OPALS) Study is about to answer that question.[26] This is the largest prehospital study ever conducted worldwide with over 25,000 cardiac arrest, trauma and critically ill patients over an 8-year period.

2.3.7. Early Rehabilitation

If most cardiac arrest survivors are unable to resume their normal activities, our resuscitative efforts may only lead to an increased burden for victim's families and on the health care system resources. The Utstein Style methodological approach to cardiac arrest reporting suggests that measures of overall patient performance should be taken before and at different intervals after the cardiac arrest occurred. While some reports using various quality of life indices estimate that cardiac arrest survivors perform slightly worse than the general population [59, 60], the largest study of one-year survivors published to date (n=189) did not find any significant difference between cardiac arrest survivors and the general population.[61] In this study, the median Health Utilities Index Mark 3 measure of quality of life was 0.88 (Inter Quartile Range 0.74-0.95) in the cardiac arrest survivor group compared to 0.85 in the age-adjusted general population control.[61]

Furthermore, we are witnessing an aggressive trend in the rehabilitation care of cardiac arrest and myocardial infarction survivors with a low cardiac ejection fraction (<=30%). The use of implantable defibrillators in that population has been demonstrated to decrease mortality by as much as 54%.[62-65]

2.4. Cardiopulmonary Resuscitation

In this section, we will explore CPR characteristics such as: 1) current standard of practice, 2) the theory behind the mechanics of CPR, 3) current research in the field of CPR, 4) the effectiveness of CPR and 5) teaching of CPR.

2.4.1. Current Standard of Practice.

Once the CPR provider determines that a victim is unconscious, 9-1-1 is called immediately. The victim's airway is then opened using one of three different techniques: the head-tilt/chin-lift, the jaw-thrust manoeuvre without head-tilt, or the jaw-thrust manoeuvre with head-tilt. If the victim is not breathing, two insufflations (mouth-to mouth) are performed. The CPR provider then checks for the presence of a carotid pulse. (Looking for a pulse is only taught to health care professionals.) If the victim has no pulse or if the CPR provider is unsure, 15 rhythmic manual compressions of at least two inches over the lower half of the sternum, followed by complete release and spontaneous re-expansion of the thorax are performed. That sequence of insufflations and chest compressions is repeated until the victim regains consciousness, the victim regains a palpable pulse, the provider is exhausted, or the EMS arrives.[17]

2.4.2. Chest Compressions: the "Cardiac Pump" and "Thoracic Pump" Models.

There exist two theories to explain how closed-chest cardiac massage functions.[66] The first is called the "cardiac pump" theory. When compressing the heart between the sternum and the vertebral column, the pressure gradient closes the valves between the ventricles and the atria, forcing forward the flow of

blood though the pulmonary artery and the aorta.[67-69] With longer resuscitation efforts, valvular function deteriorates, leaving the heart to be a simple passive conduit though which blood flows. This leads to the "thoracic pump" theory. In this model, chest compression produces a positive pressure gradient throughout the whole chest cavity, creating forward blood flow towards the brain and the periphery, while the decompression phase creates blood flow back into the chest cavity and down the coronary arteries.[10] In reality, both mechanisms are probably present simultaneously.

2.4.3. Advances in CPR Research.

Discussions on how to improve cardiopulmonary resuscitation are constantly taking place. Examples of questions include: 1) should we try to confirm the absence of pulse before starting chest compressions; 2) what is the optimal ratio of ventilations to chest compressions; 3) are ventilations necessary at all; and 4) are there better ways to administer chest compressions?

For instance, in order to achieve return of spontaneous circulation it is believed that a coronary diastolic pressure of at least 15 mm of Hg should to be generated.[70] Closed-chest compressions can generate pressures from 1 to 12 mm of Hg.[70, 71] Nonetheless, numerous cardiac arrest survivors have been reported using CPR alone.[72]

Repeated chest compressions using conventional CPR are believed to gradually decrease the pulmonary residual functional capacity, resulting in atelectasis and shunting of blood away from ventilated alveoli.[73] Active compression-decompression (ACD) devices have been tested in order to

improve on the passive re-expansion of the chest after compression. Unfortunately, most studies come to the conclusion that those devices do not improve survival to cardiac arrest.[5, 74] The physical effort necessary to use the devise also limits its applicability.[75]

Other techniques such as piston CPR or vest CPR (or chest compression by a machine) assume the availability of specialized equipment. Used for the purpose of performing CPR while in a moving vehicle or for prolonged resuscitation efforts, these techniques should be restricted to medical and EMS personnel. In our opinion, this would otherwise send the message that the lay public cannot perform efficacious CPR without this equipment. More advanced techniques such as interposed abdominal compression-CPR may add to the confusion and discourage bystanders to use a more simple chest compression technique. Finally, open-chest cardiac massage is a technique with limited indications that should only be performed by an experienced emergency physician or surgeon.

2.4.4. Effectiveness of CPR.

Since the promotion of CPR by the lay public in the 1970s, multiple reports of increased survival to cardiac arrest as a result of bystander CPR have been published.[76-79] It seems that the quality of CPR is important. Adequately performed-CPR has been described as: 1) intermittent chest expansion with inflation attempts; and 2) palpable carotid or femoral pulse associated with chest compressions.[80, 81] Adequately performed-CPR has been demonstrated to be more effective in saving lives than inadequately performed-CPR (OR 3.4; 95% CI

1.1–12.1).[82] Nonetheless, even poorly performed-CPR is believed to be of greater value than no CPR at all.[83, 84] Overall, the odd of surviving for a victim of cardiac arrest is almost four times greater if bystander CPR is administered (OR 3.7; 95% CI 2.6 – 5.1).[6] Not only is CPR efficacious alone,[72] it can also prolong the period of time during which the heart is in VF/VT, hence increasing the success of potential defibrillation.[79, 84, 85]

Although high bystander CPR rates are reported in Calgary (34%)[8] and Seattle (54%),[9] bystander CPR rates have remained low over the past ten years in Ontario (14%).[6, 7] It is distressing to think that almost nine times out of ten nothing is done before EMS arrives. This greatly limits the potential for survival. Moreover, it is possible that bystander CPR is performed correctly only 50% of the time. [82, 84, 86] We need to better understand the barriers to the public learning and administering CPR.[12, 87-92] Poor incentives, lack of motivation, inconvenience of having to leave the house for classes and cost of classes are all good reasons to explain why people may not seek CPR training. Fear of communicable diseases, fear of litigation, emotional reaction, shyness, and diffusion of responsibility in a group are reasons why even trained CPR providers may fail to apply what they have learned.

Fear of causing harm is another reason why people may hesitate to do CPR. While complications of chest compressions may include aspiration of the stomach content into the lungs, pneumothorax, gastroesophageal injury, liver injury, cardiac injury, and bone injury such as rib or sternal fractures,[10] none of

these can justify withholding a potentially life-saving procedure sure as CPR. Severe complications resulting from the administration of CPR are rare, and may occur regardless of the CPR provider's experience.

2.4.5. Teaching CPR.

In Canada, the authority to establish guidelines for resuscitation is the Heart and Stroke Foundation of Canada. They make their recommendations based on those of the International Liaison Committee on Resuscitation (ILCOR). Together with partners such as the Canadian Red Cross, St. John's Ambulance, the Canadian Ski Patrol, the Advanced Coronary Treatment (ACT) Foundation of Canada, and the Lifesaving Society, the Heart and Stroke Foundation of Canada has the mandate to train the Canadian population in CPR.

The evaluation of participants in CPR classes has evolved significantly over the past decade. At one time, students were taught and evaluated on recording manikins. A tracing would record the exact frequency of ventilations and chest compressions, as well as ventilation volumes and depth of chest compressions. These very stringent evaluation criteria made it almost impossible for laymen to successfully become certified CPR providers the first time around. With the realization that a sentiment of inaptitude was resulting from such evaluation methods, instructors no longer use recording manikins, except perhaps for constructive feedback or research purposes. Participants are no longer given a pass or fail mark but a certificate of attendance.

Meanwhile, we have also witnessed the appearance of various modular self-training methods, training videos, and simplified course contents. CPR may

now be learned in the comfort of one's own home, on television, or over the phone when calling 9-1-1. These are some of the innovations, but we still struggle to determine what should be thought, for how long, and to whom.

2.5. Existing Framework for Out-of-hospital CPR

2.5.1. Law and Regulations on CPR

The only document of law we found with regards to mandatory CPR training in Canada is the Canada Occupational Safety and Health Regulations, part of the Canada Labour Code (Appendix A). This document mentions situations where an employer has the obligation to maintain the presence of somebody trained in first aid in the work place. For example, "*At every workplace at which six or more employees are working at any time, the employer shall ensure that there is a first aid attendant*".

Born from an initiative of the ACT Foundation of Canada (a national non-profit organization dedicated to educating Canadians about illnesses which can lead to prehospital emergencies), mandatory CPR teaching in high schools is, to our knowledge, the only other program regulating CPR teaching in Canada. Mandatory CPR teaching before high school graduation is now enforced in British Columbia, Alberta, Ontario, Quebec, and Nova Scotia.

2.5.2. Training and Monitoring Agencies

We have identified the multiplicity of non-regulated agencies offering CPR classes as being a potential source of our failure to reach a critical mass of the Canadian population. In addition to the larger organizations such as the Canadian Red Cross, the St. John Ambulance, and regional Heart Saver

Committees, we have counted over 25 smaller agencies providing CPR classes in the Ottawa region alone. These agencies are usually for profit organizations and are competing for a share of the market with one another.

2.5.3 Multi-level Strategic Planning

We have contacted organizations involved in health care strategic planning at the federal, provincial, and regional level respectively: 1) the Heart and Stroke Foundation of Canada has no specific long-term strategic plan to specifically address low bystander CPR rates in Canada; 2) the Ministry of Health of Ontario is planning the launch of dispatch-assisted CPR instructions but the project is currently being delayed and no documentation on the methodology and implementation of the project is being made public at the moment; and 3) we have attended sessions held by the Ottawa Regional Heart Saver Committee. We felt that participating in such planning sessions for improving regional bystander CPR rates would be beneficial to understand the potential necessity to adapt a federal or provincial intervention to locally realities. For example, the Ottawa Regional Heart Saver Committee has endorsed the following initiatives:

1. Collaborate with the Ottawa Heart Institute's prevention and rehabilitation program in teaching CPR to families of patients at risk.
2. Identify areas of high cardiac arrest incidence in order to better distribute efforts in training the population.
3. Update and maintain a current list of all the regional training agencies on the Heart Saver's web site.

4. Create CPR classes better adapted for people with disabilities and for the elderly.
5. Continue to organize mass training events.
6. Recommend that CPR classes should last no more that two hours.
7. Send letters to physicians enjoining them to prescribe CPR classes to appropriate members of their clientele.
8. Organize a media blitz publicizing various community events.

It is our opinion that such local initiatives should be encouraged to take place and would be very unlikely to diminish the impact of any other larger scheme federal or provincial intervention designed to improve bystander CPR rates.

2.6 Thesis Rationale

Cardiovascular disease is the **primary cause of mortality in Canada** and is the leading cause of cardiac arrest. Cardiac arrest is a condition afflicting individuals in the prime of their economic productivity, 50% of whom have never had any prior manifestation of heart disease.[2] The unpredictable nature of cardiac arrest combined with its high incidence rate and very low survival rate make this condition highly amenable to a broad population based public health intervention.

Bystander CPR, defibrillation, and ALS are the major links of a concept called **"The Chain of Survival"** for out-of-hospital cardiac arrest. Through inexpensive optimization of an existing EMS, it has been demonstrated that reducing the time to defibrillation increased overall survival to cardiac arrest. Further improvement in overall survival to cardiac arrest from currently conceived **PAD programs** seems unlikely since most cardiac arrests occur in residential venues and not all victims are in VF/VT. An analysis of cardiac arrest location in the urban region of Ottawa estimates that less than 5% of the total cardiac arrest population could benefit from such PAD programs.[50] In the context of an already stretched health care system, the potential impact of PAD programs should be determined. Such analysis may help decision makers in distributing financial resources between CPR and PAD programs.

Most of the drugs in use today for **advanced cardiac care** have never demonstrated any significant improvement in survival to cardiac arrest.[52-56] Similarly, **paramedics** have yet to show any improvement on survival to cardiac

arrest. The Ontario Prehospital Advanced Life Support Study is about to answer that question.[26]

Improved bystander CPR rates could be considered the next step in improving survival to cardiac arrest in Canada. **CPR is a crucial yet underutilized link of the chain of survival**. CPR quality is important and is achievable through basic training; adequately performed-CPR has been demonstrated to be more effective in saving lives than inadequately performed-CPR .[82] Overall, a victim of cardiac arrest is almost four times more likely to survive if bystander CPR is administered.[6] Not only is CPR efficacious by itself,[72] it can also prolong the period of time during which the heart is in VF/VT, hence increasing the success of potential defibrillation.[79, 84, 85]

Although **bystander CPR rates have remained low** over the past ten years in Ontario (14%)[6, 7]other communities have demonstrated significantly better success. Widespread CPR training of the population may have a great impact on survival to cardiac arrest in the current EMS system.

This study will attempt to: 1) describe cardiac arrest epidemiology in order to determine the potential impact of bystander CPR and PAD programs on survival; 2) review systematically the determinants of bystander CPR and factors for successful training in CPR; and 3) design a trial to increase the bystander CPR rate and improve survival from out-of-hospital cardiac arrest in Ontario.

3. OBJECTIVES

General Objective:

To improve bystander CPR rates and survival for out-of-hospital cardiac arrest in Ontario.

Specific Objectives:

Part One: Cardiac Arrest Epidemiology, Potential Impact of Bystander CPR, and Potential Impact of PAD Programs

1- To describe cardiac arrest epidemiology.

2- To predict the potential impact of improving bystander CPR rates in various locations on overall survival for cardiac arrest.

3- To predict the potential impact of PAD programs on overall survival for cardiac arrest.

Part Two: Systematic Review of the Determinants of Bystander CPR

To perform a systematic review of the determinants of bystander CPR rates in order to help plan a trial by determining:

1- *Who* should be targeted to receive CPR training?

2- *What* CPR teaching program should be implemented in order to maximize understanding and retention?

3- *When* should maintenance of skills sessions occur?

4- *Where* — Should instructions be given over the phone?

5- *Why* do people lack motivation to have CPR training or are reluctant to apply their skills?

Part Three: Proposed Trial to Improve Bystander CPR Rates and Survival from Out-of-hospital Cardiac Arrest

To propose a trial designed to improve bystander CPR rates and survival from out-of-hospital cardiac arrest in Ontario.

4. METHODS

Part One: Cardiac Arrest Epidemiology, Potential Impact of Bystander CPR, and Potential Impact of PAD Programs

4.1. Study Design

We performed a retrospective analysis of data prospectively collected as part of the OPALS Study and collected new data on cardiac arrest location using database linkage and chart review.

4.2. Setting

The OPALS study is the largest prehospital study yet conducted. It involves more than 25,000 out-of-hospital cardiac arrest (primary outcome), trauma, and critically ill patients over an 8-year period. The OPALS study uses a before-after design to determine the sequential incremental benefits of rapid defibrillation followed by ALS on survival for out-of-hospital cardiac arrest.[26] Rapid defibrillation is defined as a time interval between "call received by the dispatch centre" and "vehicle with defibrillation capability arrival at the scene" of 8 minutes or less. ALS consists of Basic Life Support-Defibrillation (BLS-D) plus endotracheal intubation and administration of IV drugs. The study was carried out in three phases: in Phase I (1991-1994), retrospective collection of baseline information on cardiac arrest occurred; in Phase II (1994-1998), existing programs were optimized to achieve rapid defibrillation; and in Phase III (1998-2002), ALS was implemented. Training and "run-in" periods preceded Phase II and III (Phase IIR and IIIR). Communities were included in Phase III if they could provide rapid defibrillation more than 90% of the time.

The OPALS database includes a population-based cohort of adult out-of-hospital cardiac arrest cases of cardiac origin. The study takes place in 20 large and small Ontario communities affiliated to 11 base hospital programs (Appendix B). The combined population in those 20 communities is 3,516,812 and ranges between 15,605 and 774,072 (2001 Statistics Canada census). Because OPALS uses a community border definition that is slightly different from the municipality borders, the study base population is in fact estimated at 2,500,000. Approximately 1703 cardiac arrests occur each year in that study base population for an estimated cardiac arrest incidence of 69 per 100,000.

During Phase I (retrospective data), EMT with BLS-D training provided care for cardiac arrest victims in the 20 participating communities. Their training consisted of one year of community college including clinical work in the field (1000 hours) and in-hospital (400 hours). During Phase IIR, dispatch centres reduced their dispatch time intervals, existing ambulances were distributed more appropriately, and firefighters were trained to provide defibrillation. During Phase IIIR, EMT personnel were trained to provide ALS care. They received an additional six months of training including six weeks of classes, clinical training (280 hours), and preceptorship (400 hours).

4.3. Study Population

For the present study, we selected cardiac arrest cases included in the OPALS database between January 1st 1995 and December 31st 1999 (5-year period). January 1st 1995 was chosen to be the starting date because by that date all communities were reporting data in a prospective fashion. December

31st 1999 was chosen to be the end date because the ARIS database was not up-to-date beyond that time.

Ethics

Approval for the cardiac arrest location project is covered under the OPALS institutional review. Institutional review boards from each participating base hospital reviewed and accepted the OPALS study protocol. Informed consent was not required as all patients: were unconscious and unable to provide consent, were provided with the same standard of care, and were not randomized. Patient confidentiality was maintained throughout the study; identifiers were deleted from the OPALS and cardiac arrest location databases.

4.4. Data Collection

4.4.1. Database merging

We first extracted the cardiac arrest cases for our five-year study period from the OPALS database using SAS® version 8.01 and a programming filter that eliminated cardiac arrest cases of non-cardiac origin, cases witnessed by EMS, and cases occurring outside the chosen study period. The remaining cases were merged with the ARIS database using shared unique identifier numbers in order to obtain the addresses where cardiac arrest occurred. We then provided the Municipal Property Assessment Corporation (MPAC) with an Excel® spreadsheet containing the following variables: street number, street name, community, and the corresponding MPAC community code. They were asked to provide us with a precise location description for those addresses (Appendix C). MPAC is a corporation mandated to keep accurate and up-to-date property description for

the determination of property taxes. The MPAC database was last updated on December 19th, 2000. Unique identifier variables were also included in the information sent to MPAC to allow for later merging of the cardiac arrest location description with the other information available in the OPALS database.

4.4.2. Missing data

Base hospital staff from 11 participating base hospitals were asked to review their Ambulance Call Report (ACR) forms (Appendix D) and provide us with a cardiac arrest location if: 1) OPALS records could not be found in the ARIS database; 2) no specific address could be found in the ARIS database (e.g. cardiac arrest occurred on the street); or 3) MPAC could not provide us with a location description for the address submitted.

4.4.3. Cardiac arrest location categories

In 2001, the Ministry of Health Emergency Health Services Branch recognized the importance of information on cardiac arrest location in planning for services. They suggested an expanded list of cardiac arrest location categories for prospective data collection for the ACR. We adopted that list to ensure future comparability with our database. Because our data on cardiac arrest location is more accurate then what the Ministry had foreseen, we modified some of those categories in the following fashion for the purpose of scientific reporting: "Airport/Heliport" becomes "Airport/Heliport/Bus Station/Train Station", "Apartment/Condo. Building" becomes "Multi-Residential Dwelling", "House/Town House" becomes "Single-Residential Dwelling", and we added a category for penal institutions (category "K" was blank in the Ministry's listing) (Figure 4.1).

Figure 4.1 Cardiac Arrest Location Categories Adapted from the Ministry of Health EHS Branch

Location Code	Cardiac Arrest Location
A	Airport/Heliport/Bus Station/Train Station
B	Multi-Residential Dwelling
C	Construction Site
D	Medical Office/Clinic
E	Nursing Outpost
F	Factory/Industrial Site/Railway/Dockyard
G	Hotel
H	Hospital (Non-acute)
I	Indoor Shopping Mall
J	Single Store/Strip Mall
K	Penal Institution
L	School/College/University
M	Mining Site/Quarry
N	Nursing Home
O	Office Building
P	Recreation Facility
Q	Farm
R	Single-Residential Dwelling
S	Street/Highway/Road
T	Sports Field/Fairground/Park
U	Stadium
V	Golf Course
W	Water/Boat
X	Restaurant/Bar
Y	Casino
Z	Other (describe in remarks)

The Ministry's list also includes a variable for description of number of stories within a building. We later discovered that EMS uses this variable to describe on which floor cardiac arrest occurred rather than the total number of stories in a building. Not being useful for the purpose of our study, information on this variable was not collected. Base hospitals referred to the Ministry's list when providing us with information on cardiac arrest location. Information submitted by base hospitals and MPAC was collapsed into the categories given in Figure 4.1. Three researchers reviewed the collapsed categories and approval was reached by consensus (Appendix E).

4.5. Data Management

The cardiac arrest location database was first created using Microsoft Excel® 2000; it was later imported to SAS® version 8.01 for data analysis.

4.5.1. Data Entry

Data entry for the cardiac arrest location database was done using a standardized Excel® spreadsheet. Typing errors were avoided by transferring electronically the information provided from MPAC and the base hospitals into the main database. One person performed all the data entry into the main database (CV).

4.5.2. Data Cleaning

The cardiac arrest database was reviewed using visual inspection and Excel® data filters. SAS® frequency reports were produced to identify missing or illogical data entry. Two independent reviewers examined the database

(including CV). Decisions regarding data editing were reached by consensus. Missing information was coded as such with a period.

4.6. Data Analysis

4.6.1. Cardiac Arrest Location, Patient, and System Characteristics

Numerical and graphic descriptive statistics on cardiac arrest location were computed using Excel® 2000. We performed a descriptive analysis with 95% CI of cardiac arrest patient and system characteristics using SAS® version 8.01.

We first examined overall cardiac arrest location descriptions. Because some of the public venues had a very small number of cardiac arrest, we stratified the analysis into larger location categories: large or small residential dwelling, large or small public location, and other locations (Figure 4.2). Patient and system characteristics were examined over the 5-year study period. The same information was then separated by the larger location categories for comparison. We also examined patient and system characteristics for each study year to identify potential secular trends.

Figure 4.2 Collapsing Cardiac Arrest Locations Adapted from the Ministry of Health EHS Branch into Larger Categories*

Large Location Categories	Cardiac Arrest Location
Small Residential	Single-Residential Dwelling
Large Residential	Multi-Residential Dwelling Hospital (Non-acute) Nursing Home
Small Public Venue	Construction Site Farm Golf Course Medical Office/Clinic Restaurant/Bar Single Store/Strip Mall Sports Field/Fairground/Park
Large Public Venue	Airport/Heliport/Bus Station/Train Station Casino Factory/Industrial Site/Railway/Dockyard Hotel Indoor Shopping Mall Office Building Penal Institution Recreation Facility School/College/University Stadium
Non-specific Locations	Street/Highway/Road Water/Boat Other

*No cardiac arrest occurred in Nursing Outpost or Mining Site/Quarry locations.

4.6.2. Verifying that Bystander CPR is an Independent Predictor of Survival to Out-of-hospital Cardiac Arrest Using Logistic Regression Model Building

We performed univariate analysis and logistic regression analysis to determine respectively the unadjusted and adjusted effect of bystander CPR on survival from cardiac arrest. The effect of bystander CPR was reported using OR with 95% CI.

For the regression analysis model, we considered variables that made clinical sense on influencing cardiac arrest (Figure 4.3). All variables had less than 15% missing information. Dichotomous and categorical variables were examined using contingency tables and chi-square statistics. Categories were collapsed if contingency table cells had less than five observations. Continuous variables were examined using a univariate logistic regression model. We included variables with a p-value of less than 0.25 in the preliminary logistic regression model. The model was then examined for collinearity, confounding, and effect modification. Forward stepwise selection process was used to obtain a more parsimonious model. We examined the final model for linearity of continuous variables, the presence of outliers, and interaction terms. We used the Akaike Information Criteria, the Schwartz Criteria, -2 Log Likelihood, the Score Chi-Square, and the Hosmer-Lameshow methods to evaluate the goodness of fit of the final model.

Figure 4.3 Variables Considered for the Regression Analysis Model Evaluating the Effect of Bystander CPR on Survival to Out-of-Hospital Cardiac Arrest

Continuous Variables
- Age (measured in decades)
- Time interval from call received to vehicle with defibrillator arrived at scene

Dichotomous Variables
- Discharged alive from hospital
- Bystander CPR
- Arrest witnessed
- Gender
- Paramedic at scene

Categorical Variables
- Cardiac arrest location
- Participating community
- Initial cardiac rhythm (on cardiac monitor)

4.6.3. Predicting the Impact of Increasing Bystander CPR Rates in Various Locations

We developed a mathematical model to predict the impact of various bystander CPR rates on the overall survival to cardiac arrest and the extra number of lives saved within the larger location categories (Appendix F). This mathematical model is not conceptually linked to the logistic regression analysis of the effect of bystander CPR on cardiac arrest survival described in section 4.6.2.

First, we made the following assumptions for our mathematical model:

1- *Bystander CPR is technically well-performed 50% of the time in the OPALS study communities.*

Gallagher studied 2071 consecutive out-of-hospital cardiac arrests occurring in New York City in 1995.[82] Trained EMS personnel evaluated bystander CPR quality upon arrival. In their judgement, CPR was well performed if ventilations and chest compressions were performed in conformity with the AHA guidelines. This was the case in 46% of victims receiving bystander CPR. Similarly, the Belgium Cerebral Resuscitation Study Group determined that bystander CPR was well performed in 52% of cases.[80] For the purpose of our mathematical model, we assumed a well-performed bystander CPR rate of 50%.

2- *Survival in the technically well-performed bystander CPR group is 3.4 times higher compared to the technically incorrect bystander CPR group.*

In the same study by Gallagher, survival was 4.6% in the well-performed bystander CPR group compared to 1.4% in the technically incorrect bystander

CPR group (OR 3.4; 95% CI 1.1 – 14.0).[82] Because survival to cardiac arrest is a rare event, the relative risk and the OR are practically similar (3.3 vs 3.4 respectively). A similar difference in survival between well-performed CPR and technically incorrect CPR has been found by other authors.[83, 84]

3- *Increasing CPR teaching in the community will increase bystander CPR rates.*

We assume that a public health educational intervention will result in an increased bystander CPR rate. We base this assumption on the success observed in Calgary (34%)[8] and Seattle (54%).[9]

4- *There is a direct linear relationship between the absolute increase in bystander CPR and well-performed CPR rates.*

Because the increase in bystander CPR rate would result from a public health educational intervention, we make the assumption that the absolute increase in bystander CPR caused by the intervention would proportionally increase the rate of well-performed CPR.

Second, because there are large differences in survival rates among different cardiac arrest groups, we determined baseline bystander CPR rates and survival rates for witnessed and un-witnessed cardiac arrest cases overall and within the larger location categories.

Third, in keeping with our first assumption, victims receiving bystander CPR were divided in two equal groups; one group was assumed to have received well-performed CPR and the other group not.

Fourth, in keeping with our second assumption, we distributed the number of survivors between the well-performed CPR groups and technically incorrect CPR groups such that victims in the well-performed CPR groups had a survival rate 3.4 times higher compared to the technically incorrect CPR group.

Finally, we made the bystander CPR rate vary between 20% and 60% using 5% increments. Because the total number of cardiac arrest victims would not change, only the proportion of cardiac arrest victims belonging to specific groups could change. For example, assuming that a 25% bystander CPR rate represents a 10% absolute increase in bystander CPR compared to the baseline rate in a specific location, the proportion of victims receiving well-performed bystander CPR would increase by 10% and the proportion of victims not receiving bystander CPR would decrease by 10%. The proportion of victims receiving technically incorrect bystander CPR would stay the same.

Because a specific location could not be found for 32 cardiac arrest cases (0.4% of total), we entered a condition in the model to make the proportion of additional lives saved in each larger location categories consistent with the total number of additional lives saved overall.

4.6.4. Potential Impact of PAD Programs

We determined the potential count of cardiac arrest victims that may be amenable to PAD programs and performed a descriptive analysis with 95% CI of the existing time interval before defibrillation and survival rate in that sub-group. We selected witnessed cardiac arrest cases occurring in large or small public

locations found to be in VF/VT on first cardiac monitor analysis. EMS time intervals and current survival in this group was subsequently examined.

Part Two: Systematic Review of the Determinants of Bystander CPR

In this section, we will review systematically the determinants of bystander CPR and factors associated with successful training in CPR.

4.7. Study Characteristics

4.7.1. Study Design

We reviewed a wide spectrum of experimental and non-experimental studies published on bystander CPR including: randomized controlled trials (RCT), quasi-experiments, observational studies, literature reviews, editorials, and letters.

4.7.2. Study Subjects

We included human participants of any age, gender, culture, social status, or geographical area. We excluded studies pertaining exclusively to the curriculum of health care professionals such as physicians, medical students, nurses, and EMS personnel.

4.7.3. Type of Interventions

We reviewed all educational tools applied at the individual, group, or community level. These included computer software, media campaign, CPR instructions given over the phone, and various CPR training curriculum.

4.7.4. Outcome Measures

Success in promoting the interest for CPR training, in increasing the proportion of CPR trained individuals in the population, in increasing the

bystander CPR rate for cardiac arrest, or in increasing survival from cardiac arrest as a result of an intervention promoting CPR training.

4.8. Search Strategy

Information sources are described in Figure 4.4. Our electronic search strategy had no restriction for year, language, or status of publication and was reviewed by an information specialist (Appendix G). We searched 11 electronic databases using the OVID interface. That electronic search strategy included subject headings, truncation terms, and text words in order to access databases that do not support the use of subject headings. We used an adapted electronic search strategy for the PubMed interface.

We reviewed the Cochrane Controlled Trial Registry, hand searched the Canadian Journal of Public Health and the journal Resuscitation, reviewed the bibliography of emergency medicine textbooks and review articles, visited the Websites of numerous scientific associations, and contacted content experts in the field. Content specialists were selected on the basis of their contribution to cardiac arrest research and/or for the recognized success of their respective communities in promoting bystander CPR.

Figure 4.4 Information Sources Included in the Systematic Review

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

HAND SEARCH
Resuscitation
Canadian Journal of Public Health

EXPERTS IN THE FIELD
Calgary, Canada
Ottawa, Canada (2)
Chapel Hill, USA
Seattle, USA
Oslo, Norway

TRIAL REGISTRY
Cochrane Controlled Trial Registry

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

REVIEW OF BIBLIOGRAPHY
Textbooks
-Jackson RE. Basic cardiopulmonary resuscitation. In: Tintinalli JE, ed. Emergency Medicine, A Comprehensive Study Guide. New York: McGraw-Hill, 1996:35-37.
-Neumar RW, Ward KR. Cardiopulmonary Arrest. In: Rosen P, ed. Emergency Medicine Concepts and Clinical Practice. Vol. 1. St. Louis: Mosby, 1998:35-60.
Review Articles
-Eisenberg P, Safar P. Life supporting first aid training of the public – review and recommendations. Resuscitation 1999;41:3-18.
-Jabbour M, Osmond MH, Klassen TP. Life support courses: are they effective? Ann Emerg Med 1996;28:690-8.

4.9. Selection Process

We imported the references found in our search strategy into a bibliographical database library using Endnote version 3.1.2. Duplicates were removed manually. We used titles and abstracts to make a first selection of references that met the study characteristics described in point 4.7. A reference was also selected if a decision could not easily be made from the title or abstract alone. Hard copies of the selected articles were obtained for further examination.

One investigator (CV) reviewed the selected printed articles using standardized criteria (population, intervention, and outcome) to determine final eligibility in the systematic review (Appendix H). Studies were considered for meta-analysis if measures of spread were available or obtainable and if the principal investigator (CV) believed that clinical homogeneity was present.

4.10. Abstraction Process

A single reviewer (CV) performed data abstraction on all the selected articles using a standardized form (Appendix H). Data extraction included information on publication status, year, country, and language of publication. Description of the study design, participant, intervention, and outcomes was then extracted. The source of the data (text, table, or graph) was also mentioned.

4.11. Methodological Quality of Reports

The quality of RCT's was evaluated using allocation concealment and the validated Jadad scoring system (Appendix I).[93] The Jadad scoring system allocates points (out of a maximum of five) for quality and description of randomization, blinding, and dropouts. Case-control and cohort studies were

evaluated using the validated Newcastle-Ottawa scales (Appendix J).[94-96] These scales allocate stars (out of a maximum of nine) for quality of selection, comparability, and exposure/outcome of study participants.

4.12. Data Synthesis

Despite the large number of publications reviewed, none shared a population, intervention, or outcome measure that was homogeneous enough to allow for data synthesis. Instead, studies were grouped by topic and a final statement of evidence was made. This statement of evidence was based on the quality of the reviewed evidence, as well as with regards to possibility of implementation, effectiveness, and documented effect on bystander CPR rate or survival to cardiac arrest (Figure 4.5).[97] For example, a "I-2, A" classification means that we have enough evidence coming from methodologically strong studies to support the statement of evidence.

Figure 4.5 Classification of the Statements of Evidence Made from the Systematic Review

Quality of the Evidence	
I-1	Meta-analysis
I-2	At least one good quality RCT
II-1	Quasi-experiment of good quality
II-2	Cohort or case-control study
II-3	Case series, non-controlled trial, or descriptive studies
III	Expert opinion
Classification of the Statements of Evidence	
A	There is enough evidence to support the statement
B	There is acceptable evidence to support the statement
C	There is insufficient evidence in favor or not in favor
D	There is acceptable evidence not to support the statement
E	There is enough evidence not to support the statement

4.13 Assessment of Publication and Retrieval Bias

Statistical methods looking at publication and retrieval bias (such as Funnel plots and file drawer number) could not be computed. Instead, we reported the recall and precision of our electronic search strategy. Recall is defined as the number of papers included in the systematic review found by the electronic search strategy divided by those found by the full search strategy; precision is defined as the number of papers included in the systematic review found by the electronic search strategy divided by all papers found by the electronic search strategy. Expected values for recall and precision are up to 90% and 20% respectively.[98]

Part Three: Proposed Trial to Improve Bystander CPR Rates and Survival from Out-of-hospital Cardiac Arrest

We propose the design of a trial of fundable quality with the purpose of improving bystander CPR rates and survival from out-of-hospital cardiac arrest. To design the trial, we followed the Canadian Institutes of Health Research Guidelines for successful completion of a full grant application (Figure 4.6).[99] The trial design will be presented in part three of the results section.

Figure 4.6 Canadian Institutes of Health Research Guidelines for Successful Completion of a Full Grant Application

1. The Need for a Trial

1.1 What is the problem to be addressed?
1.2 What are the principal research questions to be addressed?
1.3 Why is a trial needed now?
1.4 Give references to any relevant systematic review and discuss the need for your trial in the light of the(se) review(s).
1.5 How will the results of this trial be used?

2. The Proposed Trial

2.1 What is the proposed trial design?
2.2 What are the planned trial interventions?
2.3 What are the proposed practical arrangements for allocating participants to trial groups?
2.4 What are the proposed methods for protecting against other sources of bias?
2.5 What are the planned inclusion/exclusion criteria?
2.6 What is the proposed duration of treatment period?
2.7 What is the proposed frequency and duration of follow-up?
2.8 What are the proposed primary and secondary outcome measures?
2.9 How will the outcome measures be measured at follow-up?
2.10 What is the proposed sample size?
2.11 What is the planned recruitment rate?
2.12 Are there likely to be any problems with compliance?
2.13 What is the likely rate of loss to follow-up?
2.14 Give details of the planned analyses.
2.15 Are there any planned subgroup analyses?
2.16 What is the proposed frequency of analyses?
2.17 Will the trial address any economic issues?
2.18 What is the estimated cost and duration of the trial?

3. Details of the Trial Team

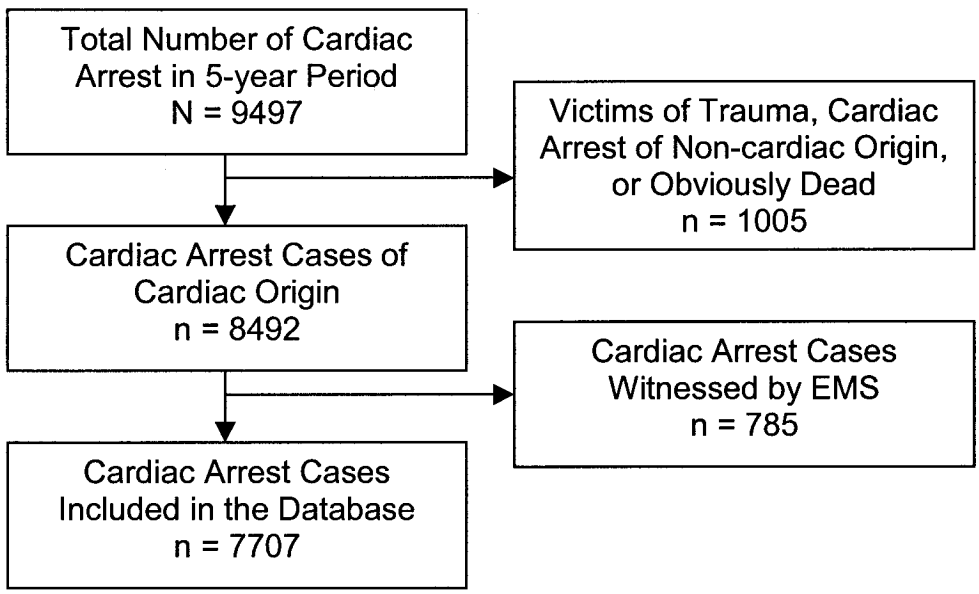
3.1 Trial management. Briefly describe the role of each applicant proposed. Please indicate whether a Data Safety and Monitoring Committee will be established and describe its composition.
3.2 International Collaboration (if applicable). Please discuss the nature of and need for any international collaboration.
3.3 Participating centers. Please list the proposed participating centers.

RESULTS

Part One: Cardiac Arrest Epidemiology, Potential Impact of Bystander CPR, and Potential Impact of PAD Programs

There were 9497 adult out-of-hospital cardiac arrests between January 1st, 1995 and December 31st, 1999 in the 20 OPALS study communities. We excluded from the analysis 1005 patients (11%) who were victims of trauma, victims of cardiac arrest of non-cardiac origin, or obviously dead. Of the remaining 8492 cardiac arrest cases of cardiac origin, EMS witnessed 785 (9%), leaving us with a cohort of 7707 consecutive cardiac arrest cases for the 5-year period database (Figure 5.1).

Figure 5.1 Profile of Cardiac Arrest Victims Included in the Database



5.1. Database development

5.1.1. Database Merging

We found 8 cases with duplicate unique identifier numbers in the cardiac arrest location database. These cases could not be successfully merged with the OPALS database. After verification of their legitimacy, cardiac arrest location description for these cases was entered manually into the final cardiac arrest location database.

5.1.2. Missing Cardiac Arrest Location Categories

Four cardiac arrest location categories were not available from the MPAC database: Airport/Heliport/Bus Station/Train Station, Casino, Construction Site, and Nursing Outpost. Base hospitals identified two cases of cardiac arrest at the Ottawa International Airport over the study period. No address was found in the ARIS database in both cases. We looked for the airport's official address in the list of addresses submitted to MPAC and found no case of "airport/heliport" cardiac arrest mislabeled under another category. A similar procedure was followed for the casinos of Windsor and Niagara Falls. We found 17 new "casino" cases that were coded under "Unspecified Commercial Property" by MPAC. It was impossible to determine the exact count of cardiac arrest occurring at construction sites. MPAC may have coded construction sites under "Vacant land", "Single family detached", or another category. Base hospitals and MPAC identified no cases of cardiac arrest occurring in nursing outpost. Nursing outposts are not present within the OPALS participating communities.

5.1.3. Changing Cardiac Arrest Location Categories

We were able to re-categorize 20 of the 32 locations initially coded under "Other". These were Office Building (5), Multi-Residential Dwelling (4), Single-Residential Dwelling (3), Recreation Facilities (3), Hotel (2), Penal Institution (1), School/College/University (1), and Single Store/Strip Mall (1). This was achieved by looking at the description provided by the base hospitals for the "Other" category or by looking up the address on the Internet.

Using the same procedures, we were able to re-categorize 23 of the 26 location coded under "Unspecified Commercial Property" by MPAC. These were Casino (17), Recreation Facility (3), Office Building (2), and Restaurant/Bar (1).

Finally, because offices can be found within larger location categories, we reviewed all cases classified under "Office Building" by MPAC. We were able to re-categorize 6 out of these 47 locations. These were Single Store/Strip Mall (3), Medical Office/Clinic (1), Recreation Facility (1), and Indoor Shopping Centre (1).

5.2. Cardiac Arrest Location, Patient, and System Characteristics

Patient and system characteristics for the 7707 cardiac arrest cases are summarized in Table 5.1. Patients were predominantly older males. Cardiac arrest was witnessed in less that half of the occasions and victims received bystander CPR only 16.5% of the time. Asystole was the most common rhythm found at the time of the first cardiac monitor analysis. EMS vehicles (fire, BLS-D, or paramedic) reached the victim's location within eight minutes of the initial call more than 90% of the time. Four percent of the overall cardiac arrest population was discharged alive from the hospital and 12.1% of those witnessed cases in VF/VT.

Table 5.1 Patient and System Characteristics for all Included Victims of Cardiac Arrest over the 5-year Period

Characteristics	N=7707
Mean Age (n=7669; SD)	68.9 (14.0)
[range]	[16-102]
Male Gender (n=7705; %)	5179 (67.2)
Witnessed Arrest (n=7707; %)	3739 (48.5)
Bystander CPR (n=7703; %)	1269 (16.5)
Initial Cardiac Arrest Rythm (n=7506; %)	
VF/VT	2765 (36.8)
PEA	1606 (21.4)
Asystole	3135 (41.8)
ALS paramedic at the Scene (n=7705; %)	2956 (38.4)
Mean Time Intervals*	
Call Received to Vehicle Stop <8 min (n=7633; %)	6975 (91.4)
Call Received to Vehicle Stop (min; 95%CI)	5.4 (5.4-5.5)
Call Received to Patient's Side (min; 95%CI)	8.1 (8.0-8.2)
Call Received to First Analysis (min; 95%CI)	10.6 (9.3-12.0)
Call Received to First Shock (min; 95%CI)	10.9 (8.6-13.2)
Return to Spontaneous Circulation (n=7707; %)	1154 (15.0)
Admitted to Hospital (n=7707; %)	824 (10.7)
Discharged Alive	
Overall (n=7707; %)	308 (4.0)
Witnessed Cases in VF/VT (n=1917; %)	231 (12.1)

*In all tables, vehicle = first vehicle with defibrillator

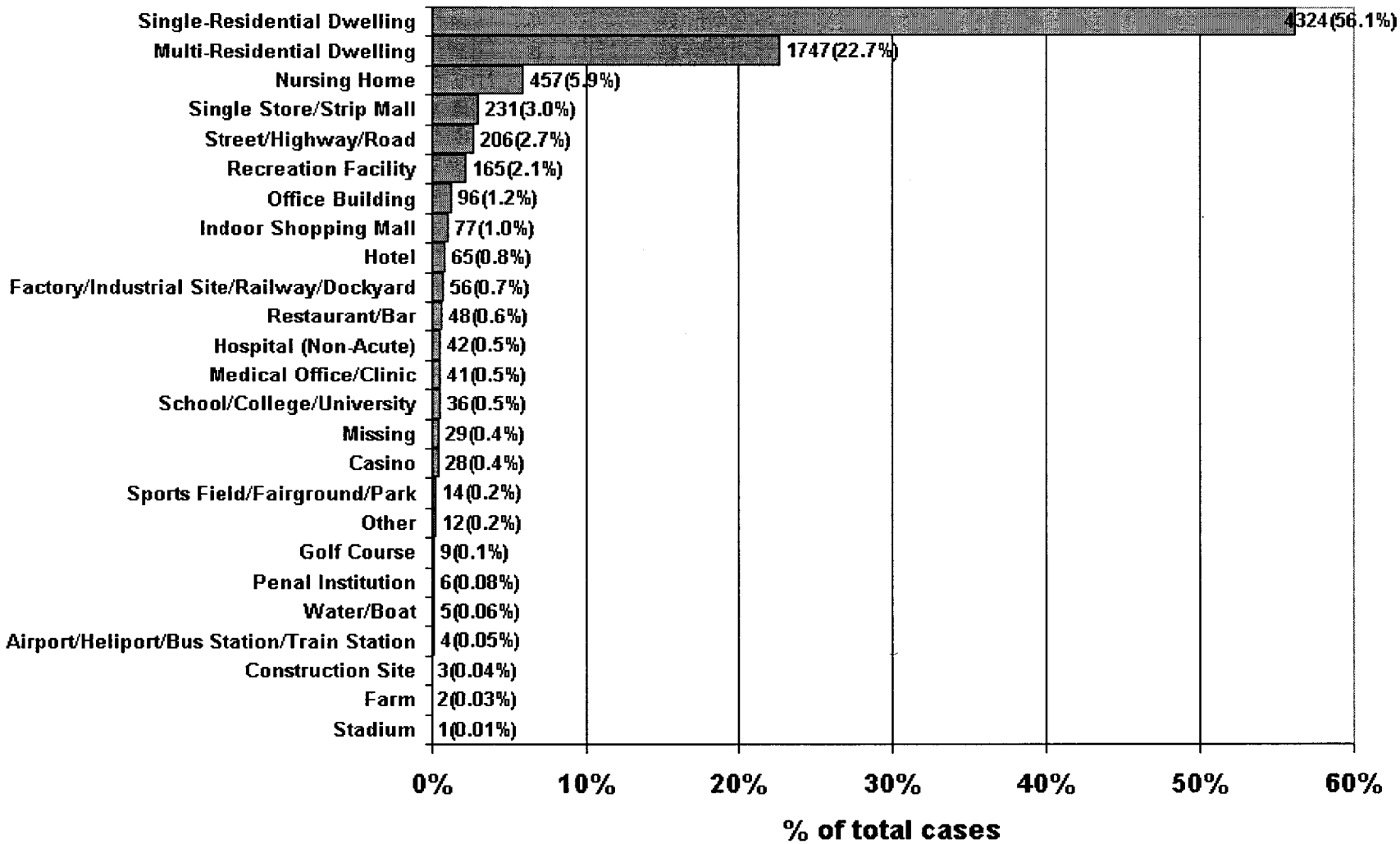
Patient and system characteristics for cardiac arrest victims receiving bystander CPR or not are summarized in Table 5.2. Because our study was not designed to perform statistical comparisons between bystander CPR groups and because multiple testing could easily find a difference by chance alone, we used visual inspection instead. Victims who received bystander CPR seemed more likely to be witnessed and to be in VF/VT at the time of first analysis by the cardiac monitor. They seemed more likely to have a return to spontaneous circulation, to be admitted to the hospital, and to be discharged alive. Other characteristics such as age, gender, presence of ALS paramedic at the scene, and time intervals seemed equally distributed between both groups.

Table 5.2 Patient and System Characteristics for Victims of Cardiac Arrest over the 5-year Period, According to Bystander CPR Status

Characteristics (Bystander CPR)	Yes N=1269	No N=6434
Mean Age (SD)	65.0 (14.5)	69.6 (13.7)
[range]	[17-100]	[16-102]
Male Gender (n; %)	919 (72.4)	4256 (66.2)
Witnessed Arrest (n; %)	852 (67.1)	2885 (44.8)
Initial Cardiac Arrest Rythm (n; %)		
VF/VT	715 (56.3)	2048 (31.8)
PEA	219 (17.3)	1387 (21.6)
Asystole	307 (24.2)	2827 (43.9)
ALS paramedic at the Scene (n; %)	485 (38.3)	2471 (38.4)
Mean Time Intervals		
Call Received to Vehicle Stop <8 min (n; %)	1150 (91.3)	5880 (91.4)
Call Received to Vehicle Stop (min; 95%CI)	5.5 (5.4-5.6)	5.4 (5.3-5.4)
Call Received to Patient's Side (min; 95%CI)	7.8 (7.6-7.9)	8.2 (8.1-8.3)
Call Received to First Analysis (min; 95%CI)	8.5 (8.3-8.6)	10.5 (9.3-11.6)
Call Received to First Shock (min; 95%CI)	8.5 (8.3-8.7)	11.7 (8.6-14.8)
Return to Spontaneous Circulation (n; %)	294 (23.2)	862 (13.4)
Admitted to Hospital (n; %)	232 (18.3)	592 (9.2)
Discharged Alive		
Overall (n; %)	123 (9.7)	187 (2.9)
Witnessed Cases in VF/VT (n; %)	99 (17.2)	131 (9.8)

Location of cardiac arrest cases is illustrated in Figure 5.2. We were able to obtain precise information in all but 29 cardiac arrest cases, yielding a 0.4% proportion of missing data. The great majority of cardiac arrests took place in residential locations (84.7%). More precisely, 56.1% occurred in "Single-Residential Dwellings", 22.7% in "Multi-Residential Dwellings", and 5.9% in "Nursing Homes". Only a minority of cases took place in public venues (4.5% and 6.9% in small and large public venues respectively) , most of which with less than one percent of the total number of cardiac arrests. Exceptions were "Single Store/Strip Mall" (3.0%), "Street/Highway/Road" (2.7%), "Recreation Facilities" (2.1%), "Office Buildings" (1.3%), and "Indoor Shopping Mall" (1.0%).

Figure 5.2 Cardiac Arrest Cases by Location (1995-2000) n = 7,707



5.2.1. Patient and System Characteristics by Larger Location Categories

Patient and system characteristics are once again summarized in Table 5.3. This time, they are organized by larger cardiac arrest location categories. It is noticeable that cardiac arrest cases occurring in residential areas are in older people, time intervals from initial call to EMS arrival are longer, and survival is significantly smaller compared to public venues. Compared to residential locations, victims of cardiac arrest in large and small public venues are younger, are more often male, are more often witnessed, are more likely to receive bystander CPR and to be in VF/VT, their time intervals are shorter, and their survival rates are better.

5.2.2. Secular Trends in Selected Patient and System Characteristics

We looked at secular trends for those same patient and system characteristics over the 5-year study period. (Table 5.4) The number of cardiac arrest per year has increased by 6.6% over the last three years of the study period. This is consistent with the 5.6% population increase in Ontario reported by Statistics Canada over the same period. Patient characteristics seem generally unchanged, whereas time intervals from initial call to EMS arrival decreased as a result of Phase II of the OPALS study. Moreover, there have been an increasing proportion of advanced care paramedics dispatched to cardiac arrests as a result of Phase III of the OPALS study. Except for 1999, survival to discharge showed an increasing trend over the study period. There were no changes in bystander CPR rates over the study period.

Table 5.3 Patient and System Characteristics by Collapsed Cardiac Arrest Location Categories

Characteristics N=7704 (%)	Small Residential N=4324 (56.1)	Large Residential N=2246 (29.2)	Small Public Venue N=348 (4.5)	Large Public Venue N=534 (6.9)	Non-specific Locations N=223 (2.9)
Mean Age (SD)	68.8 (13.3)	71.9 (14.0)	64.2 (13.9)	61.0 (14.7)	64.9 (13.0)
[range]	[16-100]	[16-101]	[18-98]	[16-102]	[21-92]
Male Gender (n=7673; %)	2929 (67.8)	1336 (59.5)	272 (78.2)	439 (82.2)	180 (80.7)
Witnessed Arrest (n=7675; %)	1940 (44.9)	995 (44.3)	252 (72.4)	399 (74.7)	135 (60.5)
Bystander CPR (n=7675; %)	575 (13.3)	255 (11.4)	116 (33.3)	236 (44.2)	75 (33.6)
Initial Cardiac Arrest Rythm (n=7675; %)					
VF/VT	1458 (33.7)	590 (26.3)	201 (57.8)	364 (68.2)	135 (60.5)
PEA	896 (20.7)	535 (23.8)	61 (17.5)	74 (13.9)	33 (14.8)
Asystole	1867 (43.2)	1050 (46.8)	77 (22.1)	85 (15.9)	49 (22.0)
Paramedic at the Scene (n=7673; %)	1577 (36.5)	909 (40.5)	128 (36.8)	238 (44.6)	96 (43.1)
Mean Time Intervals					
Call to Vehicle Stop <8 min (n=7601;%)	3884 (90.5)	2036 (91.9)	319 (92.5)	500 (94.3)	206 (94.1)
Call to Vehicle Stop (min; 95%CI)	5.6 (5.6-5.7)	5.2 (5.1-5.3)	5.1 (4.8-5.3)	5.0 (4.8-5.1)	4.9 (4.6-5.2)
Discharged Alive (n=7675; %)					
Overall	123 (2.8)	39 (1.7)	34 (9.8)	84 (15.7)	25 (11.2)

Table 5.4 Secular Trends in Selected Patient and System Characteristics over the 5-year Period

Characteristics N=7707 (%)	1995 N=1478 (19.2)	1996 N=1620 (21.0)	1997 N=1496 (19.4)	1998 N=1519 (19.7)	1999 N=1594 (20.7)
Mean Age (SD)	68.5 (13.5)	69.7 (13.1)	68.5 (14.6)	68.1 (14.5)	69.3 (13.9)
[range]	[16-99]	[16-101]	[18-98]	[16-102]	[21-92]
Male Gender (n=7705; %)	1036 (70.1)	1092 (67.4)	958 (64.1)	1023 (67.4)	1070 (67.1)
Witnessed Arrest (n=7675; %)	729 (49.3)	798 (49.3)	714 (47.7)	759 (50.0)	739 (46.4)
Bystander CPR (n=7675; %)	239 (16.2)	251 (15.5)	242 (16.2)	280 (18.4)	257 (16.1)
Initial Cardiac Arrest Rythm (n=7675; %)					
VF/VT	545 (36.9)	618 (38.2)	509 (34.0)	536 (35.3)	557 (34.9)
PEA	301 (20.4)	338 (20.9)	346 (23.1)	320 (21.1)	301 (18.9)
Asystole	598 (40.5)	611 (37.7)	588 (39.3)	634 (41.7)	704 (44.2)
Paramedic at the Scene (n=7673; %)	32 (2.2)	203 (12.5)	408 (27.3)	951 (62.6)	1362 (85.6)
Mean Time Intervals					
Call to Vehicle Stop <8 min (n=7633;%)	1231 (85.0)	1491 (92.7)	1379 (93.0)	1411 (93.4)	1463 (92.4)
Call to Vehicle Stop (min; 95%CI)	5.9 (5.8-6.0)	5.4 (5.3-5.5)	5.3 (5.2-5.4)	5.2 (5.1-5.3)	5.3 (5.2-5.4)
Discharged Alive (n=7707; %)					
Overall	60 (4.1)	61 (3.8)	65 (4.3)	75 (4.9)	47 (2.9)

5.3. Verifying that Bystander CPR is an Independent Predictor of Survival to Out-of-hospital Cardiac Arrest

5.3.1. Univariate Analysis and Unadjusted Odds Ratios

Variables that were predetermined to have a plausible role in modulating survival from cardiac arrest were listed in Figure 4.3. Univariate analysis of those variables is presented in Table 5.5. With the level of significance set at $p \leq 0.25$, "Paramedic at scene" was the only variable not to reach significance and was not included in further model building. All the other variables were significantly associated with survival from cardiac arrest ($p<.0001$), including a centre effect by base hospital ($p=0.01$).

Table 5.5 Univariate Chi-Square Analysis of Variables Associated with Survival to Cardiac Arrest

Variables	Survivors N=308	Non-survivors N=7399	Probability*
Age	64.4	69.0	<.0001
Call to Vehicle Stop (min)	4.7	5.4	<.0001
Male Gender	77.9%	66.8%	<.0001
Witnessed Arrest	82.8%	47.1%	<.0001
Bystander CPR	39.4%	15.5%	<.0001
Paramedic at Scene	60.7%	61.7%	0.73
Cardiac Arrest Rhythm			<.0001
VF/VT	89.9%	33.6%	
PEA	8.4%	21.4%	
Asystole	1.6%	45.0%	
Cardiac Arrest Location			<.0001
Small Residential	39.9%	56.8%	
Large Residential	12.7%	29.8%	
Small Public	11.0%	4.3%	
Large Public	27.3%	6.1%	
Non-specific	9.1%	3.0%	
Base Hospital			0.01
Cambridge	12.4%	11.5%	
Halton	9.8%	16.8%	
Kingston	3.9%	4.0%	
London	15.3%	10.8%	
Niagara	12.7%	12.8%	
Ottawa	16.9%	17.9%	
Peterborough	6.8%	5.7%	
Sarnia	5.9%	3.2%	
Sudbury	3.3%	4.9%	
Thunder Bay	4.6%	4.4%	
Windsor	8.5%	8.0%	

*P-values obtained by logistic regression for continuous variables and $\chi 2$ for dichotomous and categorical variables

Unadjusted ORs were calculated for variables selected from the univariate analysis and are presented in Table 5.6. Of note, VF/VT (OR 74.2; 95%CI 30.6-179.9), witnessed arrest (OR 5.4; 95%CI 4.0-7.3), bystander CPR (OR 3.6; 95%CI 2.9-4.6), and small residential locations (OR 0.2; 95%CI 0.1-0.2) were significantly associated with survival to cardiac arrest. Because asystole is historically associated with the poorest survival, it was selected as the reference term for the categorical variable "Cardiac arrest rhythm". Because survival in large public venues appears to be the highest (Table 5.3), it was selected as the reference term for the categorical variable "Cardiac arrest location". Although the centre effect by base hospital has to be accounted for in the final model, this represents a non-modifiable factor and no efforts were made to compare or isolate centres with poorer survival to cardiac arrest.

Table 5.6 Univariate Logistic Regression Analysis of Variables Associated with Survival to Cardiac Arrest*

Covariate	Intercept	Coefficient	Unadjusted OR	95%CI
Age (per 10-year stratum)	-1.756	-0.212	0.8	(0.8-0.9)
Call to Vehicle Stop (per min)	-1.985	-0.239	0.8	(0.7-0.8)
Female Gender	-3.024	-0.563	0.6	(0.4-0.7)
Witnessed Arrest	-4.302	1.688	5.4	(4.0-7.3)
Bystander CPR	-3.525	1.294	3.6	(2.9-4.6)
Cardiac Arrest Rhythm†	-6.502			
VF/VT vs Asystole		4.306	74.2	(30.6-179.9)
PEA vs Asystole		2.394	11.0	(4.2-28.6)
Cardiac Arrest Location‡	-1.6784			
Small Resid. vs Large Public		-1.853	0.2	(0.1-0.2)
Large Resid. vs Large Public		-2.358	0.1	(0.1-0.1)
Small Public vs Large Public		-0.545	0.6	(0.4-0.9)
Non-specific vs Large Public		-0.401	0.7	(0.4-1.1)

* Choosing a particular base hospital for reference comparison was judged to be arbitrary and beyond the interest of this analysis
† Asystole was associated with the worst survival in 2X2 table
‡ Large public venue was associated with the best survival in 2X2 table

5.3.2. Model Building and Adjusted Odds Ratios

The full model using all the selected variables from the univariate analysis was first considered. Coefficients and adjusted OR are reported in Table 5.7. It became apparent that age and gender were no longer significant predictors of survival. We then used stepwise selection to determine a preliminary final model. Improvement in model fit at each step was measured using the –2 Log Likelihood and the Score Chi-Square statistics (Table 5.8). Improvement in other measures of fit from the full model to the preliminary final model were as follow: Akaike Information Criteria 1954.892 to 1954.420, Schwartz Criteria 2107.432 to 2093.093, and the Hosmer-Lemeshow goodness of fit test 0.55 to 0.77.

Table 5.7 Full Logistic Regression Model Including Variables Associated with Survival to Cardiac Arrest in the Univariate Analysis

Covariate	Coefficient	Adjusted OR*	95%CI
Intercept	-4.743		
Age (per 10-year stratum)	-0.088	0.9	(0.8-1.0)
Call to Vehicle Stop (per min)	-0.206	0.8	(0.8-0.9)
Female Gender	0.046	1.0	(0.8-1.4)
Witnessed Arrest	0.697	2.0	(1.5-2.8)
Bystander CPR	0.530	1.7	(1.3-2.2)
Cardiac Arrest Rhythm			
VF/VT vs Asystole	3.904	49.6	(18.2-134.9)
PEA vs Asystole	2.415	11.2	(3.9-323.4)
Cardiac Arrest Location			
Small Resid. vs Large Public	-0.828	0.4	(0.3-0.6)
Large Resid. vs Large Public	-1.209	0.3	(0.2-0.5)
Small Public vs Large Public	-0.294	0.7	(0.5-1.2)
Non-specific vs Large Public	-0.127	0.9	(0.5-1.4)

Hosmer and Lemeshow Goodness-of-Fit Test: $\chi 2= 6.864$ DF= 8 p= 0.55

* Base hospital covariate also included in the model:

Wald $\chi 2= 20.326$ DF= 10 p= 0.03

Table 5.8 Stepwise Selection Using Covariates from the Full Model

Step	Covariate Entered	-2 Log L	Score $\chi 2$	DF	Probability
0	Intercept	2538.645			
1	Cardiac Arrest Rhythm	2096.537	406.307	2	<.0001
2	Cardiac Arrest Location	2004.057	105.769	4	<.0001
3	Call to Vehicle Stop	1974.122	26.389	1	<.0001
4	Witnessed Arrest	1950.175	22.189	1	<.0001
5	Bystander CPR	1935.183	15.640	1	<.0001
6	Base Hospital	1914.420	21.467	10	0.0181

Several verifications were made before accepting the final model: 1) we scrutinized standard errors for signs of collinearity and none was found; 2) linearity of the time interval "Call received to vehicle stop" (the only continuous variable left in the model) was confirmed by plotting it against the estimated probability of survival; 3) the absence of outliers was confirmed by plotting standardized differences in the regression estimates (DFBETA) against the estimated probability of survival; and 4) none of the interaction terms assessed were statistically significant (age and rhythm, p=0.27; bystander CPR and rhythm, p=0.71; call received to vehicle stop and rhythm, p=0.33).

Adjusted ORs for the final model are presented in Table 5.9. For every minute-delay in EMS response time, survival decreases by 20%. The odds of surviving for witnessed cases are doubled compared to un-witnessed cases. Compared to asystole, presence of VF/VT at the time of first cardiac monitor analysis remains a condition highly associated with survival (OR 49.5; 95%CI 18.2-134.4). Victims of cardiac arrest in small and large residential locations are less likely to survive compared to victims of cardiac arrest taking place in large public venues. Of note, although bystander CPR remains significantly associated with survival to cardiac arrest (OR 1.7; 95% 1.3-2.3), its OR decreased from the

value obtained in the univariate analysis (Unadjusted OR 3.6; 95%CI 2.9-4.6). Besides bystander CPR rate, the "call to vehicle stop" time interval is the only other modifiable variable left in the model.

Table 5.9 Final Logistic Regression Model Including Variables Associated with Survival to Cardiac Arrest in the Stepwise Selection

Covariate	Coefficient	Adjusted OR*	95%CI
Intercept	-5.329		
Call to Vehicle Stop (per min)	-0.202	0.8	(0.8-0.9)
Witnessed Arrest	0.692	2.0	(1.5-2.7)
Bystander CPR	0.546	1.7	(1.3-2.3)
Cardiac Arrest Rhythm			
VF/VT vs Asystole	3.901	49.5	(18.2-134.4)
PEA vs Asystole	2.384	10.9	(3.8-31.4)
Cardiac Arrest Location			
Small Resid. vs Large Public	-0.870	0.4	(0.3-0.6)
Large Resid. vs Large Public	-1.269	0.3	(0.2-0.4)
Small Public vs Large Public	-0.310	0.7	(0.5-1.2)
Non-specific vs Large Public	-0.152	0.9	(0.5-1.4)

Hosmer and Lemeshow Goodness-of-Fit Test: $\chi 2 = 4.844$ DF= 8 p= 0.77
* Base hospital covariate also included in the model:
Wald $\chi 2 = 20.918$ DF= 10 p= 0.02

5.3.3. Analysis of Variables Associated with Bystander CPR

We then explored potential confounders of the effect of bystander CPR on survival to cardiac arrest by modeling bystander CPR using logistic regression. We used stepwise selection to consider variables significantly associated with bystander CPR. We verified the model assumptions for collinearity, linearity of continuous variable, and presence of outliers. The Hosmer and Lemeshow goodness of fit test had a value of 0.60, sign that our model could predict very well the probability of receiving bystander CPR (Table 5.10).

Age, witnessed status, cardiac arrest rhythm, and location of cardiac arrest were each significantly associated with the presence of bystander CPR

(p<.0001). Coefficient and adjusted OR for those cofactors are presented in Table 5.10. Bystander CPR rate decreases by one percent with each year-increment in age. Witnessed status is associated with an increased rate of bystander CPR. The odds that VF/VT will be present are almost doubled when bystander CPR is being provided (OR 1.9; 95%CI 1.6-2.2). Compared to large public places, bystander CPR was less likely to occur in all the other locations.

Because witnessed status, cardiac arrest rhythm, and cardiac arrest location were associated both with bystander CPR and survival, we can consider these variables to be confounders of the effect of bystander CPR on survival.

Table 5.10 Final Logistic Regression Model Including Variables Associated with Bystander CPR in the Univariate Analysis

Covariate	Coefficient	Adjusted OR	95%CI
Intercept	-0.403		
Age (per 10-year stratum)	-0.152	0.9	(0.8-0.9)
Witnessed Arrest	0.549	1.7	(1.5-2.0)
Cardiac Arrest Rhythm			
VF/VT vs Asystole	0.631	1.9	(1.6-2.2)
PEA vs Asystole	0.162	1.2	(0.9-1.4)
Cardiac Arrest Location			
Small Resid. vs Large Public	-1.233	0.3	(0.2-0.4)
Large Resid. vs Large Public	-1.331	0.3	(0.2-0.3)
Small Public vs Large Public	-0,339	0.7	(0.5-0.9)
Non-specific vs Large Public	-0.225	0.8	(0.6-1.1)

Hosmer and Lemeshow Goodness-of-Fit Test: $\chi 2= 6.425$ DF= 8 p= 0.60

5.4. Predicting the impact of increasing bystander CPR rates in various locations.

Before computing the mathematical model described in Appendix F, we determined specific survival rates by location, witnessed status, and bystander CPR status (Table 5.11). Predicted overall survival to cardiac arrest and

additional number of lives saved per year according to variable community bystander CPR rates is illustrated in Figures 5.3 and 5.4. Both graphs show a linear relationship of bystander CPR with survival to cardiac arrest and additional number of lives saved per year in the 20 OPALS study communities (population=2.5 million).

Table 5.11 Survival to Cardiac Arrest by Location Category, Witnessed Status, and Bystander CPR Rate

Location	Witnessed (%)	Bystander CPR (%)	Survival (%)
All Locations N=7707	Yes (48.5)	Yes (22.8)	12.2
		No (77.2)	5.2
	No (51.5)	Yes (10.5)	4.6
		No (89.5)	1.0
Small Residential n=4324	Yes (44.9)	Yes (17.3)	7.8
		No (82.7)	4.6
	No (55.1)	Yes (10.1)	2.5
		No (89.9)	0.8
Large Residential n=2246	Yes (44.3)	Yes (16.7)	4.8
		No (83.3)	2.5
	No (55.7)	Yes (7.1)	3.4
		No (92.9)	0.6
Small Public Venue n=348	Yes (72.4)	Yes (39.3)	16.2
		No (60.7)	9.2
	No (27.6)	Yes (17.7)	5.9
		No (82.3)	3.8
Large Public Venue n=534	Yes (74.7)	Yes (47.5)	22.8
		No (52.5)	14.8
	No (25.3)	Yes (34.8)	12.8
		No (65.2)	3.4
Non-specific n=223	Yes (60.5)	Yes (40.7)	18.2
		No (59.2)	12.5
	No (39.5)	Yes (22.7)	15.0
		No (77.3)	2.9

*There were 32 cases (0.4%) where cardiac arrest location could not be defined

Figure 5.3 Predicted Overall Survival to Cardiac Arrest According to Variable Community Bystander CPR Rates

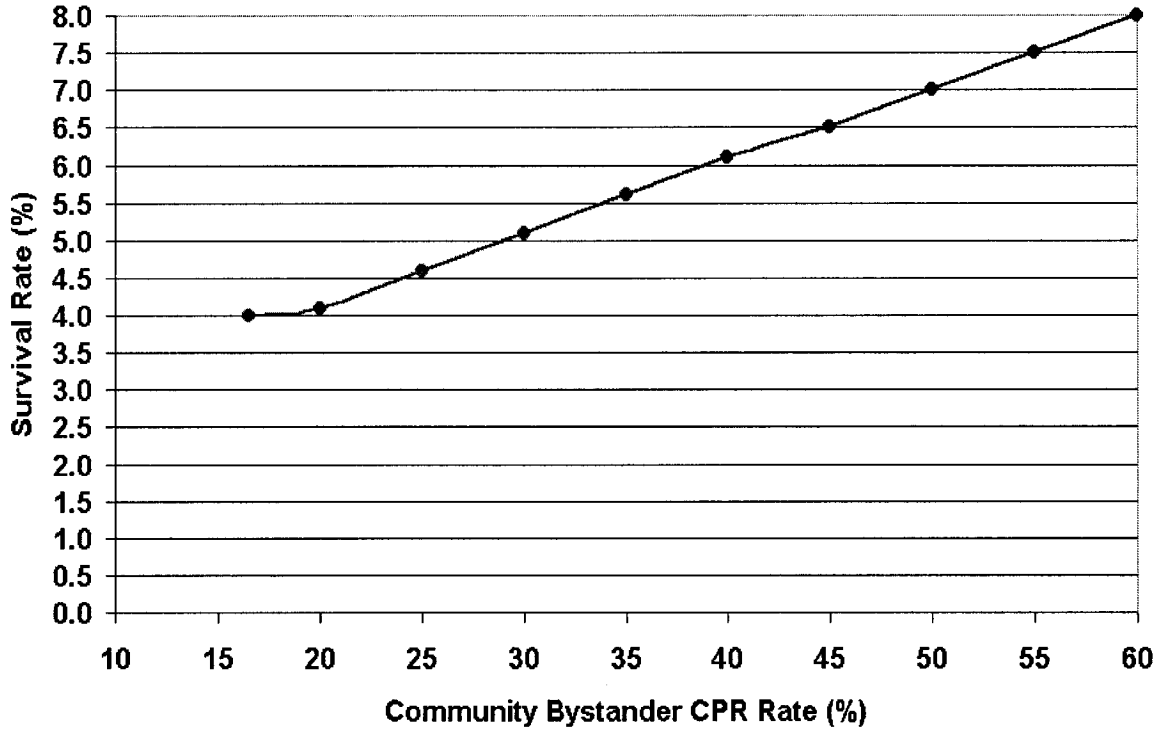
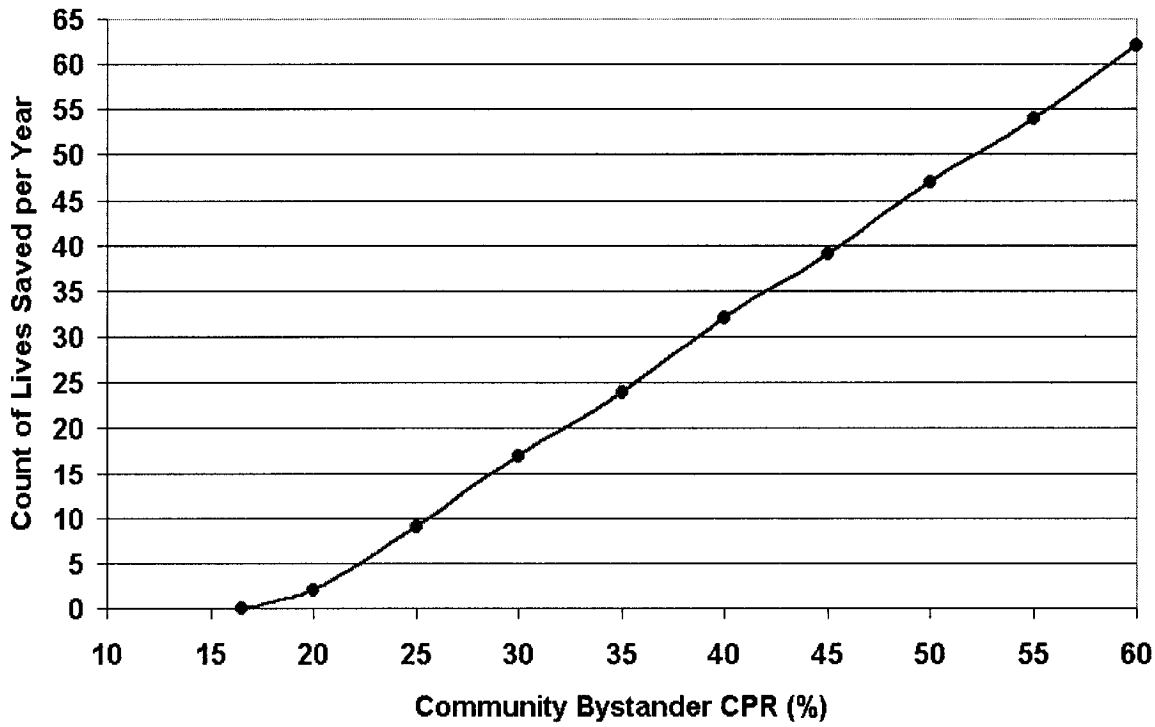


Figure 5.4 Predicted Additional Number of Lives Saved per Year According to Variable Community Bystander CPR Rates in 20 Participating OPALS Communities (1542 cardiac arrests per 2.5 million population base)



Specific predicted survival rates and additional number of lives saved per year in all cardiac arrest locations are reported in Table 5.12. Providing we could reach a bystander CPR rate of 35%, as is the case in Calgary, Alberta, survival to cardiac arrest could reach 5.6% (absolute and relative increases of 1.6% and 28.6%), for an additional number of lives saved per year of 24. Similarly, providing we could reach a bystander CPR rate of 50%, as is the case in Seattle, Washington, survival to cardiac arrest could reach 7.0% (absolute and relative increases of 2.0% and 42.9%), for an additional number of lives saved per year of 47.

It should be noted that residential locations would benefit the most from efforts in increasing bystander CPR rates. Since the great majority of cardiac arrest cases take place in residential areas, any change in bystander CPR rates in those locations would have a great impact. For an overall bystander CPR rate of 35%, 23 of the additional 24 lives potentially saved per year (96%) would be saved in residential locations. Similarly, for an overall bystander CPR rate of 50%, 42 of the additional 47 lives potentially saved per year (89%) would be saved in residential locations.

Table 5.12 Predicted Overall Survival to Cardiac Arrest and Additional Number of Lives Saved per Year According to Variable Community Bystander CPR Rates in Various Location Categories in OPALS Communities (population 2.5 million)

	All Locations		Small Residential		Large Residential		Small Public Venue		Large Public Venue		Non-specific	
Baseline /year	N=1542		n=865		n=450		n=70		n=107		n=45	
% Survival	4.0		2.8		1.7		9.8		15.7		11.2	
% CPR Rate	16.5		13.3		11.4		33.3		44.2		33.6	
Variable Bystander CPR Rates	Predicted Survival	Add. # lives	Predicted Survival %	Add. # lives	Predicted Survival %	Add. # lives	Predicted Survival %	Add. # lives	Predicted Survival %	Add. # lives	Predicted Survival %	Add. # lives
20	4.1	2	2.9	1	1.9	1	-	-	-	-	-	-
25	4.6	9	3.5	6	2.4	3	-	-	-	-	-	-
30	5.1	17	4.1	11	3.0	6	-	-	-	-	-	-
35	5.6	24	4.5	15	3.5	8	-	-	-	-	13.4	1
40	6.1	32	5.0	19	3.9	10	11.2	1	-	-	15.6	2
45	6.5	39	5.5	23	4.4	12	12.7	2	-	-	15.6	2
50	7.0	47	6.0	28	4.8	14	12.7	2	16.6	1	15.6	2
55	7.5	54	6.3	30	5.0	15	14.1	3	18.5	3	17.9	3
60	8.0	62	6.7	34	5.5	17	14.1	3	20.4	5	17.9	3

*There were 32 cases (0.4%) where cardiac arrest location could not be defined

5.5. Potential Impact of PAD Programs

We examined the potential impact of PAD programs on survival to cardiac arrest. Assuming that AED devises could be available in all large and small public venues, only a small proportion of the total population of cardiac arrest victims would benefit from PAD. Since PAD could solely be beneficial to witnessed cardiac arrest cases with VF/VT, only 96 victims per year (6.2% of annual total) would be amenable to such a program (Figure 5.5). Moreover, cardiac arrest victims corresponding to PAD's premises for success already benefit from the highest reported survival (Table 5.13). PAD programs would not only have to improve upon an existing survival rate of 21.0%, they would also have to be faster than an already excellent time interval from call received to arrival at scene of 4.9 minutes.

Figure 5.5 Number of Cardiac Arrest Victims Potentially Amenable to PAD per Year

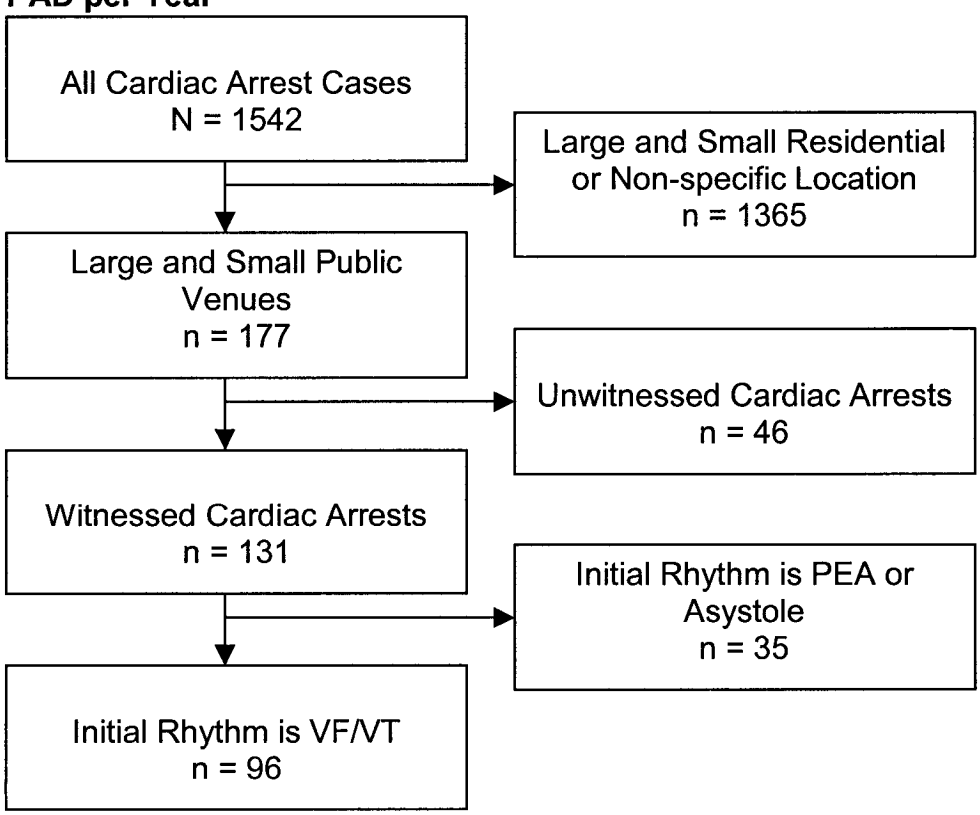


Table 5.13 Existing Survival Rate and Time Intervals for Patients Potentially Amenable to Public Access Defibrillation

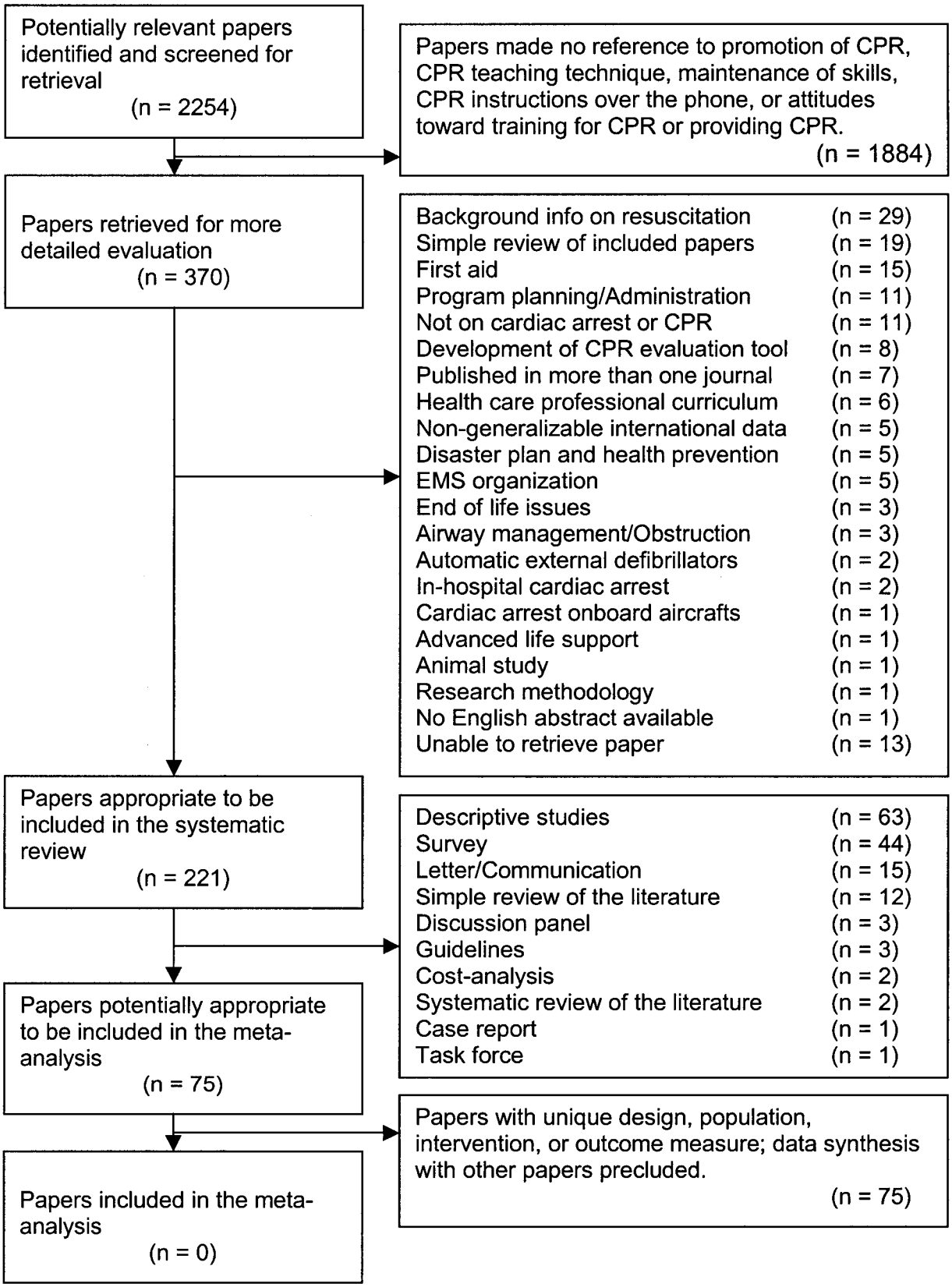
Characteristics	N=96
Mean Time Intervals	
Call Received to Vehicle Stop <8 min (n=94; %)	90 (95.1)
Call Received to Vehicle Stop (min; 95%CI)	4.9 (4.7-5.1)
Call Received to Patient's Side (min; 95%CI)	7.1 (6.9-7.3)
Call Received to First Analysis (min; 95%CI)	7.7 (7.5-7.9)
Call Received to First Shock (min; 95%CI)	8.0 (7.8-8.3)
Discharged Alive (n=96; %)	
Overall	20 (21.0)

Part Two: Systematic Review of the Determinants of Bystander CPR

The search strategy identified 2254 potentially relevant papers. They were downloaded to a reference management software for initial screening by title and abstract. Using predetermined selection criteria (Appendix H), we rejected 1884 publications. We used the same criteria to review printed copies of the remaining 370 papers. Characteristics of the 149 publications rejected at this stage are presented in Figure 5.6. We could not locate 13 publications despite exhaustive research and librarian support. Our systematic review includes 221 publications, none of which could be synthesized by meta-analysis.

Our electronic search strategy was successful in retrieving 78.3% of all papers included in the systematic review. This high recall rate was achieved at the cost of having to review a large number of publications not relevant to our topic (precision of 8.1%). With 21.7% of all publications included in the systematic review coming from a source different than the electronic search, we are confident that a significant effort was made to find most of the information pertaining to our topic of interest. As mentioned earlier, other means to ascertain for publication bias could not be computed.

Figure 5.6. Systematic Review Trial Flow



Characteristics of the 221 papers included in the systematic review are presented in Table 5.14. Over 65% of the literature on CPR originates from the USA and is predominantly published in English. Most publications are hypothesis generating rather than hypothesis testing. Nearly 50% of the information comes from surveys or descriptive analysis. We came across two systematic reviews: one on effectiveness of life support courses [100], the other on infections potentially acquired during CPR.[101] Hypothesis testing studies are described in more detail in Table 5.15. Those include RCTs (38), quasi-experimental (24), before-after (11), case-control (1), and cohort studies (1).

Table 5.14 Systematic Review Characteristics

Systematic Review	N=221 papers
Median Year of Publication [range]	1994 [1961-2001]
Publication Status (n; %)	
Full Paper	205 (92.8)
Abstract	16 (7.2)
Country of Publication (n; %)	
USA	145 (65.6)
United Kingdom	22 (10.0)
Canada	11 (5.0)
Belgium	6 (2.7)
Germany	6 (2.7)
Norway	6 (2.7)
Sweden	6 (2.7)
Australia	5 (2.3)
Netherlands	3 (1.4)
Austria	2 (0.9)
Finland	2 (0.9)
Japan	2 (0.9)
Spain	2 (0.9)
Brazil	1 (0.5)
Italy	1 (0.5)
Singapore	1 (0.5)
Language of Publication (n; %)	
English	217 (98.1)
German	3 (1.4)
Japanese	1 (0.5)
Topic*(n=299; %)	
Promotion and Provision of CPR Courses	89 (29.8)
Understanding/Teaching CPR	72 (24.1)
Attitude, Motivation, and Reluctance	65 (21.7)
Maintenance of Skills	51 (17.1)
Instructions Over the Phone	22 (7.4)
Research Methodology (n; %)	
Descriptive	63 (28.5)
Survey	44 (19.9)
RCT	38 (17.2)
Quasi-experiment	24 (10.9)
Letter/Communication	15 (6.8)
Simple Review of the Literature	12 (5.4)
Before-after	11 (5.0)
Discussion Panel	3 (1.4)
Guidelines	3 (1.4)
Cost-analysis	2 (0.9)
Systematic Review	2 (0.9)
Case-control	1 (0.5)
Cohort Study	1 (0.5)
Task Force	1 (0.5)
Case-report	1 (0.5)

*A paper may cover more than one topic.

Table 5.15 Hypothesis Testing Studies: Characteristics by Methodology

Study	Participants	Intervention	Outcome Measure	Jadad	Allocation Concealment	Conclusion
RCT						
Assar 2000 N=505	Population of South Wales Mean age 42	1-Staged CPR teaching (2 hrs) 2-Conventional CPR teaching (2 hrs)	Multiple CPR skill comparisons (with no statistical adjustment)	2	Not Used	Staged teaching leads to better skills.
Atkinson 1999 N=48	Volunteers trained in CPR or not Age range 23-56	1-CPR without instructions 2-CPR instructions on the phone 3-CPR instructions by video-link 4-Instructions given by instructor	No. ventilations, No. chest compressions, hand position, and time to CPR	1	Not Used	Video-link instructions were best. Telephone instructions were good. Previous training had no influence on skills.
Batcheller 2000 N=202	Recruted from community Mean age 59.4	1-Video self-training in CPR (25 min) 2-Conventional CPR teaching (4 hrs)	Effective ventilation, effective compressions, and effective CPR delivery	2	Not Used	Self-trained did generally better than conventionally trained.
Baubin 1996 N=12	Professional rescuers Mean age 30.8 +/- 7.9	1-Perform regular CPR 2-Perform CPR with ACD device	Duration of CPR, quality of CPR, oxygen consumption, heart rate, and lactate level	1	Not Used	Conventional CPR demands less energy than ACD and can be performed longer (29 min vs 16 min).
Berden 1993 N=96	Nurses Mean age 28.7 +/- 7.1	1-Retested at 3 months + refresher 2-Retested at 6 months + refresher 3-Retested at 1 year	CPR skills	2	Not Used	Instructions every 6 months are necessary.
Bilger 1997 N=200	Medical (18%) and laypeople (82%) Mean age 38.4	1-Telephone prompt alongside manikin 2-No telephone prompt	Calling 9-1-1 for help	2	Not Used	Group trained with prompt telephone remembered to call 9-1-1 more often.
Capone 2000 N=202	Auto industry employees 55% between 21-35	1-TV spots on CPR (60 sec) 2-Nothing	CPR skills	3	Not Used	Both groups had similarly bad CPR skills.
Chamberlain 2001 N=495	Population of South Wales Mean age 42	1-Staged CPR teaching (2 hrs) 2-Conventional CPR teaching (2 hrs)	Likelihood of returning for further training or retraining	2	Not Used	Staged teaching led to higher likelihood of return visits to complete or repeat training.
Coleman 1990 N=49	College students Age range 18-70	1-Self-taught class (4 hrs) 2-Conventional CPR teaching (4 hrs)	Written exam and skill exam according to Mandel check-list	2	Not Used	Both groups were equivalent.
Donnelly 2000 N=250	Laymen Age unknown	1-Europeen Resuscitation guidelines 2-ILCOR guidelines 3-American Heart guidelines	CPR skills evaluated according to CARE and VIDRAP protocol	2	Not Used	Europeen and ILCOR guidelines appeared easier to learn; retention is poor irrespective of method.
Dracup 1986 N=134	Heart disease patients Mean age 59 Family members Mean age 49	1-CPR teaching (90 min) 2- Heart disease education (90 min) 3-Nothing	Multiple adjective affect checklist, psychological adjustment to illness scale, and CPR quiz.	1	Not Used	Anxiety was worst in CPR group. Adjustment to illness was worst in CPR and education group compared to placebo.
Dracup 1994 N=337	Family members of heart disease patients Mean age 59 +/- 10.5	1-CPR teaching only 2-CPR + education on heart disease 3-CPR + social support 4-Nothing	24-item self administered questionnaire	1	Inadequate	Very positive feeling about CPR training without an increased sense of burden or responsibility compared to placebo.

Study	Participants	Intervention	Outcome Measure	Jadad	Allocation Concealment	Conclusion
Dracup 1997 N=674	Heart disease patients Mean age 62.9 +/- 10.1 Family members Mean age 59.0 +/- 10.9	1-CPR teaching only 2-CPR + education on heart disease 3-CPR + social support 4-Nothing	Multiple adjective affect checklist, psychological adjustment to illness scale, and Spanier dyadic adjustment scale	1	Inadequate	Patients coped better if their family members received social support.
Dracup 1998 N=480	Parents of sick infants Mean age 29.9 +/- 8.4	1-Conventional CPR class 2-Conventional CPR class + social support 3-CPR self-training video	Mandel CPR skill checklist, PAIS, multiple affect checklist, and perceived social support scale	2	Not Used	No difference between group 1 and 2; self-training may not be appropriate for that population.
Dracup 2000 N=335	Parents of sick infants Mean age 30 +/- 8	1-Conventional CPR class 2-Conventional CPR class + social support 3-CPR self-training video	Psychological adjustment to illness, Speilberger state of anxiety inventory, McMaster family assessment device, PAIS	1	Inadequate	CPR training increases adjustment to disease although anxiety is increased at first. Group 2 did best.
Eisenberg 1995 N=17318	Washington households Head of household >50	1-CPR self-training video 2-Nothing	Bystander CPR rate n=65 cardiac arrests	2	Not Used	Sending a video to households does not increase bystander CPR.
Hallstrom 2000 N=520	9-1-1 callers Age unknown	1-Instruction to do chest compression 2-Instruction to do full CPR	Delivery of intervention and survival to hospital discharge	3	Adequate	Group 1 more likely to complete instructions. Survival was similar.
Hawks 1992 N=84	University students Age unknown	1-CPR + bystander education (2 hrs) 2-CPR training alone	Helping behavior and appropriateness of intervention	4	Adequate	Group 1 helped significantly more often; trend toward more appropriate intervention in group 1.
Kaczorowski 1998 N=44	Medical student Age unknown	1-Video + unsupervised manikin practice at 3-5 months 2-Booster training + supervised manikin practice at 3-5 months 3-No booster training session	Neonatal knowledge and skill retention at 6-8 months	2	Not Used	No difference between groups. All groups performed significantly bad.
Kittleson 1986 N=96	University students Age unknown	1-Conventional CPR teaching 2-CPR teaching with task behavior 3-CPR teaching with progressive part practice	19-item skill competency scale	1	Not Used	Innovative teaching methods did much better than conventional teaching.
Komelasky 1990 N=28	Parents of apneic infants Mean age 29.8	1-CPR + home visit/manikin practice 2-CPR + telephone/clinic follow-up	Speilberger state-trait anxiety inventory and CPR skills	2	Not Used	No difference in anxiety level or CPR skills between groups.
Liberman 2000 N=61	CEGEP students Mean age 24.8 +/- 12.5	1-4 hrs, manikin:student 1:4 2-4 hrs, manikin:student 1:1 3-2 hrs, manikin:student 1:1 4-11 min, self-training video+manikin	CPR skills	1	Not Used	No difference between groups. Self-training video group did just as well.
Mandel 1987 N=67	City employee Age unknown	1-CPR theory review (3 pages) 2-CPR video review (15 min)	CPR skills	1	Not Used	Overall skills were similar; better compression rate in video group.
Messmer 1993 N=30	Substance abuse mothers Mean age 28.6 +/- 5.3	1-Interactive CPR video + manikin 2-Conventional CPR training	CPR knowledge and skills	1	Not Used	Conventional CPR training method led to better results.
Moser 1999 N=335	Parents of sick infants Mean age 30.5 +/- 8.5	1-Video on CPR 2-Conventional CPR teaching 3-Conventional CPR + social support 4-Nothing	CPR attitude scale, willingness to attempt CPR, anxiety, sense of burden, and feeling of loss of control	1	Not Used	Intervention groups did better on all counts. Groups 2 and 3 did bettr than group 1.

Study	Participants	Intervention	Outcome Measure	Jadad	Allocation Concealment	Conclusion
Moser 2000 N=196	Family members of heart disease patients Mean age 59 +/- 10.5	1-CPR + education on heart disease 2-CPR + social support 3-Nothing	Multiple affect adjective check list and control attitudes scale	1	Not Used	Perceived control and emotional adjustment improved in both groups.
Nelson 1984 N=104	Medical students, hospital personnel, and laypeople Age unknown	1-Modular CPR class +/- refresher 2-Conventional CPR +/- refresher	Written exam, CPR skills, and harmful behavior	1	Not Used	At 1 year, all groups equal. At 2 years, groups with refresher did better. At 4 years, all groups did bad.
Ruppert 1999 N=261	Health care workers and laymen Age unknown	1-Using a live person 2-Using a manikin	Determination of breathing status (yes or no)	1	Not Used	Only 5% could make the correst diagnosis within the 5 sec recommended by AHA.
Shantzis 1983 N=90	University students Age unknown	1-Modular CPR teaching 2-Conventional CPR teaching	CPR knowledge and skills.	1	Not Used	Neither groups could perform CPR after 9 weeks.
Shotland 1985 N=163	University students Age unknown	2X2X2 table varying: Ambiguity, number of bystander, training status	Helping behaviour	2	Not Used	Ambiguous situation and presence of many bystanders decreases helping behaviour. Training only influence nature of help provided.
Su 2000 N=43	Paramedics Age unknown	1-Knowledge + manikin refresher 2-Manikin refresher 3-Knowledge refresher 4-No refresher	Pediatric CPR knowledge and skills measured at 12 months	2	Not Used	All groups returned to pre-training level at 12 months with or without a refresher at 6 months.
Todd 1998 N=89	Medical students Mean age 23.1 +/- 2.9	1-Video self-training (34 min) 2-Conventional CPR class (4 hrs)	Overall CPR competency and skills	5	Unclear	Video self-training led to superior competency and skills.
Todd 1999 N=107	Baptist Church laymen Mean age 34.4 +/- 8.6	1-Video self-training (34 min) 2-Conventional CPR class (4 hrs)	Written test, overall CPR competency, and CPR skills	5	Adequate	Video self-training led to similar competency and skills.
Toms 1998 N=unknown	Laymen Age unknown	1-Conventional CPR class + peer coaching 2-Conventional CPR class	CPR knowledge and skills	1	Not Used	Outcome measure not influenced by peer coaching.
Vanderschmidt 1975 N=400	School children Age 8th and 11th grade	1-Didactic teaching + manikin 2-Didactic teaching only	CPR knowledge and skills	1	Not Used	Group 1 did better. 11th grade students did better.
Ward 1997 N=169	University students Age unknown	1-Wallet size check list 2-Longer, more detailed check list 3-No check list	CPR skills 2 months later	1	Not Used	Longer check list did the best. No difference between wallet size check list and no check list.
Wik 2001 N=24	Paramedics Age unknown	Cross-over trial 1-3 min CPR, automated feedback 2-3 min CPR, no feedback	CPR skills	2	Not Used	Automated voice advisory manikin rapidly improves CPR skills.
Yatel 1989 N=106	Nurses 3 different ward) Age unknown	1-HeartSaver CPR teaching 2-BCLS teaching	CPR skills	1	Not Used	Area of work did not make a difference. Group 2 did better.
Quasi-experiment						
Bang 1999 N=427	9-1-1 callers reporting cardiac arrest Mean age 69 +/- 15	1-Phone instruct./no previous training 2-Phone instruct./previous training 3-Phone instruct./CPR aborted 4-No instruct. re previous training 5-Instructions declined by caller 6-No instructions offered	Adequacy of cardiac arrest by dispatcher, survival to hospital discharge.	-	-	High accuracy of dispatchers for diagnosis of cardiac arrest. Bystanders with previous CPR training did better, more so if they received phone instructions. Phone instruct. Increases survival.

Study	Participants	Intervention	Outcome Measure	Jadad	Allocation Concealment	Conclusion
Berkebile 1975 N=446	School children Age range 12-13, 15-17	1-Conventional CPR teaching 2-Self-training + manikin 3-CPR video only 4-CPR video + manikin 5-Nothing	CPR knowledge and skills. Attempt at doing CPR.	-	-	Self-training compares to conventional CPR teaching. Manikin practice is important. CPR video only was better than no instructions at all.
Braslow 1997 N=642	Laymen Mean age 32.8	1-Self-instruction video 1 (30 min) 2-Self-instruction video 2 (35 min) 3-Conventional CPR class (3-4 hrs)	Chest compression, ventilation, and overall CPR skills	-	-	Video 2 did better than video 1 (prototype) and conventional teaching. Also if >40 years old.
Breivik 1980 N=230	Laymen Mean age 31	1-Self-training at home + observer 2-Self-training at home + no observer 3-Self-training at driving school 4-Nothing	CPR knowledge and skills	-	-	All intervention groups shares similar CPR knowledge; CPR skills were best in group 3.
Carter 1984 N=143	Laymen Mean age 53.5 +/- 7.4	1-Protocol phone instruct./know CPR 2-Protocol phone instruct. 3-Impro. phone instruct./know CPR 4-Impro. phone instruct.	CPR cycle, ventilations, compressions, confusion, unrequested returns to phone, and time to first compression	-	-	Protocol phone instructions did better than impromptu instructions. Groups without prior CPR knowledge did as well with instruct.
Edwards 1985 N=65	Oil company employee Age unknown	1-Interactive video-disc CPR class 2-Conventional CPR class	CPR knowledge, skills and retention	-	-	Knowledge and skills deteriorated at 3 months. Groups were similar.
Flesche 1995 N=188	Laymen Age unknown	1-Phone instruct./ no CPR training 2-No phone instruct./ CPR trained	Overall CPR effectiveness, time to ventilation and compression	-	-	Group 1 started CPR components later but were more effective.
Greig 1996 N=72	Nurses Age unknown	1-Teaching classes of 6 2-Teaching classes of 15-20	CPR knowledge and skills	-	-	Small group did better than large. Both groups improved.
Handley 1998 N=48	Laymen Mean age 27.3	1-Thought 4-step sequence (2 hrs) 2-Thought 8-step sequence (2 hrs)	CPR skills	-	-	No difference between groups.
Hawks 1998 N=98	University students Mean age 22.8	1-American Red Cross CPR 2-National Safety Council CPR 3-Emergency helping behaviour class + CPR 4-Nothing	Helping behaviour (yes or no)	-	-	All intervention groups demonstrated improved propensity to help compared to control group. Group 3 did best.
Kurtilla 1979 N=102	Army conscripts Mean age 20 +/- 2	1-2-hour class/recording manikin 2-3-hour class/non-recording manikin	CPR skills (recorded), 3 different set of criteria	-	-	Nobody passed the test in group 2.
Latane 1968 N=58	University students Age unknown	1-Alone in smoke-filling room 2-With 2 actors in smoke-filling room 3-3 subjects in smoke-filling room	Time necessary to notice and report the smoke	-	-	Alone subject noticed and reported smoke much faster.
Lester 1997 N=243	High school students Age range 11-12	1-CPR class taught by teacher 2-CPR class by teacher + peer	CPR knowledge and skills	-	-	Girls did better than boys in group 2. Overall no difference.
Lind 1961 N=466	School children Age range 12-14	1-CPR class + manikin (2 hrs) 2-CPR video only	Quality of ventilations	-	-	Manikin-trained group did much better.
Long 1992 N=30	Parents of sick infants Mean age 29	1-Didactic CPR teaching 2-Audio-video CPR teaching	CPR knowledge and skills	-	-	No difference between groups.
Lucia 1999 N=28	Health care professional Mean age 34 +/- 6	1-Sedentary CPR instructors 2-Fit laymen without CPR training	Heart rate, VO_2 max, and lactate levels for 18-min CPR session	-	-	Physical fitness may have a positive influence on resuscitation.

Study	Participants	Intervention	Outcome Measure	Jadad	Allocation Concealment	Conclusion
Noordergraaf 1997 N=161	Medical students Age unknown	1-Actar 911 manikin 1:1 ratio 2-Little Anne manikin 1:1 ratio 3-Recording resusci Anne 4-5:1 ratio	CPR skills	-	-	No difference between groups. Individual manikin preferred.
Schlessel 1995 N=83	Parents of healthy infant 60% between 25-35	1-Infant CPR training (4 hrs) 2-Nothing	CPR knowledge, self-efficacy, and anticipated anxiety	-	-	CPR knowledge better, self-efficacy better, and less anxiety.
Vankershaver 1989 N=265	School students Age 12, 14, 17, and 20	1-Test plus second training 2-Test only	CPR knowledge, CPR skills, and fear to apply CPR	-	-	Skills improved with repeated training unlike knowledge and fear.
Winchell 1966 N=2027	Laymen and health care 20 different groups	1-Practiced on manikin (10 groups) 2-No manikin practice (10 groups)	CPR skills on recording manikin	-	-	Group 1 did better.
Beaman 1978 N=27	University students Age unknown	1-Info on diffusion of responsibility 2-Nothing	Helping behaviour (yes or no)	-	-	Knowing about diffusion of responsibility improved helping.
Pantin 1982 N=92	University women Age unknown	1-Video on helping in emergencies 2-No video	Helping behaviour in group size of 2 vs 6	-	-	Delay in helping if larger group size, except in group 1.
Friesen 1984 N=63	Nurses Age unknown	1-Self-paced teaching method 2-Didactic teaching	CPR knowledge and skills retention at 2 and 8 weeks	-	-	No difference between groups.
Gombeski 1982 N=unknown	Laymen Age unknown	1-Teaching in 3 sessions (8 hrs) 2-Teaching in 1 session (4 hrs)	CPR knowledge and skills at one year	-	-	Both groups substandard. Group 1 did better.
Before-after						
Alvarez 1975 N=42	High school students Age unknown	1-Medic II program (includes mandatory CPR class in high school)	CPR knowledge and skills at 12 months	-	-	Did well on written exam. Did fair on skill testing.
Becker 1999 N=unknown	Population based Age unknown	1-Public service announcements teaching CPR on TV	Rate of bystander CPR for 289 cardiac arrests	-	-	Bystander CPR increased from 43% to 55% $p<0.05$
Bircher 1983 N=87	School children Age range 10-12	1-First aid and infant CPR via video, lecture, demonstration, and practice	CPR skills	-	-	Young children can learn to do infant CPR well.
Bosma 1989 N=unknown	High school students Age unknown	1-System for training and assessing resuscitation skills (STARS) 2-Delayed prompting technique 3-Conventional CPR teaching	Number of errors and time to reach preset criterion for CPR skill	-	-	Delayed prompting technique did best.
Conroy 1989 N=51	Post-partum mothers Age unknown	1-17-min video, 20 min lecture, and manikin practice. Revision in 2nd time.	CPR knowledge	-	-	Knowledge increased but not maintained at 6 months.
Culley 1991 N=267	9-1-1 callers Age unknown	1-Phone instructions provided to callers reporting cardiac arrest	Bystander CPR rate and survival to hospital discharge	-	-	Bystander CPR rate increased from 32% to 54% $p<0.001$. Trend toward improvement in survival.
Curry 1987 N=85	Health care professional Age unknown	1-Conventional CPR training	CPR knowledge and skills at 6 and 12 months	-	-	Knowledge back to pre-test level at 6 months. Skills back to pre-test level at 12 months.
Delooz 1984 N=unknown	Flemish population Age unknown	1-TV flashed with goal to promote CPR classes, followed by survey	Awareness, understanding, and commitment to take CPR class	-	-	Awareness and understanding increased. Commitment to take CPR class mainly in <25 years old.
Sunde 1998 N=421	Laymen Age unknown	1-Mass mailing calendars with CPR 2-Calendar +/- manikin to take home	CPR skills	-	-	Mass mailing of CPR instructions not useful. Practice is necessary.
Pane 1989 N=1388	Targeted laymen Age >60	1-Targeted recruitment of seniors for mass CPR training, then survey	Demographic data compared to previous mass training event	-	-	The >60 age group doubled. More family member of cardiac patients.

Study	Participants	Intervention	Outcome Measure	Jadad	Allocation Concealment	Conclusion
Eisenberg 1984 N=446	9-1-1 callers Mean age 53.5 +/- 16.6	1-Phone instructions provided to callers reporting cardiac arrest	Bystander CPR rate and survival to hospital discharge	-	-	Bystander CPR rate increased by 11.1% (95%CI 1.8-20.4). Four lives may have been saved.
Case-control	Cases	Control	Outcome Measure	Newcastle-Ottawa Scale		Conclusion
Goldberg 1984 N=501	1-Family members of heart disease patients	1-Family members of non-cardiac patients 2-Random neighbourhood control	Previous CPR training status (yes or no)		6/9	Family members of cardiac patients were less likely to be trained in CPR; if they were, they had taken the class much further in the past compared to both control.
Cohort study	Cohort	Control	Outcome Measure	Newcastle-Ottawa Scale		Conclusion
Jackson 1997 N=927	1-Victims of cardiac arrest at home	1-Victims of cardiac arrest in a public venue	Likelihood of receiving bystander CPR		6/9	More likely to receive bystander CPR in public venue: crude OR 3.8 (99%CI 2.5-5.9), adjusted OR 1.8 (95%CI 1.1-2.9)

Organization of the Results from the Systematic Review

The large number of studies included in our systematic review precludes their individual detailed description. Instead, we grouped the studies by topic and summarized them. At the end of each topic we included a statement along with a measure of the quality of the evidence behind it (Figure 4.5). A summary of all the statements of evidence appears in Table 5.16; we will go over all of them in detail in the following sections.

Table 5.16 Summary of Findings from the Systematic Review along with Quality and Classification of the Statements of Evidence

Suggestion	Class
Training family members of individuals with heart disease	I-2, A
Simplifying the content of CPR classes	II-1, A
Effectiveness of Braslow's self-training video	I-2, A
Maximizing time spent practicing skills on a manikin	I-2, A
Providing Dispatch-assisted CPR instructions	I-2, A
Teaching concepts of ambiguity and diffusion of responsibility	I-2, A
Reassuring trainees about low risk of disease transmission	II-3, A
Using television to promote CPR	II-3, B
Reducing CPR classes duration	I-2, B
Effectiveness of self-training modular courses	I-2, B
Retraining scheduled every year	I-2, B
Organizing mass training events	II-3, C
Prescribing CPR, physicians should be responsible	II-3, C
Training children, effectiveness on cardiac arrest outcomes	I-2, C
Training parents of newborn, effectiveness on outcomes	I-2, C
Mandatory CPR training at time of renewing driver's licence	III, C
Teaching CPR using peer coaching	II-3, C
Informing trainees about what to expect in case of arrest	II-3, C
Performance of CPR by individuals with heart disease	I-2, D
Using staged strategy for CPR training	I-2, D
Checking of pulse by laymen before initiating CPR	I-2, D
Removing airway and breathing management from CPR	I-2, E

5.6. *Who* Should Be Targeted to Receive CPR Training?

One approach to improving bystander CPR rates is to train as many CPR providers as possible in the general population. For that purpose, teaching CPR in large groups during **"mass training"** events is an interesting concept. Such events can reach groups of a few hundred to thousands of participants at a time.[102-105] The success of mass training is linked to the type of publicity used to promote the event. An attempt at recruiting participants by means of personal invitation only had a 9% response rate.[106] Free self-training CPR videos were mailed to 8,659 households as part of another project with little effect on bystander CPR rates.[107] Successful organizations use a multi-media approach. Such publicity can also be tailored so that a targeted group can be reached.[108, 109] This being said, mass training events usually attract young participants unlikely to witness cardiac arrest and the effect of such interventions on survival to cardiac arrest has not been demonstrated in the literature. (Class II-3, C)

While participating in a mass training event requires a minimum amount of motivation and commitment, **television** could passively reach a large portion of the population. Television has an influence on awareness and understanding of CPR, whether CPR is portrayed, demonstrated, or publicized in spots or TV shows.[28, 110, 111] Television is regarded as a privileged window into the 50 years and older population.[112] An American Heart Association task force published in 1992 recommended that mass media be used to convey the CPR message.[113] In an experiment taking place in Seattle, Washington, repeated CPR instructions on television might have led to a significant rise in bystander

CPR rate.[114] The use of television to promote or teach CPR should be developed. (Class II-3, B)

Given that up to 78% of **CPR class participants** join simply to fulfil a job requirement, targeting the population at large may not achieve the desired goal.[89, 115, 116] In addition, 10 to 15% of the population suffers from long-term hearing, visual, or physical **reduction in abilities** that may require tailored teaching strategies.[17, 117] Furthermore, since the report of an obese 46-year old man suffering a fatal myocardial infarction during CPR training[118], it has been suggested that some people may not be able to sustain the **effort associated with providing CPR**.[12] Heart rate, blood pressure, and lactate level have been shown to rise during prolonged CPR efforts.[75, 119-121] CPR is an aerobic exercise that could elicit ischemic symptoms in people with heart disease.[119, 121] Little is known about the physiologic demand on individuals with cardiac disease of performing CPR for a short period of time, or until EMS arrives. (Class I-2, D)

Although cardiac patients may be limited in their ability to perform CPR, their spouses are most likely to witness cardiac arrest. [122, 123] It has been suggested by many that we should **target family members** of patients with cardiac disease.[4, 32, 124-132] As little as 9% of that target group have received CPR training, the most optimistic figure being from Seattle at 25%.[133-136] **Advancing age** decreases interest in CPR training.[88, 137-139] When asked why they did not seek training, older people had no specific reason, mentioned

the inconvenience of having to leave the house, bad health, or cost.[140, 141] Some just do not understand why they should know CPR when they can call 9-1-1.[142] While one study associates older age with failing to succeed in CPR training (OR 0.92)[143], other publications show a high success rate in that group.[144-146] Although some authors suggest the addition of counselling to deal with the extra responsibility and stress associated with being a potential CPR provider[147, 148], CPR training has been shown to decrease anxiety and increase emotional adjustment and sense of empowerment in family members of cardiac arrest patients.[149-151] Family members of cardiac patients are at risk of witnessing cardiac arrest; they are physically capable of performing CPR, receptive to the suggestion that they should be trained, and can benefit emotionally from CPR training. (Class I-2, A)

Although it makes sense to recruit family members of patients with cardiac disease for CPR classes, we ought to ask ourselves how successful we are at doing so. A suggestion has been made that physicians should **"prescribe" CPR training** to family members of patients with cardiac disease.[152] The number of surveyed physicians suggesting CPR training to family members of their own patients ranges from 6% to 50%.[135, 153-157] Of those not currently promoting CPR, 70% to 90% said they were interested in doing so in the future.[157, 158] Physicians should be responsible for screening and suggesting CPR training to family members of patients with cardiac disease. (Class II-3, C)

But family members of patients with cardiac disease are not the only ones receiving some attention. **Students** represent another group that is being

targeted for CPR teaching.[47, 159-161] While CPR knowledge and skills improve with age,[162] children as young as 10 years old can be taught CPR.[163-170] Although there is good evidence that young students can learn CPR skills, this group is the least likely to encounter cardiac arrest [171] and the effectiveness of this intervention in changing cardiac arrest outcomes has not been demonstrated. (Class I-2, C)

In addition to students, **parents** of healthy and sick infants alike can learn CPR.[172-178] Although teaching CPR to all parents before leaving the nursery has been suggested [179, 180] and learning CPR has been ranked the number one priority in a survey of parents leaving with an infant from the neonatal intensive care,[181] we lack the evidence of the effect of such an intervention on outcomes of infant respiratory or cardiac arrest. (Class I-2, C)

Finally, it has been suggested that CPR training should become mandatory at the time of obtaining or renewing one's **driver's licence**.[47, 159] Although such measures are already taking place in Oslo, Norway, their efficacy in improving bystander CPR rates has not been clearly demonstrated. (Class III, C)

5.7. *What* CPR Training Program Should Be Implemented in Order to Maximize Understanding and Retention?

The approach to CPR teaching is slightly different in various national groups, associations, and councils. In an attempt to evaluate **different CPR teaching guidelines**, students were randomized to the ERC, the ILCOR, or the AHA program.[182] In another study, the Heart Saver and the basic cardiac life

support (BCLS) programs were compared.[183] While the ERC, ILCOR, and BCLS students performed better, all programs share similar content delivery methods and no clear support can be given to one over the other. Assar and colleagues have recently proposed another 3-stage program.[184-186] In the Bronze stage, students are taught to recognize a cardiac arrest, call for help, open the airway, and perform chest compressions; in the Silver stage, they are taught how to provide ventilation and pediatric first aid; and in the Gold stage, pediatric CPR and neonatal first aid. While students attending the Bronze stage are more likely to return for subsequent instructions compared to students conventionally taught in a single session (offered to come back for refresher sessions), 49% failed to attend the Silver stage and were never taught how to deliver ventilation. Although students finishing all three stages seem to have better skills than conventionally trained students, only 38% of them completed the program.[186] This low rate of completion limits the effectiveness of staged training. (Class I-2, D)

Regardless of the origin of CPR teaching guidelines, there is conflicting evidence with regards to **course length**. While eight-hour training sessions are associated with better retention of skills at one year,[12, 187, 188] CPR can be taught successfully in four, three or even two-hour sessions.[129, 167, 189] Shorter training sessions may also help recruitment for CPR classes. (Class I-2, B)

If we accept that shorter CPR classes should be the norm, the concept of **clarity of presentation** will become important. In a study using validated

readability formulas (Smog and Flesch-Kincaid), it was determined that transcripts of CPR classes correspond to a 10th grade level.[190] The American literacy council estimates that 23 million American adults may not be able to comprehend the content of CPR classes.[190] Anecdotes, extra material, and digression from the CPR curriculum have also been associated with poorer comprehension.[143] Efforts have been made to improve upon delivery and understanding of CPR content. Some authors suggest various cognitive and behavioural approaches to teaching CPR; [191-193] others developed mnemonics such as learning CPR to the tune "Take me out to the ball game".[142] While it has been suggested that more information on recognition of myocardial infarction and the low risk of infection associated with CPR be provided during CPR training,[113, 124] the authors of three separate reviews of the literature[159, 194, 195] and at least one quasi-experiment [189] agree that the content of CPR classes should be reduced and simplified. (Class II-1, A)

While teaching CPR concepts in a simplified matter may help, being able to perform CPR skills is paramount. Adequate CPR is described as chest rise with every ventilation and palpable pulse with every chest compression.[196] This being said, not all health care professionals can rapidly and accurately **determine if a victim is breathing or if a pulse is present**.[46, 197] Laymen have even more difficulty in checking for a pulse; when it is present, 47% can find it within five seconds and 74% within 10 seconds.[45] The ERC and the Heart and

Stroke Foundation of Canada no longer recommend that laymen check for the absence of a pulse before initiating CPR.[17, 198] (Class I-2, D)

Another debate involves teaching **chest compression alone or with ventilation**. Most of the evidence supporting the chest compression alone approach comes from animal data.[199] Contrary to animal anatomy, the human upper airway does not stay spontaneously open, preventing the free flow of air during chest compressions.[73] A suggestion was made that chest compression alone should not be the answer to poor teaching skills and reluctance to do mouth-to-mouth.[200] The Belgium Cerebral Resuscitation Study Group reports observational data on survival to discharge from hospital amongst 885 cardiac arrest cases receiving bystander CPR of 16% (95%CI 13-19) with conventional CPR versus 11% (95%CI 7-14) with chest compressions alone.[80] In another study on dispatch instructions, 62% of 9-1-1 callers could perform CPR according to directives whereas 81% of them could at least perform chest compressions correctly p=0.005.[201] While chest compressions alone may be appropriate for instructions over the phone, airway and breathing management should not be removed from the CPR curriculum. (Class I-2, E)

Once a set a skills to be taught in CPR classes has been agreed upon, we need to ensure that students will master these skills. **Visual prompts and hands-on exposure** are another essential component of the CPR curriculum.[202] Students' CPR skills improve significantly when they are given the opportunity to practice on a manikin.[168, 203-205] Although sophisticated interactive manikins have been designed,[19, 206, 207] cheaper basic models

may do just fine.[208] Most important is the opportunity to practice in small groups[209] and to maximize the time spent practising the skills during CPR training.[194, 195, 210, 211] (Class I-2, A)

The concept of adequate time to practice CPR skills is closely related to the pace at which various people can learn. For this reason, **modular self-training courses** have been designed and evaluated.[180, 212] For the most part, participants in self-training modular courses do just as well as their counterpart taking conventional CPR classes.[100, 163, 213, 214] (Class I-2, B)

Another popular self-training method uses **videos**.[115, 130, 159, 195] It is usually much faster (approximately 30 minutes) and gives results similar to conventional CPR training in most cases.[144, 165, 167, 179, 215-219] A few studies found conventional CPR teaching superior to video self-teaching.[178, 220, 221] The best results have been obtained using a video carefully developed by Braslow and his colleagues.[222] The video was developed, improved, and then validated on a group of medical students.[223] Its effectiveness was confirmed in a Baptist Church volunteer group and compared favourably to results obtained using the conventional AHA CPR teaching program.[224] (Class I-2, A)

Finally, other self-training methods have used **peer coaching** (where a family member or a friend acts as an assistant to the instructor)[225, 226] and **peer teaching** (where a family member of friend becomes the instructor after having received basis CPR training).[227, 228] While peer coaching does not

seem to help CPR instructors and participants, teaching of family members by laymen recently trained in CPR is promising. Such a program was able to successfully train 1,303 laymen over a few-weeks period.[228] (Class II-3, C)

5.8. *When* Should Maintenance of Skills Sessions Occur?

Irrespective of the teaching method, **retention of CPR knowledge and skills** is poor.[100, 159, 160] The Heart and Stroke Foundation of Canada currently recommends yearly retraining.[17] There is a large amount of literature demonstrating a significant decrease in CPR knowledge and skills after one year.[164, 169, 188, 203, 210, 214, 229-235] Trainees may go back to pre-training levels as early as six months after their CPR class.[170, 236-239] Other authors have studied CPR knowledge and skill retention at four months,[167, 183, 240, 241] three months,[162, 213, 216, 242] two months,[177, 212, 243], and six weeks.[173, 189] In a randomized controlled trial comparing modular to conventional CPR teaching, neither group exhibited effective CPR performances 9 weeks after their training.[244]

One study claims that retention of CPR knowledge and skills is poor because students never learned them well in the first place. In a descriptive study, investigators independently examined students as they were being tested at the completion of their CPR class.[245] While all of them received their CPR certification, none of them passed according to strict AHA criteria.

Other facts may question the correlation between failing on a CPR test and the inability to save a life. Four years after training, 60% of people surveyed

still felt confident in their ability to provide CPR.[246] In a descriptive study of 922 witnessed cardiac arrests receiving bystander CPR, the interval since last CPR training did not significantly influence survival.[123] In a cohort study of 9-1-1 callers reporting cardiac arrest and being offered dispatch CPR instructions, the group that declined the instructions because of prior CPR training (at any point in time) was associated with a survival of 11%, whereas survival in the group where CPR instructions were refused for another reason than CPR training was 3%.[247]

While there is strong evidence that CPR knowledge (on a written exam) and skills (on a manikin) deteriorate significantly after six to twelve months, there is less evidence that retraining within that period is associated with further improvement in survival to cardiac arrest. (Class I-2, B)

5.9. *Where* – Should Instructions Be Given Over the Phone?

CPR instructions over the phone could remedy the low bystander CPR rate observed in residential dwellings.[129, 152] At a time when such instructions were not being routinely provided to Buffalo citizens, 77% of those surveyed expected they would be told what to do when calling 9-1-1.[248]

Although the accuracy of dispatchers at detecting cardiac arrest over the phone has been observed to be as high as 90%,[247] two studies of recorded 9-1-1 calls determined that CPR instructions were appropriate and possible in only 30 to 37% of all confirmed cardiac arrest cases.[249, 250] While a majority of callers are emotionally capable to follow instructions,[247, 251, 252] they are not in close range with the victim in up to 50% of times.[251-253]

Experimental studies determined that previously untrained laymen could successfully perform CPR while being provided with instructions over the phone.[254-256] Similar experiments have shown that callers often struggle with providing ventilations, delaying the start of chest compressions by as much as four minutes.[257] In a randomized controlled trial of instructions to provide full CPR versus chest compressions alone, complete delivery of the instructions was achieved in 62% and 81% respectively.[201]

Despite those shortcomings, CPR instructions over the phone have been credited with increasing bystander CPR rate by 11.1% (95%CI 1.8-20.4),[258] with increased survival compared to receiving no bystander CPR [OR 1.45 (95%CI 1.21-1.73)],[259] and with producing survival rates comparable to victims receiving CPR from a bystander previously trained (7% and 11% respectively).[247] The highest survival is achieved when previously trained bystanders accept to be reminded of what to do over the phone (18%).[247]

There is strong evidence that 9-1-1 dispatchers should provide CPR instructions to callers. (Class I-2, A)

5.10. *Why* Do People Lack Motivation to Have CPR Training or Are Reluctant to Apply Their Skills?

Many authors have asked people **why they were not interested in taking a CPR class**.[102, 138, 140, 142, 167, 218, 260, 261] In the most part, it simply never occurred to them it was something they should be doing. Other common reasons were lack of time or interest, inconvenience of having to leave the house, cost, inability to find a course, bad health or physical limitations, fear

of contracting HIV, and fear of being sued. With regards to **legal fears**, nobody has ever been successfully sued for having provided CPR.[262, 263] To the contrary, the notion of negligence and failure to provide support could have legal consequences.[264]

More important than the fear of litigation is the **fear to contract an infectious disease**. Historically, tuberculosis and polio were major concerns on the minds of potential rescuers.[113] In our time, HIV and hepatitis B have replaced those diseases.[113, 265] Two surveys published in the late eighties reported that up to 50% of CPR students and instructors alike believed HIV to be transmissible despite standard precautions or simply from giving mouth-to-mouth to a manikin.[266, 267] In another survey published during the same period, 90% of homosexuals knew that HIV could not be transmitted from mouth-to-mouth ventilations.[268]

No case of HIV, hepatitis B, hepatitis C, or Creutzfeld-Jakob disease has ever been reported as a result of providing CPR to a victim or a manikin.[101, 124, 269] Nonetheless, 15 cases of *Neisseria meningitidis,* three cases of enteric pathogens, two cases of labial herpes, and one case of tuberculosis in 1965 have been linked to providing CPR.[101] The only three documented cases of horizontal transmission of HIV to health care professionals involved a significant amount of blood and the absence of basic precautions.[101] Another author reports on 21 CPR class participants sharing the same manikin with an individual later found to be at a high contagious stage of hepatitis B.[270] None of the

uninfected participants contracted the disease. It is extremely safe to practice CPR; ongoing fears about disease transmission should be addressed when teaching CPR. (Class II-3, A)

Besides disease transmission, there exist other deterrents to the practice of CPR. Mouth-to-mouth ventilation is an intimate act that may influence the decision of potential rescuers to perform CPR.[80, 92] **Willingness to perform CPR** seem directly related to the closeness of relationship with the victim.[104, 108, 126, 134, 141, 271-273] In a survey conducted in 1995, 68% mentioned they would perform only chest compressions on a stranger.[274] Other conditions such as vomit, dentures, blood, body odour, and alcohol smell may be unexpected.[91, 225, 275, 276] Information on what to expect if required to perform CPR should be provided. (Class II-3, C)

CPR certification is associated with increased confidence in one's ability to provide care, which in turn is associated with an increased helping behaviour.[128, 133, 211, 277-280] But **CPR training is still not an assurance of action** when the time comes for the rescuer to apply what he or she knows.[281] Social scientists have studied the effects of ambiguity and the presence of other bystanders on helping behaviour. The more obvious it is that actions are required in a specific situation, the more likely it is that someone will help.[250, 282-284] It has been suggested that people are often unable to make a decision rather than choosing not to help.[284] The other concept has to do with diffusion of responsibility. It has been clearly demonstrated that overall helping behaviour

decreases with an increasing number of bystanders.[283, 285-288] Although the likelihood of finding someone with CPR training in a crowd increases, the helping behaviour of that rescuer will be reduced by the presence of the other bystanders. Simple and complex behavioural methods exist to address those issues.[289-291] CPR teaching should include information on the concepts of ambiguity and diffusion of responsibility. (Class I-2, A)

Finally, a majority of laymen who had the opportunity of using CPR **describe the experience as being positive.**[89, 90] When asked to describe the feelings associated with their actions, they mentioned humanity, competence, obligation, courage, and exposure.[292]

In Summary

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

What – The content of most CPR classes need to be simplified and shortened. Time spent training on manikin should be maximized, checking for a pulse should be omitted for laymen, and ventilations should continue to be thought. CPR classes should include information about the very low risk of disease transmission and about the concepts of ambiguity and diffusion of

responsibility. The use of visual aids such as the Braslow video and self-training methods should be encouraged.

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

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

Why – The lack of motivation to leave the house and register for a CPR class seem to be a major determinant of low bystander CPR rates, perhaps more so than the fear of disease transmission or litigation. We need to consider measures that will actively recruit individuals such as teaching CPR on television or mandatory training at the time of renewing a driver's license.

Part Three: Proposed Trial to Improve Bystander CPR Rates and Survival from Out-of-hospital Cardiac Arrest

We have demonstrated the effectiveness of bystander CPR and the potential impact of various bystander CPR rates on survival from cardiac arrest (Sections 5.3 and 5.4). We also performed a systematic review of the literature to understand why bystander CPR rates have remained low over the past ten years in Ontario (Sections 5.6 to 5.10). With the OPALS study soon to be completed in 2003, optimal conditions will be in place to study the impact of an intervention

designed to improve bystander CPR rates and survival from out-of-hospital cardiac arrest.

5.11. Objectives

The objectives of the proposed trial are to determine the effects of multiple interventions at the level of numerous Ontario community base hospitals on: 1) survival and morbidity from pre-hospital cardiac arrest; and 2) bystander CPR rates. Our hypothesis is that the community intervention will improve bystander CPR rates, survival, and morbidity from cardiac arrest.

5.12. Design

Similarities amongst people choosing to live in a given community imply a lack of independence that needs to be addressed in the design and analysis of any proposed intervention trial. In order to test our community intervention, we are proposing the design of a randomized controlled trial using cluster randomization of community base hospitals. Each base hospital is responsible for one or more adjacent communities. This will help to limit the contamination that may occur when two neighbouring communities are assigned to different treatment groups. Moreover, compared to randomization by communities, randomization by base hospitals is more likely to generate clusters of similar size. While we acknowledge the loss of power and the need for a larger sample size associated with cluster randomization, we believe this is the most appropriate design when evaluating innovations in health care policies. [293] As it is the case in this trial, a community educational program to modify community

bystander CPR rates should be implemented and analyzed at the community level.

While stratified and matched-pair designs can increase the study power and improve the distribution of factors associated with the outcome measure, it has been suggested that effective matching is unlikely in studies like ours involving less than six matched pairs. [293]

5.13. Setting

Our study will take place in communities currently involved with the OPALS study. The OPALS study takes place in 20 large and small Ontario communities (population range 16,000 to 750,000) affiliated to 11 base hospital programs (Appendix B). Those communities share the following characteristics: 1) a 9-1-1 emergency telephone system; 2) an ambulance defibrillation program; and 3) rapid arrival of a vehicle with defibrillation capability within 8 minutes 90% of the time or more. The study base population is estimated at 2,500,000. Approximately 1703 cardiac arrests occur each year in that study base population for an estimated cardiac arrest incidence of 69 per 100,000.

Care for cardiac arrest victims in the 20 participating communities is provided by EMTs with BLS-D training or by paramedics with ALS training. EMT training consists of one year of community college including clinical work in the field (1000 hours) and in-hospital (400 hours). Paramedics receive an additional six months of training including six weeks of classes, clinical training (280 hours), and preceptorship (400 hours).

5.14. Study Population

Our study population will consist of cardiac arrest cases of cardiac origin as defined by the Utstein Style.[1] (Figure 2.1) The study team will review every cardiac arrest case in detail for inclusion criteria. An independent data monitoring committee will review all the evidence available in unclear cases such as when a victim had regained spontaneous circulation before EMS arrival at the scene. A decision to include those cases in the study will be reached by consensus.

Cardiac Arrest Cases

Inclusion criteria:

1- Presumed cardiac origin.

2- Emergency responders attempted resuscitation.

Exclusion criteria:

1- Less than 16 years of age.

2- Obviously dead as defined by the Ambulance Act of Ontario (decomposition, rigor mortis, or other).

3- Trauma victims.

4- Cardiac arrests clearly of a non-cardiac origin.

5- EMS witnessed cardiac arrest. (Only excluded from the analysis)

5.15. Ethical Considerations

We will seek approval from the appropriate institutional ethics review boards. Our project will respect the International Ethical Guidelines for Biomedical Research Involving Human Subjects.[294] We will request a waiver of informed consent for cardiac arrest victims included in the study because they will not be randomly assigned to different intervention groups. Beyond the

community intervention designed to improve bystander CPR rates, cardiac arrest victims will all be provided with the same standard of care currently offered by EMS and will not be exposed to undue risk or discomfort. Participating base hospitals, EMT, victims, victim's family members, city officials, government officials, and investigators will not receive any monetary reward beyond what is required for completion of the project. Patient confidentiality will be respected throughout the trial.

With regards to the notion of equipoise, although we have demonstrated that bystander CPR increases survival to cardiac arrest, the intervention's effect on bystander CPR rates, and consequently on survival, is not known. Further concerns for equipoise could be addressed by offering a different yet useful community health program such as a smoking cessation program to the control groups.[295]

5.16. Intervention

Based upon epidemiological data on cardiac arrest, results from a systematic review of the literature on the determinants of bystander CPR, and communications with a convenient sample of experts in the field, we are suggesting the use a multiple interventions framework to improve bystander CPR rates and survival from cardiac arrest. Designing such an intervention is an intricate venture that can be the object of a thesis on its own. Extensive communications with content experts, Government, City, and CPR training agency officials need to take place. The population often needs to be consulted in public hearings. It is also advisable to determine the feasibility of such an

intervention in a pilot study before it is introduced in a large-scale trial. For all these reasons, only a preliminary multiple interventions framework is presented in this thesis.

Development of a New Intervention

a. Cardiac Arrest Epidemiology in Ontario

A few key factors have been identified from the descriptive epidemiological data presented in Section 5.2. We have confirmed that more than 85% of all cardiac arrests occur in residential dwellings. Cardiac arrests occurring in public locations are much less frequent and already share a preferential survival rate (table 5.3.). In addition, the typical cardiac arrest victim is a 69 year-old male. Spouses and family members of patients with risk factors of documented cardiac disease should be targeted by CPR training campaigns.

b. Systematic Review of the Literature on Bystander CPR

We have performed an exhaustive systematic review of the literature on distribution and determinants of bystander CPR. Results of the review have been summarized in Table 5.16.

c. Content Experts

We have consulted with three content experts from Calgary, Canada [2], Seattle, Washington [3], and Oslo, Norway [4] and, in order of importance, the interventions that provided their communities with the best bystander CPR rates in North America and Europe were:

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[2] Dr. Andy Anton
[3] Dr. Mickey Eisenberg
[4] Dr. Lars Wik

Calgary, Canada:

1. Dispatch CPR instructions

Seattle, Washington:

1. Dispatch CPR instructions
2. Thirty-second public service announcements on teaching CPR
3. Free at-home CPR training provided by firefighters (Medic II program)
4. Targeted CPR teaching recruiting participants in senior centres

Oslo, Norway:

1. Dispatch CPR instructions
2. Mandatory training during military service
3. Mandatory training as part of obtaining a driver's licence
4. Mandatory training of all 6th and 7th graders

d. Multiple Interventions Methodology

We reviewed methodological issues with regards to the design, implementation, and analysis of multiple interventions trials and will apply these principles to the proposed intervention. [296] We also contacted two methodological experts in the field of multiple interventions [5,6] to assist us in planning our intervention.

e. Preliminary Multiple Interventions Framework

In the course of our multiple interventions study, communities within base hospitals randomized to the intervention group would implement all the following interventions:

---

[5] Mrs. Barbara Riley
[6] Dr. Nancy Edwards

1- Provide dispatch CPR instructions to callers reporting a victim of cardiac arrest.
2- Institute a home based CPR teaching program in answer to our findings that most cardiac arrests occur in residential dwellings.
3- Implement recruitment strategies targeting seniors and family members of patients with cardiac disease.
4- Institute recurrent 30-second public announcements spots on TV teaching components of CPR.
5- Centralize all CPR training agencies under the governance of provincial Heart and Stroke Foundation chapters and standardize CPR teaching among training agencies.
6- Develop a 2-hour simpler CPR course including Braslow's video teaching aid, maximum manikin practice time, reassurance about extremely low risk of disease transmission during CPR, and teaching of ambiguity and diffusion of responsibility concepts.
7- Implement yearly to bi-yearly CPR renewal using self-training modular courses in association with manikin practice, possibly making it mandatory at the time of renewing driver licenses.

5.17. Baseline Assessment

Baseline assessment will take place immediately before allocation in order to avoid bias in the collection of information. Information with regards to individual characteristics, bystander CPR rates, survival rates, system characteristics, and community performance relating to the inclusion criteria are already in the

OPALS database. This information has been collected on a continuous basis since 1994 and should therefore prevent regression toward the mean or floor-and-ceiling effects. Additional information on local initiatives to increase bystander CPR rates will be collected from local officials and regional Heart Saver committees.

5.18. Randomization, Allocation Concealment, and Blinding

We will use a blocked randomization method. Allocation will be performed using a generated table of random numbers and a block size of four. Although we have a small number of clusters in the study, blocked randomization will allow for a more even distribution between the intervention and control groups.

In order to maintain allocation concealment, participating communities will not be made aware of the randomization method, they will go through the allocation process in a random order, allocation assignments will be kept in an opaque envelop, and only the principal investigator will manipulate the envelopes.

Once the allocation is revealed, blinding will not be possible. Our study intervention consists of actively teaching CPR and hopefully changing the behavior of a community regarding performance of CPR in cases of cardiac arrests. Fortunately, survival from cardiac arrest is a very hard outcome that is unlikely to be influenced by collection bias.

5.19. Outcome Measures

Primary outcome

The primary outcome measure will be survival to hospital discharge, which will be ascertained from the ACR form, by reviewing medical documents from the receiving hospital, or by communicating with the patient's family physician.

Secondary outcomes

We will document the occurrence of bystander CPR, whether the bystander had received prior CPR training, and if the bystander received CPR instructions by telephone at the time of the arrest.

The quality of bystander CPR will be evaluated. Upon arrival at the scene of a cardiac arrest, EMT will be asked to document if the victim's chest was rising with each ventilation and if a palpable pulse was present with each chest compression.

We will measure other outcomes as suggested by the Utstein style methodology on reporting of data from out-of-hospital cardiac arrest.[1] Such outcome measures include witnessed status, initial cardiac arrest rhythm, return of spontaneous circulation, admission to hospital, survival at one year, various time intervals, and the quality of life of survivors. Quality of life will be assessed at one year by means of the Health Utility Index.[297]

5.20. Data Collection, Data Management, and Data Entry

Paramedics will record patient clinical information and a summary of interventions performed on the ACR form (Appendix D). Regional base hospital

personnel already review all cardiac arrest cases in detail as part of the ambulance defibrillation quality assurance program. Information on cardiac rhythm is obtained from portable cardiac monitor-defibrillation units; time intervals for each cardiac arrest cases are obtained from the ACR and the ARIS database. All this information is stored permanently by the base hospitals and will be submitted monthly to a data coordinating centre located at the Ottawa Hospital, Civic campus.

Emergency medical technicians already document whether bystander CPR was performed or not. As part of the proposed study, they will also be asked to document the location of cardiac arrest, if the bystander is a layman or a health care professional (EMT, nurse, or physician), if the bystander received CPR training, if they received dispatch-assisted CPR instructions, and if CPR was performed correctly.

Quality of CPR can rapidly be evaluated in the following fashion:[81]

1- Is mouth-to-mouth being performed?

If so, is the chest rising with the insufflation of air?

2- Are chest compressions being performed?

If so, are they accompanied by a palpable carotid or femoral pulse?

The study database will be created using SAS® version 8.01. Cardiac arrest cases included in the database will be assigned two unique identifiers: one assigned by the dispatch centre and a study case number.

Well-trained data entry clerks will perform data entry into the database. They will use standardized data entry screens with built-in logic and range

checks to minimize data entry errors. Double data entry will be done for key variables.

5.21. Data Analysis

General logistic regression models are inappropriate to analyse cluster-randomized trials because they assume that every observation is independent . We will use the generalized estimating equations approach (GEE). This method allows for cluster-level and individual-level covariate adjustment, and does not require a parametric distribution. We will use a model-based adjustment for the effect of clustering, with the simple assumption that intraclass correlation among clusters is equal. Intention-to-treat statistical analysis will be performed using the PROC GENMOD procedure available from SAS® version 8.01.

Variables to be considered for inclusion in the model are mentioned in Figure 5.7. Those variables were selected on the basis of their plausible or previously recognized association with survival to cardiac arrest. Crude OR will be obtained using univariate analysis. Categorical variables will be collapsed if cells with event counts of less than five are encountered. Statistical significance will be set at p 0.25 for initial selection of variables to be included in the full model. Using the stepwise method and a level of significance set at $p<0.05$, we will determine a preliminary final model using variables from the full model. Final adjusted OR will be obtained after the model has been checked for collinearity, confounding, effect modification, linearity of the continuous variables, outliers, and interaction terms.

Figure 5.7 Variables Considered for the Cluster Analysis Model Evaluating the Effect of a Community Intervention on Bystander CPR Rates and Survival to Out-of-Hospital Cardiac Arrest

Continuous Variables
- Age (measured in decades)
- Time interval from call received to vehicle with defibrillator arrived at scene

Dichotomous Variables
- Discharged alive from hospital
- Bystander CPR performed
- Training status of bystander
- Dispatch-assisted CPR instructions
- Community intervention (group allocation)
- Arrest witnessed
- Gender
- Paramedic at scene
- Public access defibrillation used

Categorical Variables
- Cardiac arrest location
- Participating base hospital
- Initial cardiac rhythm
- Bystander CPR quality
- Who performed bystander CPR

In the situation where there are less than ten clusters per group, the generalized estimating equations approach may no longer be applicable. [293] If this was the case, a two-sample t-test applied to the cluster-specific event rates may be more reliable.

5.22. Sample Size Calculation for Cluster Randomization

We used the formula suggested by Donner and Klar [293] for sample size calculation of cluster trials comparing proportions:

$$n = \frac{(Z\alpha_{/2} + Z\beta)^2 [P_1(1 - P_1) + P_2(1 - P_2)][1 + (m_0 - 1)\rho]}{(P_1 - P_2)^2}$$

Where:

n = required number of cardiac arrests per intervention group
$Z\alpha_{/2}$ = 1.99 (using p=0.046 for O'Brien-Fleming interim analysis)
$Z\beta$ = 0.84 (chosen for power of 80%)
P_1 = expected survival (%) in the intervention group
P_2 = expected survival (%) in the control group
$P_1 - P_2$ = Minimally clinically significant difference
m_0 = estimated cluster size, based on known clusters of variable sizes
ρ = intracluster correlation coefficient

The inflation factor (IF) by which the usual sample size needs to be increased to account for cluster randomization is represented by:

$$IF = [1 + (m_0 - 1)\,\rho]$$

The estimated cluster size based on known clusters of variable sizes is slightly smaller than the simple average of cluster sizes and is given by:

$$m_0 = (1/(k - 1))\,(M - \Sigma_{j=1 \text{ to } k}\, m_j^2 / M)$$

Where:

k = number of clusters
M = number of cardiac arrests in all OPALS base hospitals over the study period
m_j = number of cardiac arrests in a specific base hospital over the study period

While 2n represents the total number of cardiac arrests required, the number of clusters (or base hospitals) required for the study (k) = $2n/m_0$. Expected survival rates in relation to variable community CPR rates were discussed in Section 5.4. Results from Table 5.12 were used to determine potential values for P_1. As reported in Section 5.2, we expect the survival rates in the control groups to be 4%. Based on the published literature of interventions for improving survival to cardiac arrest,[7, 26, 298] current experiences with the OPALS study, and communications with experts in the field of cardiac arrest

research, we have determined the minimally clinically significant difference in overall survival to be an absolute increase of 2% (from 4% to 6%).

In order to estimate the intraclass correlation coefficient (ρ), we performed a standard one-way analysis of variance of survival to cardiac arrest among 11 base hospitals (Table 5.17).

Table 5.17 Results of a standard one-way analysis of variance of survival to cardiac arrest among 11 base hospitals

Source	DF	Sum of Squares	Mean Squares	F Value	Pr > F
Model	10	0.881	0.088	2.31	0.01
Error	7689	298.879	0.038		
Corrected Total	7699	294.760			

The intraclass correlation coefficient can then be computed using the following equation:

$$\rho = (MSC - MSW) / (MSC + (m_0 - 1) MSW)$$

Where:
MSC = Mean Square Error among base hospital
MSW = Mean Square Error between base hospitals

We obtained the following results after computation of the formulas:

m_0 = 680

ρ = 0,0019

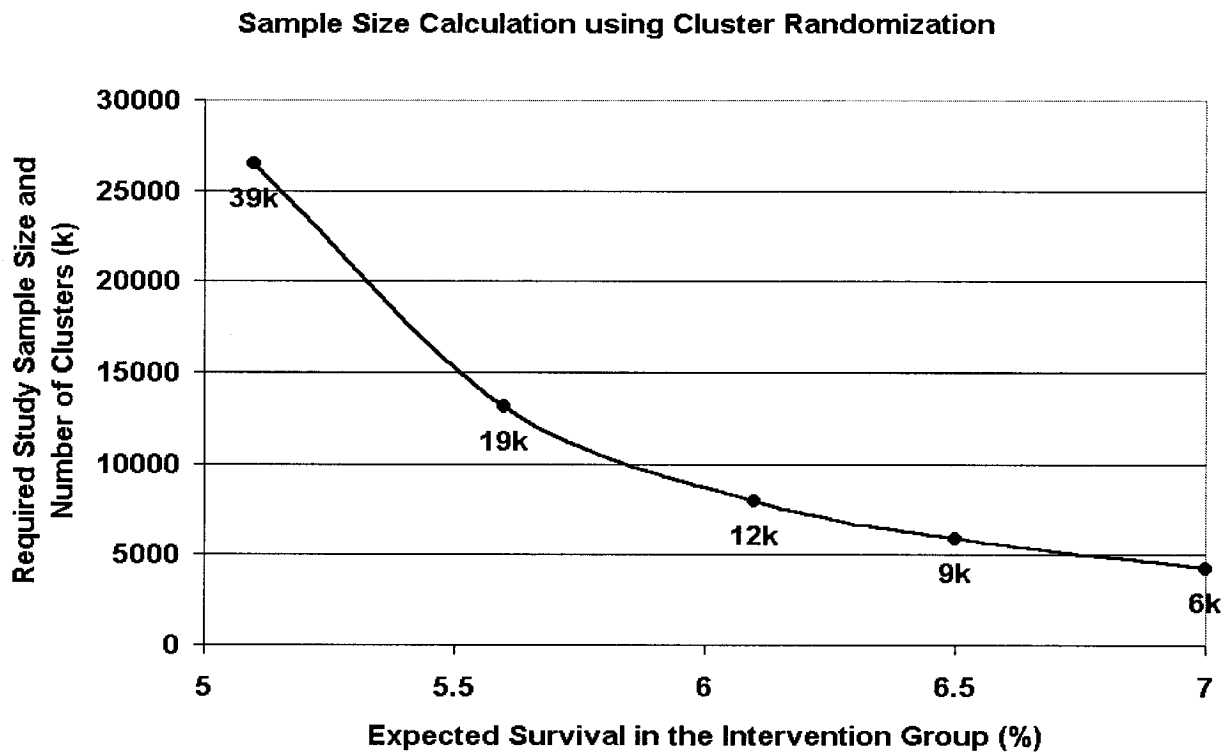
IF = 2.3

Sensitivity analysis using variable survival rates for the intervention group with corresponding bystander CPR targets, required sample size, and required number of clusters (base hospitals) is presented in Table 5.18 and Figure 5.8.

Table 5.18 Required Sample Size (N) and Number of Clusters (K) According to Variable Bystander CPR Targets and Expected Survival Rate in the Intervention Groups

Bystander CPR Rates (%)	Expected Survival (%)	N =	K =
30	5.1	26,449	39
35	5.6	13,145	19
40	6.1	8,000	12
45	6.5	5,851	9
50	7.0	4,241	6

Figure 5.8 Required Sample Size (N) and Number of Clusters (K) According to Variable Expected Survival Rate in the Intervention Groups



Obtaining a survival rate of 5.1% in the intervention groups (1.1% absolute difference) would require doubling our current bystander rates to 30%, the recruitment of 26,449 cardiac arrest cases, and 39 clusters. A more reasonable goal, providing we can achieve a bystander CPR rate of 40% and 6.1% survival

in the intervention groups (2.1% absolute difference), would be to recruit 8,000 cardiac arrests cases in 12 clusters.

Feasibility

With approximately 1,600 cardiac arrests occurring each year in the 11 OPALS base hospitals, we would need 5 years to complete the study. Providing we can recruit a large centre such as Toronto to obtain the required 12th cluster, it would be feasible to complete the trial within 3 to 5 years.

Alternatives would be to use stratified or matched-pair randomization, adjust for baseline characteristics in the analysis, recruit communities not currently enrolled in the OPALS study, or prolong the study period. Another alternative would be to use bystander CPR rates as the outcome rather than survival to cardiac arrest. We have demonstrated in Section 5.3 that bystander CPR is a strong predictor of survival to cardiac arrest; bystander CPR rate could therefore be a reasonable surrogate outcome measure for our intervention. Although changing the unit of randomization from base hospitals to single cases would certainly increase power and more than cut in half the required sample size for the study, this would be mathematically incorrect and is not a reasonable option.

5.23. Interim Analysis

Sequential analysis will be performed once a year using the O'Brien-Fleming method (four interim analysis and the final analysis). This method uses progressively narrowing boundaries for rejecting the null hypothesis over time and sets the level of significance for the final analysis at p=0.046. This

requirement of the O'Brien-Fleming method was already accounted for in the sample size calculation. For ethical considerations and in order to save valuable resources, we will stop the study as soon as we reach statistical significance for our primary outcome. In the event that survival would prove to be significantly improved in the intervention groups, no time would be lost waiting for the completion of the study before all participating communities could implement the intervention.

6. DISCUSSION

This thesis has established new landmarks in out-of-hospital cardiac arrest research: 1) we developed the largest and most accurate database on cardiac arrest location yet published, 2) we used the largest known database on prehospital cardiac arrest to determine patient and system characteristics, current and potential effect of various bystander CPR rates on survival to cardiac arrest, and the potential impact of PAD programs on overall survival to cardiac arrest, 3) we performed the most comprehensive systematic review and analysis of bystander CPR determinants published to date, and 4) we planned and described a cluster-randomized trial implementing a public health intervention in the field of prehospital cardiac arrest. These are all large steps toward improving cardiac arrest survival. We believe our results could be generalized to any community with an ambulance defibrillation program in place.

6.1. Overall Importance of Improving Bystander CPR Rates

Cardiovascular disease and cardiac arrest are the number one cause of mortality in Canada. We also determined the average cardiac arrest victim to be a 69 year-old male. According to Statistics Canada, the 45 to 65 year-old age group increased by 35.8% over the last decade.[299] It is conceivable that the next decade will bring a significant increase in the number of cardiac arrest victims.

A decreasing trend in mortality from ischemic heart disease has been observed all over the world.[40-42] This phenomenon is not yet fully understood by researchers in the field. Some would like to credit improvements in the health

care system.[40] The Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA) trial is an international, multicenter trial commissioned by the World Heath Organization (WHO). Thirty-eight populations from 21 countries and four continents each contributed ten years of data to the study between 1979 and 1996. It has been reported that over the study period, incidence of myocardial infarctions decreased from 221 to 179 / 100 000 per year (p=0.0002).[40] This was accompanied by improvements in systolic blood pressure, cholesterol levels and smoking habits.[40, 42, 43] Other factors such as increasing severity of disease in an aging population[40], increasing smoking rates in women, and increasing overall body mass index in the general population[43] may ultimately reverse that reassuring trend.

A study performed in 1994 by the Heart and Stroke Foundation estimated the annual financial burden of cardiovascular disease on the Canadian economy to be 18 billion dollars.[2] The estimated initial cost for the care of a single cardiac arrest patient, expressed in 1996 US dollars, in a standard Emergency Medical System (EMS) is 5900$ (interquartile range 3200$ to 10 900$).[300] Ottawa researchers have recently received funding in order to conduct a cost-analysis of interventions in the care and prevention of heart disease as part of the Cardiac Outcomes Related to Economics (CORE) multi-institution collaboration project.

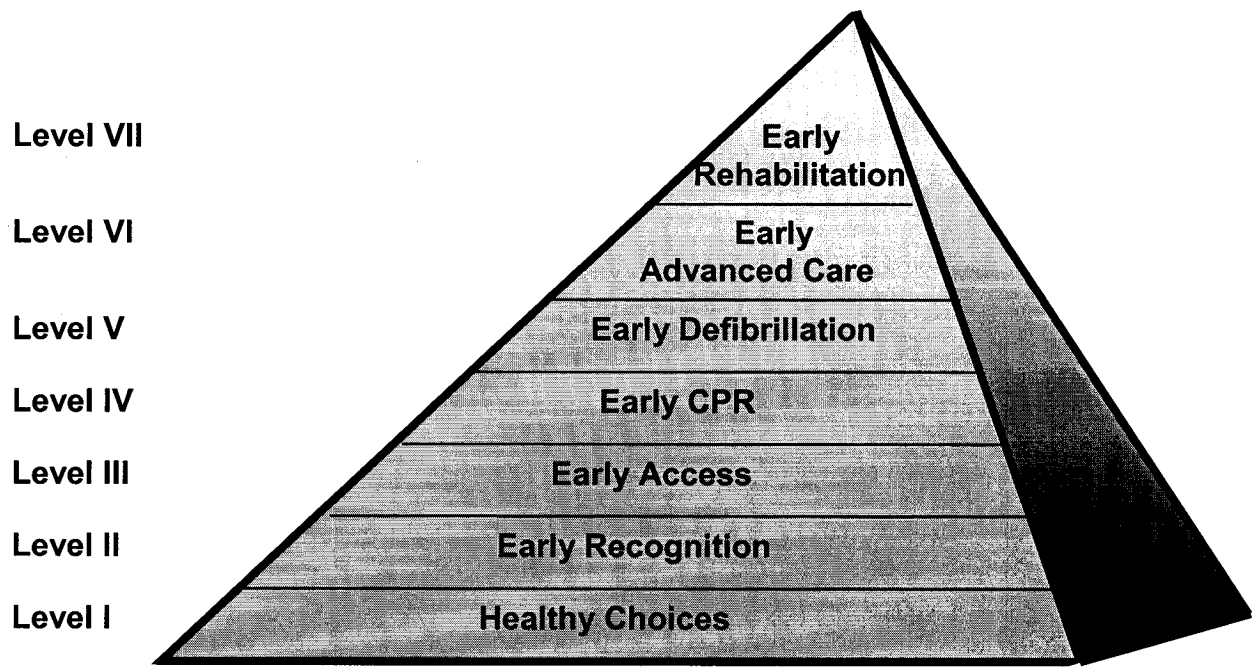
A growing number of cardiac arrest victims combined with consistently increasing health care costs are likely to put a significant strain on the health care system. This predicament will be compounded by the added societal loss of productivity resulting from the premature demise of a competent work force. It is

essential that significant improvements take place in the care for out-of-hospital cardiac arrest in the years to come.

6.2. The Chain of Survival Concept Revisited

The chain of survival concept implies that survival from cardiac arrest can only be as "strong" as the weakest link in the chain. No hierarchical importance is given to the succession of links. This being said, it is our opinion that a "Pyramid of Survival" model may better put in perspective the relative importance of each "link", now referred to as "level" (Figure 6.1).

Figure 6.1 The Pyramid of Survival Model



In this new model, survival to cardiac arrest depends on the "strength" of every level, where each level can only be as strong as the one(s) supporting it. For example: 1) early recognition of cardiac arrest (level II) would be required less frequently if people adopted healthier lifestyles in prevention of cardiac disease [39]; 2) early access to EMS (level III) can only occur if cardiac arrest is recognized early; 3) the effectiveness of CPR (level IV) is improved by its early administration by bystanders or early access to EMS personnel [76-79]; 4) the effectiveness of defibrillation (level V) is improved by early administration of CPR [79, 84, 85]; 5) the effectiveness of advanced care (level VI) is very limited in the absence of successful defibrillation [52-56]; and finally 6) rehabilitation (level VII) can only occur when a victim survives to cardiac arrest. This new model implies that for defibrillation, advanced cardiac care, and survival to cardiac arrest to reach their full potential, the CPR level needs strengthening first.

6.3. Cardiac Arrest Epidemiology

Summary of findings

We presented patient and system characteristics for the cardiac arrest victims included in our database. The classic cardiac arrest victim is a 69 year-old male, dying at home while his wife awaits EMS arrival. While victims of cardiac arrest occurring in large and small public places are younger, more often witnesses, more likely to be in VF/VT, have faster EMS time intervals, and have better survival rates, we determined that most cardiac arrests occur in small and large residential dwellings.

Strengths

We used the largest known pre-hospital database to analyse characteristics of consecutive cardiac arrest victims over a 5-year period. The information included in this database has been collected using a rigorous methodology.[26] We developed the largest and most accurate database on cardiac arrest location yet published.

Limitations

With regards to determination of specific cardiac arrest location, we were provided with location descriptions as per December 2000, at which time the MPAC database was last updated. It is possible that a cardiac arrest occurring before December 2000 may have occurred in a location that had a different purpose at the time. While this is more likely to have occurred in commercial locations, we believe that the impact on the precision of the cardiac arrest location database should be very little.

Other studies

Although they often get a lot of media attention, cardiac arrests in public venues are rare occurrences. Other authors come to similar conclusions and mention the difficulty to identify high-risk public locations for cardiac arrest.[301, 302] All agree to say that most cardiac arrest cases occur in residential dwellings.

Importance

These findings have implications beyond the collection of data on cardiac arrest victims and can help us, for example, determine a population group that should be targeted for CPR training. The data suggests that spouses of

individuals at risk for cardiac arrest should be targeted in an intervention designed to increase overall bystander CPR rates and survival from cardiac arrest.

Future research

The epidemiological data on cardiac arrest and information on specific cardiac arrest locations collected during the course of our study could serve as a platform for other projects in the field of out-of-hospital cardiac arrest research. For instance, such information is essential in the planning of a community intervention to improve bystander CPR and survival to cardiac arrest.

6.4. Potential Impact of Bystander CPR on Cardiac Arrest Survival

Summary of findings

We looked at the effectiveness of bystander CPR in saving lives. Although bystander CPR remained strongly associated with survival from cardiac arrest, the OR decreased significantly when adjusted for witnessed status, initial arrest rhythm, cardiac arrest location, and time interval between call received and vehicle stopped. We have determined that these variables were also associated with the presence or absence of bystander CPR. Therefore, we can say they are confounding the effect bystander CPR has on survival from cardiac arrest.

We designed a mathematical model to determine the potential impact of various bystander CPR rates on cardiac arrest survival in 20 Ontarian communities. Increasing bystander CPR rates could significantly increase survival from cardiac arrest and additional number of lives saved per year. Moreover, we are suggesting that an intervention designed to increase bystander

CPR rates in the community should have its greatest impact on survival from cardiac arrest occurring in both large and small residential dwellings. These locations not only have the highest number of cardiac arrests, they currently have the lowest bystander CPR and survival rates to cardiac arrest.

Strengths

A mathematical model predicting the impact of bystander CPR on cardiac arrest survival can only be as precise as the data that is inserted in the model. Once again, we benefited from a large and well-developed pre-hospital database; we believe that the results of our predictions on survival from cardiac arrest should be very close to what would be expected to happen in real life.

Limitations

We have built our database using a subset of the OPALS study during which only prospective data was being collected. Our database spreads over the implementation periods of Phase II (rapid defibrillation) and Phase III (paramedics) of the OPALS study. Although we have noticed a small increase in the number of cardiac arrests, a small decrease in time intervals, a greater involvement of paramedics over time, and slightly increased survival from cardiac arrest over our study period, all the other patient and system characteristics remained unchanged.

We used the OR to measure the effect of bystander CPR on survival from cardiac arrest. In studying rare events (as it is the case for survival from cardiac arrest), the ORs calculated are close approximations of the relative risk.

Other studies

Our results indicated that the OR for bystander CPR was confounded by several variables. Similar findings have been reported in the literature when adjusting the OR for bystander CPR, for initial arrest rhythm, and cardiac arrest location.[131]

Data form Seattle indicates that a survival rate of 30% can be achieved for witnessed cardiac arrest cases receiving bystander CPR.[34] This figure is impressive despite representing only a subgroup of the whole cardiac arrest population. This survival rate may represent a ceiling on possible survival from cardiac arrest given non-modifiable variables such as witnessed status, initial cardiac rhythm, and realistic time intervals.[33] Seattle has taken a systematic approach to improving bystander CPR rates since the early seventies and remains an example to follow in prehospital cardiac arrest care.

Other communities such as Akita and Otsu, Japan are reporting overall survival rates from cardiac arrest of 15% and 9% in association with bystander CPR rates of 49% and 29% respectively.[85] While our results seem modest compared to the data reported in Japan on overall survival, improving our current bystander CPR rate from 16% to 40% would lead to a clinically significant improvement in survival of 2%. Another mathematical model using logistic regression in a different subset of the OPALS database corroborates our findings.[303]

Importance

Determining the effect of various community bystander CPR rates on survival from cardiac arrest is of first importance in order to justify the potential benefit and feasibility of a large study.

Future research

In order to improve bystander CPR rates and survival to cardiac arrest, we are proposing a cluster-randomized trial using communities affiliated to regional base hospitals.

6.5. Potential Impact of PAD Programs on Cardiac Arrest Survival

Summary of findings

It is our impression that PAD programs will have a very limited impact on overall survival from out-of-hospital cardiac arrest. We have demonstrated that no more than 6% of the entire cardiac arrest population could potentially be amenable to such programs. Moreover, this represents the best-case scenario where AED would be readily available in all public places, and where the public would actually make use of them.

Strengths

Combining the information from our cardiac arrest location database with the descriptive data provided from the OPALS database, we were able to determine realistic expectations for the success of PAD programs.

Limitations

The variable "Initial cardiac rhythm" represents the first rhythm observed on a cardiac monitor. In the case of cardiac arrest victims, cardiac rhythm can

change over time and progress from VF/VT to asystole. While some victims are in asystole from the time of collapse, it is conceivable that some cardiac arrest victims, classified as having an initial rhythm of asystole on cardiac monitor, may have been in VF/VT at the time of collapse. This potential classification bias is time dependant, and was limited by shorter time intervals between initial call to 9-1-1 and the use of a cardiac monitor in the case of cardiac arrests occurring in public places.

The OPALS study defines its participating communities using borders that may be somewhat different from the actual municipal boundary. This is the case because communities are defined in accordance with base hospital coverage rather then by actual municipal boundaries. While this may produce a slightly more urban-like database than would normally be the case, we don't believe this would justify questioning the external validity of our findings.

Other studies

Recent publications seem to support our concerns with the future impact of PAD programs. In a retrospective cohort study of 15,189 cardiac arrests, a statistical model was used to estimate the potential effect of PAD programs on overall survival from cardiac arrest in public location.[304] Classification of these locations into suitable and potentially suitable sites for PAD was reached by way of consensus. In their model, it is estimated that overall survival to cardiac arrest may increase from 5% to a range of 6.3% to 6.5%, depending on the assumptions made regarding defibrillator coverage.[304] Although the authors concluded that the use of additional resources for wide scale coverage of PAD

might not be justified by the marginal improvement in survival, we may argue that a 1.3% to 1.5% absolute increase in survival is attractive. This being said, their model assumed that 21% of cardiac arrests occurred in suitable or potentially suitable public locations for PAD and that the public would have no hesitation to use the AED.

Data was collected on the public use of AED in a prospective observational study taking place in three busy Chicago international airports serving more than 100 million passengers per year.[305] Over a two-year period, they collected information on 21 consecutive non-traumatic cardiac arrest cases, 18 of which were in VF/VT. An AED was not nearby nor used within five minutes in four of these 18 cases, and none of these four patients survived. Three others remained in VF/VT despite the rapid use of AED and eventually died. Among the remaining 11 victims who survived, only six of the AED users had never received prior instructions on how to use the devise, three of which were physicians.[305] Essentially, one would expect only 1.5 laymen AED user per year in their study setting.

Importance

It is especially important to put the potential impact of PAD programs in perspective in the context of limited health care resources. It is our opinion that financial resources may be better spent on promoting bystander CPR.

Future research

Despite a limited role of PAD programs on overall survival from cardiac arrest, using what we know about cardiac arrest locations and the patient and

system characteristics associated with those locations, we may be able to find specific locations where the use of AED may be appropriate and economically attractive.

6.6. Systematic Review of the Determinants of Bystander CPR

Summary of findings

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

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

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

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

Why – The lack of motivation to leave the house and register for a CPR class seem to be a major determinant of low bystander CPR rates, perhaps more so than the fear of disease transmission or litigation. We need to consider measures that will actively recruit individuals such as teaching CPR on television or mandatory training at the time of renewing a driver's license.

Strengths

We performed the most comprehensive systematic review and analysis of bystander CPR determinants published to date. While the diversity of patient populations, interventions, and outcome measures precluded a formal meta-analysis, we were able to group studies by topics and suggest statements of evidence, along with the quality of the evidence supporting that statement. In order to receive a high score, an intervention needed to be based on solid research methodology and to prove its effect on bystander CPR rates or survival from cardiac arrest.

Limitations

We used standardized criteria for study selection and data extraction. While we could not evaluate selection and extraction bias with formal statistical testing such as Funnel plots or file drawer numbers, our search strategy recall was in agreement with current methodological standards for systematic

reviews.[98] In other words, we found an adequate number of studies in sources other than electronic searching. We mentioned that the precision of our search strategy was less then what is usually expected for a systematic review. This is the result of our broad-based search strategy. While we could have restricted our search strategy to experimental or well-designed observational studies, we felt that important information could be missed if we neglected to review other types of publications such as editorials, letters, and expert communications. The only consequence of such a strategy was an increased workload for the study reviewer (CV).

Other studies

We identified two other systematic reviews of the literature pertaining to CPR.[100, 101] Jabbour and colleagues reviewed the effectiveness of basic and advanced life support courses on the basis of mortality and morbidity, retention of knowledge, and change in practice behaviour. With regards to basic life support, they conclude that knowledge retention is poor, that modular courses are effective, and that more studies on provider behaviours are warranted.[100] The Mejicano review addresses only the issue of disease transmission during CPR.[101]

We found two other large reviews of the literature on CPR.[130, 159] Neither review describes the methodology by which publications were identified and selected. The review by Chehardy uses a recommendation classification system similar to our statement of evidence but does not address most of the topics covered in our review.

Importance

Developing an intervention designed to increase bystander CPR cannot be successful without an in depth and broad understanding of bystander CPR determinants. Our systematic review of the literature provides the necessary background to designing such an intervention.

Future research

We have identified a multitude of concepts with limited scientific support during the course of our systematic review of the literature on bystander CPR. Some of the research questions may pertain to: 1) the efficacy of television publicities to teach CPR; 2) the long term effect of training school children in CPR on survival; or 3) the effect of mandatory training at the time of renewing a driver's license.

6.7. Proposed Trial to Improve Bystander CPR Rates and Survival from Out-of-hospital Cardiac Arrest

Summary of findings

We have chosen cluster randomization because we think this is the most appropriate design when studying the effects of a public health intervention like the one we are suggesting. We explained that members of a community share characteristics that result in a lack of independence among them. A measure of similarity among community members in given by the intra-class correlation factor, which in turn is used to calculate the inflation factor, a measure by which regular sample size calculation need to be increased to account for the lack of independence among individuals from a same group.

We have decided to use base hospitals as the unit of randomization in order to limit contamination between intervention groups. While one or several communities are contiguous to one another among the catchman area of a single base hospital, base hospitals are geographically more distinct from one another. A second advantage to using base hospitals as the unit of randomization is obtaining groups with more uniform number of cardiac arrests during the study period.

Strengths

We decided to recruit base hospitals already involved in the OPALS study for the following reasons: 1) uniformity of standard of care; 2) uniformity of time intervals; 3) availability of research personnel in each centre; and 4) eight years of experience in collecting cardiac arrest data for the account of the OPALS study. As the OPALS study is supposed to complete recruitment by 2003, we do not believe that overlapping both trials will be an issue.

Limitations

With regards to the proposed trial to improve bystander CPR and survival from cardiac arrest, past experience with the implementation of paramedics and ALS in Ontario suggest that certain communities may refuse to participate in the trial if they view an assignment to the control group as unacceptable.[26] We could address this by offering a different yet useful community health program such as a smoking cessation program to the control groups.[295] This would have the added advantage to avoid a potential Hawthorne effect. Likewise, the Ministry of Health may decide to legislate and adopt our intervention in part or in whole. In

both conditions, we could use a before-after design as an alternative. In that case, instead of randomizing base hospital communities to the intervention or control group, they would all receive the intervention. Outcome measures such as survival to cardiac arrest and bystander CPR rates would be evaluated prospectively before being compared to the already considerable background information available from all base hospitals for those same outcome measures.

Finally, while we have demonstrated that a cluster randomized trial is feasible in terms of sample size calculation, number of clusters required, and recruitment rate, the intervention suggested needs further development before the proposal can be submitted for funding. In this collaborative effort to implement a multiple interventions trial, ethical approval will need to be obtained from the Ottawa Hospital institutional review board. At the cluster level, participation of the base hospitals, City officials, and 9-1-1 dispatch coordinators will be required. The Ministry of Transportation will need to approve our project to include mandatory CPR training at the time of driver's license renewal in communities belonging to the intervention groups. Consent from each individual belonging to a given cluster cannot possibly be obtained; public health authorities will be asked to represent the population in their decision to participate in the studies. Public hearings will be organized if deemed necessary.

Other studies

Several authors have neglected to apply such principles in the design of studies involving groups or communities; others have applied these same principles at the time of the analysis only.[293] While in the first example authors

run the risk to find a difference between interventions when in fact it does not exist, studies from the second example will often lack the power to find a difference if it existed.

Importance

There currently is no clear reproducible systematic approach to improving community bystander CPR rates available in the literature. Results from the cluster randomization trial could have a major impact on the approach to improving bystander CPR rates all over the world.

Future research

We were able to compute an intra-class correlation factor for survival from cardiac arrest using a large sample of cardiac arrest victims. Such information is essential and difficult to obtain at the time of planning a cluster-randomized trial on cardiac arrest. Our results may help other researchers in the field of out-of-hospital cardiac arrests determine more accurate sample size for their projects.

Each of the elements suggested as part of the multiple interventions study may be studied individually for their isolated impact on survival from cardiac arrest. Such analysis may help improve and simplify the intervention and help control the cost of the intervention.

7. CONCLUSIONS

Cardiovascular disease and cardiac arrest are the number one cause of death in Canada. Despite the recent implementation of rapid defibrillation and paramedics in 20 Ontarian communities, overall survival rates from cardiac arrest remain among the lowest ones in North America. We have suggested that further improvements in rapid defibrillation via the implementation of PAD programs may not have the impact on survival people have been hoping for. We have demonstrated the potential impact of various bystander CPR rates on survival from cardiac arrest, we have studied the determinants of bystander CPR in a systematic review of the literature, and we are proposing the first large scale Canadian multiple interventions trial with the objective of improving bystander CPR rates and survival from cardiac arrest on Ontario.

The proposed study should provide clear evidence that a systematic public health intervention in the field of bystander CPR will improve survival from cardiac arrest. We expect our results will help the Provincial and Federal Ministry of Health take decisions with regards to the implementation of our program at a Provincial and Federal level. Similarly, the results of our study could significantly affect other international communities equipped with an existing EMS.

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9. APPENDICES

APPENDIX A: Canada Occupational Safety and Health Regulations

Canada Labour Code (R.S. 1985, c. L-2)

...

Part II Canada Occupational Safety and Health Regulations (SOR/86-304)

...

PART XVI
FIRST AID

Interpretation

16.1 The definitions in this section apply in this Part.

"ambulance response time" means the time required for an ambulance with trained personnel and emergency medical equipment to reach the workplace from the nearest point of dispatch under normal travel conditions. (délai d'intervention ambulancière)

"first aid attendant" means a holder of a valid basic or standard first aid certificate. (secouriste)

"first aid station" means a place, other than a first aid room, at which first aid supplies or equipment are stored. (poste de secours)

"health unit" means a facility that is under the charge of a physician or a person who is registered as a registered nurse under the taws of any province, and that, if it is under the control of the employer, meets the minimum requirements of a first aid room contained in this Part. (service de santé)

"medical treatment facility" means a hospital, medical clinic or physician's office, at which emergency medical treatment can be dispensed. (installation de traitement médical)

"remote workplace" means a workplace for which the ambulance response time is more than two hours. (lieu de travail isolé)

"standard first aid certificate" means the certificate issued by an approved organization for successful completion of a two-day first aid course. (certificat de secourisme général) SOR/88-68, s. 13(E); SOR/2000-328, s. 2.

General

16.2 (1) Every employer shall establish, and keep up to date, written instructions that provide for the prompt rendering of first aid to an employee for an injury, an occupational disease or an illness.

(2) The employer shall keep a copy of the instructions readily available for consultation by employees. SOR/88-632, s. 70(F); SOR/2000-328, s. 2

First Aid Attendants

16.3 (1) At every workplace at which six or more employees are working at any time, the employer shall ensure that there is a first aid attendant.

(2) At every remote workplace at which two or more employees are working at any time, the employer shall ensure that there is a first aid attendant.

(3) At every workplace at which an employee is working on live high voltage electrical equipment, the employer shall ensure that

(a) a first aid attendant is readily available; or

(b) at least one of the employees has the training necessary to provide resuscitation by mouth-to-mouth resuscitation, cardiopulmonary resuscitation or an equivalent direct method:

(4) At every workplace that is required to have a first aid attendant, the employer shall ensure that the first aid attendant at the workplace is qualified by having at least

(a) if the workplace is an office workplace for which the ambulance response time is

(i) up to two hours, a basic first aid certificate, or

(ii) more than two hours, a standard first aid certificate;

(b) if the workplace is any other workplace, other than a workplace in a wilderness area, and the ambulance response time for the workplace is

(i) less than twenty minutes, a basic first aid certificate, or

(ii) twenty minutes or more but not more than two hours, a standard first aid certificate;

and

(c) if the workplace is in a wilderness area, a standard first' aid certificate and wilderness first aid training that is specially designed to meet the first aid needs of persons who work, live or travel in such an area. SOPé2000-328, s. 2:

16.4 (1) A first aid attendant referred to in section 163 or paragraph 16.10(1)(a)

(a) shall be assigned' to a first aid station or first aid room;

(b) shall be readily available and accessible to employees during working hours;

(c) shall render first aid to employees who are injured or ill at the workplace;

(d) shall, if required, accompany an injured or ill employee to a health unit or a medical treatment facility and render first aid in transit;

(e) shall, in providing care to an injured or ill employee, not be overruled by anyone not trained in first aid; and

(f) shall be in charge of providing care for the injured or ill employee until the treatment is complete or the employee is under the care of an equally or more qualified caregiver.

(2) The first aid attendant referred to in subsection (1)

(a) shall work close to the first aid station or first aid room to which the first aid attendant is assigned; and

(b) shall not be assigned duties that will interfere with the prompt and adequate rendering of first aid. SOR/2000-328, s. 2.

APPENDIX B: Base Hospitals and Study Communities

Base Hospitals	Study Community	Population (Stat Can 2001)
Halton Mississauga	Burlington	150,836
	Oakville	144,738
	Mississauga	612,925
Cambridge	Cambridge	110,372
	Kitchener-Waterloo	190,399-86,543
Kingston	Kingston	114,195
Niagara	Niagara Falls	78,815
	St. Catharines	129,170
	Port Colborne	18,450
	Welland	48,402
	Grimsby	21,297
London	London	336,539
Ottawa-Carleton	Ottawa-Nepean-Gloucester	774,072
Peterborough	Peterborough	71,446
	Port Hope-Cobourg	15,605-17,172
	Lindsay	21,949
Sarnia	Sarnia	70,876
Sudbury	Sudbury	160,488
Thunder Bay	Thunder Bay	109,016
Windsor	Windsor-Tecumseh	208,402-25,105
	Total:	**3,516,812**

APPENDIX C: Municipal Property Assessment Corporation Property Codes and Descriptions

Code	Property Code Description
100	Vacant res land not on water
101	Second tier vacant lot
102	Vacant land of conserv auth
103	Municipal park
104	Vacant exempt land
105	Vacant commercial land
106	Vacant industrial land
107	Provincial park
108	Federal park
109	Rec land not on water/tract
110	Vacant land parcel on water
111	Island - single ownership
112	Multi-res vacant land
120	Water lot
200	Farm - no res and no outblds
201	Farm with res and no outblds
210	Farm with outblds only
211	Farm with res with outblds
220	Farm no-res with com/ind
221	Farm with res and com/ind
230	Intensive farm without res
231	Intensive farm with res
240	Mf prop -vacant not on water
241	Mf prop -vacant on water
242	Mf prop-seasonal noton water
243	Mf prop-seasonl res on water
244	Mf prop - res not on water
245	Mf prop - res on water
260	Vac res,com,ind land-pt farm
261	Non-farm bld, ptn being farm
301	Single fam det not on water
302	+1 struc res-at least 1 occ
303	Residence with com unit
304	Residence with com/ind bldg
305	Link home
309	Freehold townhouse/rowhouse
311	Semi-detached residential
312	Residence & gt one res unit
313	Single fam.detached-on water
322	Semi-det - on one roll #
332	Res - 2 self-contained units
333	Res - 3 self-contained units

Code	Property Code Description
334	Res - 4 self-contained units
335	Res - 5 self-contained units
336	Res - 6 self-contained units
340	Multi-res - not row housing
350	Row- 3 to 6 units one title
352	Row- 7 or + units one title
360	Rooming/boarding house
361	Bachelorette
363	Housekeeping cottages
365	Group home (per municip.act)
370	Res condo- not 371/372
371	Res condo conv -6 units plan
372	Res condo conv 6+ units plan
373	Cooperative housing -equity
374	Cooperative housing -no equ
381	Mobile home(s)
382	Mobile home park
383	Bed & breakfast (predom use)
385	Time share- fee simple
386	Time share- right-to-use
391	Seasonal dwg - 1st tier
392	Seasonal dwg - 2nd tier
395	Seasonal dwg - no water frtg
399	Unspecified residential prop
400	Office
401	Medical or dental bldg
405	Office use (converted house)
406	Retail use (converted house)
410	Retail
411	Restaurant-conventional
412	Restaurant-fast food
415	Concert/thea/movie/drive-in
420	Service station
421	Spec auto shop/rep/coll/wash
422	Auto dealership
428	Regional shopping centre
429	Community shopping centre
430	Neighborhood shopping centre
431	Department store
432	Bank
440	Hotel
441	Tavern/pub/small hotel

Code	Property Code Description
450	Motel-not seasonal
451	Motel-seasonal
460	Resort lodge
462	Cottage resort
470	Multi-7+res/condo/commercial
471	Retail with residential
472	Retail with office(s)
473	Retail with 1+ non-retail
475	Commercial condominium
480	Parking lot without garage
481	Parking gar -separate prop
486	Campground-any owner
487	Kiosk/billboard
488	Pipeline-trans/field/gather
489	Pipeline-other than code 488
490	Golf course
491	Ski resort
492	Marina
496	Communication system
497	Railway right-of-way
498	Railway lands/bldgs sec 29-3
499	Unspecified commercial prop
500	Mine
510	Heavy indust - not specified
511	Paper mill
512	Cement/asphalt manuf. Plant
513	Metals/steel/rel steel plant
514	Auto assembly/manuf/parts
515	Shipyard/drydock
520	Stand indust - not specified
521	Distillery/brewery
522	Grain handling-elevators
523	Feed mill
530	Warehousing
531	Mini-warehousing
540	Other industrial
550	Petrochemical plant
555	Genco hydraulic gen station
556	Genco nuclear gen station
557	Genco gen st (fossil fuel)
558	Servco transformer station
559	Meu generating station
560	Meu transformer station
561	Servco hydro rights-of-way
562	Private hydro rights-of-way

Code	Property Code Description
563	Private hydraulic gen st
564	Private nuclear gen station
565	Private gen st (fossil fuel)
566	Private transformer station
575	Industrial condominium
580	Industrial mall-(non-condo)
590	Sew/treat/disp/inciner plant
593	Gravel pit/quarry/sand pit
595	Heat or steam plant
600	Institutional prop-unspec
601	Post secondary education
602	Multi-occ educ inst res/dorm
605	School - elem or secondary
608	Day care / nursery
610	Educ institution - unspec
611	Inst residence(s) - unspec
621	Hospital - private/public
625	Nursing home
626	Old age/retirement home
627	Health care facility -unspec
630	Penal institution
700	Special purpose prop-unspec
701	Church
702	Cemetery/memorial gardens
705	Funeral home
710	Recreational sport club
711	Bowling alley
715	Race track-auto and horse
718	Exhibition/fair grounds
720	Sports comp/pool/arena/stad
725	Amusement park
730	Museum/art gallery/non-prof
731	Library and literary inst
735	Assembly/community hall
736	Club - private/fraternal
741	Airport
742	Public transport facility
743	International bridge/tunnel
750	Scien/pharma/med research
760	Military-armouries/cfb/spec
800	Special purpose
805	Post office
810	Fire hall
812	Ambulance base
815	Police station

APPENDIX D: Ambulance Call Report Form

Ontario

Ministry of Health and Long-Term Care

Emergency Health Services

Ambulance Call Report

Confidential when completed

Screened areas must be completed for all patient carrying calls. Please press hard, you are making multiple copies.

Warning System Used

To Scene	To Destination
☐ ☐	None ☐ ☐
☐ ☐	Lights only ☐ ☐
☐ ☐	Lights & Siren ☐ ☐

Ambulance Administration

CACC | Call No. | Service name

Date (ymd) | Service No. | Station | Vehicle No. | Start (km) | PU (km) | Destination(km) | Special codes | Geo. code/UTM

Pick-up location | PU code | Dispatch | Return | Patients | Sequence

Patient Identification

Surname | Given name | Birth Date (ymd)

Mailing Address (street) | Same as P/U ☐ | City/Town

Clinical Information

Nature of Emergency/Transfer Chief complaint | Nature code | Time of occurence

History of present condition

Pertinent past Hx: 1 ☐ Cardiac 2 ☐ Asthma 3 ☐ Emphysema 4 ☐ Bronchitis 5 ☐ CVA/TIA 6 ☐ Hypertension 7 ☐ Convulsions 8 ☐ Diabetes 9 ☐ Other

Medications

Allergies: ☐ NKA ☐ ASA ☐ Sulfa ☐ Penicillin ☐ Other

Treatment prior to ambulance arrival ☐ Police ☐ Fire ☐ Bystander ☐ Other

1 ☐ Arrest witnessed by EMS personnel 2 ☐ Arrest witnessed by bystander 3 ☐ Arrest unwitnessed

CPR started by: ☐ Bystander ☐ BLS crew ☐ Other ☐ Police/Fire ☐ ALS crew

Duration of CPR prior to crew arr. Min.

Patient name | Age: | Gender: ☐ M ☐ F | Weight(kg) | Case severity | General Appearance: Head/Neck; Chest (air entry); Abdomen; Back; Pelvis; Extremities

Hospital Administration

Health No. | Ver. | DND/RCMP Social Ins No. | Registration No. | Hospital code

Billed by: ☐ hospital/clinic ☐ Operator ☐ Other

Charge

☐ Patient ☐ D.N.D.
☐ Employer ☐ Coroner
☐ W.C.B. ☐ Chargeable welfare
☐ D.V.A. ☐ Other

No charge

☐ Inter hospital transfer ☐ Home for aged
☐ Home care ☐ Recipient general welfare assistance
☐ Homes for special care ☐ Other
☐ Nursing home patient

Billing evaluation

In my professional medical opinion ambulance use was:

☐ *Essential, a medical / other necessity*

☐ *Non essential,* not a medical necessity/other transport suitable

Signature *(medical practitioner/approved authority)*

Basic fee Patient's portion

Charge for km over 40

Other charge

Amount billed

Payment received: ☐ Initials

Disposition in Hospital *Emergency Dept.*

☐ Refused treatment & released
☐ Treated (observed) & released
☐ Transferred to Adm. Dept.
☐ Transfered to another hospital
☐ Morgue

Out Patient

☐ O.P. Clinic ☐ Ca. Clinic
☐ X-Ray ☐ Other
☐ In-patient returning ☐ In-patient discharged

1881-45 (99/09)

Clinical Information (continued)

Time		1	2	3
Vital Signs	rate			
	rhythm			
	volume			
	rate			
	rhythm			
	volume			
	colour			
	condition			
	temp.			
		/	/	/
+ reacts – no reaction c eyes closed	R size			
	R react.			
	L size			
	L react.			
Coma Scale – Eye opening	4	SPONTANEOUS		
	3	TO VOICE		
	2	TO PAIN		
	1	NONE		
Verbal response	5	ORIENTED		
	4	CONFUSED		
	3	INAPPROPRIATE WORDS		
	2	INCOMPREHEN. SOUNDS		
	1	NONE		
Motor response	6	OBEYS COMMAND		
	5	LOCALIZE (PAIN)		
	4	WITHDRAW (PAIN)		
	3	FLEXION (PAIN)		
	2	EXTENSION (PAIN)		
	1	NONE		
Total				

Procedures

Time	Medicine or Procedure	Code	Result	Initials	No.

Remarks and/or procedures continued

If Physician at scene – name:

Final Assessment By Crew

Problem Location (if trauma)

Secondary problem

Patient transport | Other

General Administration

Time of Call Events	Call received	Crew notified	Crew mobile	Arrived scene	Arrived patient	Departed scene	Arrived destination	T.A.T. response

Base hospital | Base hospital No. | Base hospital physician name (if patch) | Notification time (if patch)

Receiving facility: signature | Hospital No.

White–Patient chart Blue–Billing office Canary–Base hospital Pink–Ambulance service

1881–45 (99/09)

APPENDIX E: Correspondence of the Location Categories Provided by MPAC and the Cardiac Arrest Location Categories Adapted from the Ministry of Health EMS Branch

Location Categories	MPAC Property Description	Total
Missing	Missing	29
Airport/Heliport/Bus Station/Train Station	Missing	2
	OFFICE BUILDING	2
Casino	Missing	11
	UNSPECIFIED COMMERCIAL PROPERTY	17
Construction Site	Missing	3
Factory/Industrial Site/Railway/Dockyard	Missing	10
	STANDARD INDUSTRIAL PROPERTIES NOT SPECIFICALLY IDENTIFIED BY OTHER INDUSTRIAL PROPERTY CODES	19
	OTHER INDUSTRIAL (ALL OTHER TYPES NOT SPECIFICALLY DEFINED)	8
	HEAVY INDUSTRIAL PROPERTIES NOT SPECIFICALLY IDENTIFIED BY OTHER INDUSTRIAL PROPERTY CODES	7
	INDUSTRIAL MALL (NON-CONDOMINIUM)	4
	WAREHOUSING	3
	AUTOMOTIVE ASSEMBLY/AUTO PARTS MANUFACTURING PLANT	2
	INDUSTRIAL CONDOMINIUM	1
	PAPER MILL	1
	SPECIAL PURPOSE	1
Farm	FARM WITH A RESIDENCE (WITH OR WITHOUT SECONDARY STRUCTURES) AND FARM OUTBUILDINGS	1
	LAND IMPROVED WITH A NON-FARM BUILDING, OWNED BY A (NON-FARMER) WITH SOME OF THE LAND BEING FARMED	1
Golf Course	Missing	2
	GOLF COURSE - REGARDLESS OF OWNERSHIP	7
Hospital (Non-Acute)	Missing	28
	HOSPITAL, PRIVATE AND PUBLIC	14
	ALL SPECIAL PURPOSE PROPERTIES NOT SPECIFICALLY DEFINED	2
Hotel	Missing	12
	HOTEL	27
	MOTEL (OTHER THAN SEASONAL)	24
Indoor Shopping Mall	Missing	14
	OFFICE BUILDING	1
	COMMUNITY SHOPPING CENTRE	34
	REGIONAL SHOPPING CENTRE	28
Medical Office/Clinic	Missing	2
	OFFICE BUILDING	1
	MEDICAL/DENTAL BUILDING	27
	OTHER HEALTH CARE FACILITY (E.G., CLARKE	1

	INSTITUTE)	
	RESIDENCE WITH A COMMERCIAL UNIT (I.E., DOCTOR'S OFFICE, AGENCY)	10
Multi-Residential Dwelling	ALL INSTITUTIONAL PROPERTIES NOT SPECIFICALLY DEFINED	2
	VACANT RESIDENTIAL LAND NOT ON WATER (1)	2
	Missing	268
	COOPERATIVE HOUSING - EQUITY	7
	COOPERATIVE HOUSING - NON-EQUITY	43
	GROUP HOME AS DEFINED IN CLAUSE 240 (1) OF THE MUNICIPAL Act.	6
	MULTIPLE OCCUPANCY EDUCATIONAL INSTITUTIONAL RESIDENCE LOCATED ON OR OFF CAMPUS (I.E., DORMITORIES)	2
	MULTI-RESIDENCE, MORE THAN 6 SELF-CONTAINED UNITS (1), BUT DOES NOT INCLUDE ROW HOUSING	915
	LARGE MODERN COMPLEX HAVING MULTI-RESIDENTIAL (7 UNITS OR MORE) AND/OR CONDOMINIUM WITH COMMERCIAL USE	9
	OTHER INSTITUTIONAL RESIDENCE (E.G., CONVENTS)	17
	RESIDENCE WITH MORE THAN ONE RESIDENTIAL UNIT, TYPICALLY A CONVERSION	17
	RESIDENTIAL CONDOMINIUM CONVERSION STILL RENTED WITH SEVEN OR MORE UNITS IN THE CONDOMINIUM PLAN	5
	RESIDENTIAL CONDOMINIUM, EXCLUDING THOSE DEFINED BY CODES 371 AND 372	454
Nursing Home	Missing	110
	NURSING HOME (ALL TYPES).	134
	OLD AGE/RETIREMENT HOME	213
Office Building	ALL SPECIAL PURPOSE PROPERTIES NOT SPECIFICALLY DEFINED	2
	Missing	14
	OFFICE BUILDING	41
	UNSPECIFIED COMMERCIAL PROPERTY	2
	SPECIAL PURPOSE	4
	BANKS AND SIMILAR FINANCIAL INSTITUTIONS, INCLUDING CREDIT UNIONS (EXCLUDING	3
	COMMERCIAL CONDOMINIUM	10
	FIRE HALL	1
	OFFICE USE CONVERTED FROM HOUSE	6
	POLICE STATION	2
	RESIDENCE WITH A COMMERCIAL/INDUSTRIAL USE BUILDING	2
	RETAIL WITH OFFICE(S)	8
	SCIENTIFIC/PHARMACEUTICAL/MEDICAL RESEARCH FACILITY	1
Other	VACANT RESIDENTIAL LAND NOT ON WATER (1)	6
	Missing	5
	VACANT INDUSTRIAL LAND (1)	1
Penal Institution	Missing	6

Recreation Facility	ALL SPECIAL PURPOSE PROPERTIES NOT SPECIFICALLY DEFINED	2
	ALL INSTITUTIONAL PROPERTIES NOT SPECIFICALLY DEFINED	2
	Missing	53
	OFFICE BUILDING	1
	UNSPECIFIED COMMERCIAL PROPERTY	3
	ASSEMBLY HALL, COMMUNITY HALL	10
	BOWLING ALLEY	2
	CHURCH (ALL DENOMINATIONS WITH OR WITHOUT MANSE)	21
	CLUBS, PRIVATE AND FRATERNAL	34
	COMMERCIAL SPORT COMPLEXES (INCLUDING RACQUET, POOLS, ARENAS, AND STADIUMS, ETC.)	22
	CONCERT HALL/THEATRE/CINEMA/MOVIE HOUSE/DRIVE-IN THEATRE	4
	FUNERAL HOME	3
	RECREATIONAL SPORT CLUB (INCLUDING YACHT, CURLING, ETC., BUT EXCLUDING GOLF CLUBS AND SKI RESORTS)	8
Restaurant/Bar	Missing	18
	UNSPECIFIED COMMERCIAL PROPERTY	1
	RESTAURANT - CONVENTIONAL	14
	RESTAURANT - FAST FOOD	10
	TAVERN/PUBLIC HOUSE/SMALL HOTEL	5
School/College/University	ALL SPECIAL PURPOSE PROPERTIES NOT SPECIFICALLY DEFINED	1
	VACANT RESIDENTIAL LAND NOT ON WATER (1)	1
	Missing	6
	SCHOOL (ELEMENTARY OR SECONDARY, INCLUDING PRIVATE)	17
	POST SECONDARY EDUCATION - UNIVERSITY, COMMUNITY COLLEGE, ETC.	11
Single Store/Strip Mall	VACANT RESIDENTIAL LAND NOT ON WATER (1)	1
	Missing	15
	OFFICE BUILDING	1
	UNSPECIFIED COMMERCIAL PROPERTY	3
	SPECIALITY AUTOMOTIVE SHOP/AUTO REPAIR/COLLISION SERVICE/CAR OR TRUCK WASH	4
	DEPARTMENT/DISCOUNT STORE	7
	AUTO DEALERSHIP	8
	AUTOMOTIVE FUEL STATION WITH OR WITHOUT SERVICE FACILITIES	9
	RETAIL WITH MORE THAN ONE NON-RETAIL USE	11
	RETAIL	42
	RETAIL WITH RESIDENTIAL UNIT(S) (ABOVE OR BEHIND)	43
	NEIGHBOURHOOD SHOPPING CENTRE, INCLUDING MORE THAN 2 STORES ATTACHED AND UNDER	87
Single-Residential Dwelling	ALL SPECIAL PURPOSE PROPERTIES NOT SPECIFICALLY DEFINED	1

	ALL INSTITUTIONAL PROPERTIES NOT SPECIFICALLY DEFINED	1
	VACANT RESIDENTIAL LAND NOT ON WATER (1)	2
	ROW HOUSING, WITH THREE TO SIX UNITS UNDER ONE TITLE	7
	LINK HOME	8
	MORE THAN ONE STRUCTURE USED FOR RESIDENTIAL PURPOSES	8
	RESIDENTIAL PROPERTY WITH 5 SELF-CONTAINED UNITS (1)	9
	ROOMING OR BOARDING HOUSE	13
	MOBILE HOME - ONE OR MORE HOMES ON A PERCEL OF LAND WHICH IS NOT A MOBILE HOME PARK OPERATION	15
	SINGLE FAMILY DETACHED ON LAKE OR RIVER	25
	RESIDENTIAL PROPERTY WITH 4 SELF-CONTAINED UNITS (1)	26
	RESIDENTIAL PROPERTY WITH 6 SELF-CONTAINED UNITS (1)	28
	RESIDENTIAL PROPERTY WITH 3 SELF-CONTAINED UNITS (1)	36
	FREEHOLD TOWNHOUSE/ROWHOUSE	39
	SEMI-DETACHED WITH BOTH UNITS UNDER ONE OWNERSHIP	39
	ROW HOUSING, WITH SEVEN OR MORE UNITS UNDER ONE TITLE	108
	RESIDENTIAL PROPERTY WITH 2 SELF-CONTAINED UNITS (TYPICALLY A DUPLEX) (1)	131
	SEMI-DETACHED RESIDENTIAL USE (INCLUDES TRUE SEMI AND SINGLE SEMI LINKS)	239
	Missing	251
	SINGLE FAMILY DETACHED (NOT ON WATER)	3338
Sports Field/Fairground/Park	Missing	10
	AMUSEMENT PARK	1
	CAMPGROUND, REGARDLESS OF OWNERSHIP	1
	CEMETERY/MEMORIAL GARDENS	1
	MUNICIPAL PARK (EXCLUDES PROVINCIAL PARKS, FEDERAL PARKS CAMPGROUNDS (2)	1
Stadium	RACE TRACK, AUTO AND HORSE	1
Street/Highway/Road	Missing	204
	HOSPITAL, PRIVATE AND PUBLIC (PARKING)	1
	PARKING LOT - WITHOUT PARKING GARAGE	1
Water/Boat	Missing	3
	MARINA - DEFINED AS A COMMERCIAL FACILITY FOR THE MAINTENANCE, STORAGE, SERVICE AND/OR SALE OF WATERCRAFT	2

APPENDIX F: Mathematical Model for Predicting Survival and Additional Number of Lives Saved per Year in All Cardiac Arrest Locations According to Predetermined Bystander CPR Rates

		%	N (cardiac arrest)	Survival	N (alive)
Witnessed A	Bystander CPR	C	[(C-D)+(D/2)]*A (D*A)/2	F*[3.4*(2/4.4)] F*(2/4.4)	[1] [1]
	No Bystander CPR	1 – C	(1 – C)XA	G	[1]
Unwitnessed B	Bystander CPR	C	[(C-E)+(E/2)]*B (E*B)/2	H*[3.4X(2/4.4)] H*(2/4.4)	[1] [1]
	No Bystander CPR	1 – C	(1 - C)*B	I	[1]
Total = A+B				Survival (%) =	[2]
				Add. # Lives/year =	[3]

Where:
A = N witnessed
B = N unwitnessed
C = Assumed bystander CPR rate
D = Bystander CPR rate in witnessed cases
E = Bystander CPR rate in unwitnessed cases
F = Survival in witnessed cases receiving bystander CPR
G = Survival in witnessed cases not receiving bystander CPR
H = Survival in unwitnessed cases receiving bystander CPR
I = Survival in unwitnessed cases not receiving bystander CPR
J = Baseline survival in location category

Where:
[1] = N (cardiac arrest)*Survival
[2] = Σ [1]/(A+B) * 100
[3] = (([2]*(A+B)) – (J*(A+B)))/5

Where:
-Bystander CPR has been divided into two equal groups — the top line representing well-performed CPR, the bottom line representing incorrect bystander CPR.
-Survival in well-performed bystander CPR is 3.4 times better than in the incorrect bystander CPR group.

Therefore (in witnessed cases for example):
(incorrect CPR survival)+3.4*(incorrect CPR survival)/2 = F

4.4*(incorrect CPR survival) = F*2

(incorrect CPR survival) = F*(2/4.4)

(well-performed CPR survival) = F*[3.4*(2/4.4)]

APPENDIX G: Electronic Search Strategies for the Systematic Review

OVID search (25/10/01)

PreMEDLINE/MEDLINE, EBM Cochrane-ACP JC-DARE, EBM Cochrane controlled trials register, Biological Abstract, CINAHL, Current Content, Dissertation Abstract, ERIC, HealthSTAR, PAIS International, PsyInfo, SocioFile

Teaching

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

CPR

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

to the Population

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

Merging medical subject headings with text word search.

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

Combining concepts

11. and/8-10

PUBMED search (31/10/01)

#4 Search #1 AND #2 AND #3

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

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

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

APPENDIX H: Standardized Selection and Abstraction Form for the Systematic Review and Meta-analysis

First author's last name: _____ Paper #: _____

Population

Human?
- O No (exclude) → D/C Instruct.O
- O Yes (continue)

Medical personnel curriculum?
- O Yes (exclude) → Elderly O
- O No (continue)

Baby/familyO
Mass trainingO
Review O
No instructorO
Hardware O
Other O

Intervention/Outcome

Check all that applies: (include if at least one applies) →
- O Promotion and provision of CPR courses (Who?)
- O Understanding/teaching CPR (What?)
- O Instructions over the phone (Where?)
- O Maintenance of skills (When?)
- O Attitude, motivation, reluctance (Why?)

If none of the above, exclude. →

Promotion O
Teaching O
Over phoneO
Maintenance O
Attitude O
Other O

RCT O
Quasi-exp. O
Observation O
Letter/com. O
Other O

O Included
O Excluded

Demographics

Publication status: OPublished OIn press or submitted OAbstract OOther:_____
Year of publication: _____

Country: OUnited-States OCanada OOther: _____

Language: OEnglish
OOther: _____
Translator required OYes ONo

Funded by drug co. OYes ONo or not mentioned

Specifications

Method

- Study ORCT (fill Jadad) OQuasi-exp. OObservational OLetter/Communication
  OOther: _____
- Blinding OSingle ODouble OTriple ONot mentioned
- Intention to treat OYes ONo ONot mentioned

Participants

Inclusion (describe)

Exclusion (describe)

Age range: _____

Comparison of baseline characteristics

○Similar ○Not reported

○Significant differences present

Specify: _____

_____

Describe Intervention/Observations

Data extracted from:

○Table or text ○ Graph *OR* → ○**Statistically inferred using:**

○ Mean difference ○ p-value

Sample size: _____

RCT ○Yes ○No (go to bottom)

1. Control group: _____ N=_____
2. Intervention: _____ N=_____
3. Intervention: _____ N=_____
4. Intervention: _____ N=_____

Intervention	Outcome measure	SD	N	CI (or IQR)
Control group				

Summary of findings if not a RCT:

○There is information missing preventing inclusion for the meta-analysis.

APPENDIX I: Jadad and Allocation Concealment Scoring Systems

Methodological Quality of Report, Jadad Scale

1. **Randomization:** Was the study described as randomized (i.e. including words such as randomly, random, randomization)?

A trial reporting that it is "randomized" is to receive one point.
Trials describing an appropriate method of randomization (table of random numbers, computer generated) receive an additional point.

However, if the report describes the trial as randomized and uses an inappropriate method of randomization (e.g. date of birth, hospital number), a point is deducted.

Total points: 0 1 2

2. **Double-blinding:** Was the study described as double-blind?

A trial reporting that it is "double-blind" is to receive one point. Trials that describe an appropriate method of double-blinding (identical placebo: colour, shape, taste) are to receive an additional point.

However, if the report describes the trial as double-blind and uses an inappropriate method (e.g. comparison of tablets VS injection with no dummy), a point is deducted.

Total points: 0 1 2

3. **Withdrawals and dropouts:** Was there a description of withdrawals and dropouts?

A trial reporting the number of and reasons for withdrawals or dropouts is to receive one point. If there is no description, no point is given.

Total points: 0 1

Overall Score: _____
Low = 0-2
Moderate = 3-4
High = 5 (max)

Adequacy of Allocation Concealment: (check one)

Central randomization; numbered or coded bottles or containers; drugs prepared by a pharmacy, serially numbered, opaque, sealed envelopes, etc. ❍ **ADEQUATE**

Alternation; reference to case record # or date of birth, etc. ❍ **INADEQUATE**

Allocation concealment fits neither category. ❍ **UNCLEAR**

Or, not reported. ❍ **NOT USED**

APPENDIX J: Newcastle – Ottawa Quality Assessment Scales
COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort
   a) Truly representative of the average_____(describe) in the community ✯
   b) Somewhat representative of the average_____ in the community ✯
   c) Selected group of users eg nurses, volunteers
   d) No description of the derivation of the cohort

2) Selection of the non-exposed cohort
   a) Drawn from the same community as the exposed cohort ✯
   b) Drawn from a different source
   c) No description of the derivation of the non-exposed cohort

3) Ascertainment of exposure to implants
   a) Secure record (eg surgical records) ✯
   b) Structured interview ✯
   c) Written self report
   d) No description

4) Demonstration that outcome of interest was not present at start of study
   a) Yes ✯
   b) No

Comparability

1) Comparability of cohorts on the basis of the design or analysis
   a) Study controls for _____(select the most important factor) ✯
   b) Study controls for any additional factor ✯ (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome
   a) Independent blind assessment ✯
   b) Record linkage ✯
   c) Self report
   d) No description

2) Was follow-up long enough for outcomes to occur?
   a) Yes (select an adequate follow up period for outcome of interest) ✯
   b) No

3) Adequacy of follow up of cohorts
   a) Complete follow up - all subjects accounted for ✯
   b) Subjects lost to follow up unlikely to introduce bias - small number lost ~ >____% (select an adequate %) follow up, or description provided of those lost) ✯
   c) Follow up rate <____% (select an adequate %) and no description of those lost
   d) No statement

Newcastle – Ottawa Quality Assessment Scales
CASE CONTROL STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?
   a) Yes, with independent validation ✯
   b) Yes, eg record linkage or based on self-reports
   c) No description

2) Representativeness of the cases
   a) Consecutive or obviously representative series of cases ✯
   b) Potential for selection biases or not stated

3) Selection of Controls
   a) Community controls ✯
   b) Hospital controls
   c) No description

4) Definition of Controls
   a) No history of disease (endpoint) ✯
   b) No description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
   a) Study controls for_____ (Select the most important factor.) ✯
   b) Study controls for any additional factor ✯ (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure to breast implants
   a) Secure record (eg surgical records) ✯
   b) Structured interview where blind to case/control status ✯
   c) Interview not blinded to case/control status
   d) Written self report or medical record only
   e) No description

2) Same method of ascertainment of implants for cases and controls
   a) Yes ✯
   b) No

3) Non-Response rate
   a) Same rate for both groups ✯
   b) Non-respondents described
   c) Rate different and no designation